航空航天

CHINA AEROSPACE STUDIES INSTITUTE

# China's Defense S&T Key Lab System

# 2025 Update

国防科技重点实验室

KLSTND

Key Laboratory of Science and Technology for National Defence

**Prepared by BluePath Labs**

**By Matthew Bruzzese**

Printed in the United States of America
by the China Aerospace Studies Institute
October 2025
To request additional copies, please direct inquiries to
Director, China Aerospace Studies Institute,
Air University, 55 Lemay Plaza, Montgomery, AL 36112

All photos licensed under the Creative Commons Attribution-Share Alike 4.0 International license, or under the Fair Use Doctrine under Section 107 of the Copyright Act for nonprofit educational and noncommercial use.
All other graphics created by or for China Aerospace Studies Institute
Cover art is from http://mil.news.sina.com.cn/china/2016-02-24/doc-ifxprucs6455587.shtml

E-mail: Director@CASI-Research.ORG
Web: http://www.airuniversity.af.mil/CASI
https://twitter.com/CASI_Research @CASI_Research
https://www.facebook.com/CASI.Research.Org
https://www.linkedin.com/company/11049011

Disclaimer
The views expressed in this academic research paper are those of the authors and do not necessarily reflect the official policy or position of the U.S. Government or the Department of Defense. In accordance with Air Force Instruction 51-303, Intellectual Property, Patents, Patent Related Matters, Trademarks and Copyrights; this work is the property of the U.S. Government.

Limited Print and Electronic Distribution Rights
Reproduction and printing is subject to the Copyright Act of 1976 and applicable treaties of the United States. This document and trademark(s) contained herein are protected by law. This publication is provided for noncommercial use only. Unauthorized posting of this publication online is prohibited. Permission is given to duplicate this document for personal, academic, or governmental use only, as long as it is unaltered and complete however, it is requested that reproductions credit the author and China Aerospace Studies Institute (CASI). Permission is required from the China Aerospace Studies Institute to reproduce, or reuse in another form, any of its research documents for commercial use. For information on reprint and linking permissions, please contact the China Aerospace Studies Institute.

Cleared for Public Release, Distribution unlimited.

# Table of Contents


Introduction ..... 1

Overview of Defense S&T Key Labs ..... 2

- Number of Defense S&T Key Labs ..... 3
- Management ..... 5
- Leadership ..... 9
- Research ..... 10
- Relationship between State Key Labs and Defense S&T Key Labs ..... 15
- Collaboration with U.S. Institutions ..... 18

Notes on the Data Presented in this Directory ..... 19

- Translations of Lab Names and Attempts at Obfuscation ..... 19
- Chinese Names and Aliases ..... 20
- Research Fields ..... 20
- Lab Affiliations ..... 20
- "Key Data" Fields ..... 20
- Research Direction ..... 20
- Notable Applications ..... 21
- Notable Collaborations ..... 21
- Lab Equipment ..... 21
- Translations ..... 21
- Sources ..... 21
- Special Thanks ..... 21

Lab Data ..... 22

- List of Labs by Year Founded ..... 22
- List of Labs by Location ..... 24
- List of Labs by Parent Institution ..... 26
- List of Labs by Domain Research ..... 29
- List of Labs by Equipment Research ..... 32
- List of Labs by Functional Research ..... 35
- List of Labs with New Names Under Reorganization ..... 39

1. Defense S&T Key Laboratory of Advanced Composite Materials ..... 43
2. Defense S&T Key Laboratory of Advanced High-Temperature Structural Materials ..... 48
3. Defense S&T Key Laboratory of Aero-Engine Aerodynamics and Thermodynamics ..... 52
4. Defense S&T Key Laboratory of Aerospace Systems Simulation ..... 58
5. Defense S&T Key Laboratory of Aircraft Control and Integration Technology ..... 63
6. Defense S&T Key Laboratory of Airfoil and Blading Aerodynamics ..... 69
7. Defense S&T Key Laboratory of Antennas and Microwave Technology ..... 78
8. Defense S&T Key Laboratory of Aviation Engine High-Altitude Simulation Technology ..... 86
9. Defense S&T Key Laboratory of Aviation Plasma Dynamics ..... 92

10. Defense S&T Key Laboratory of Ballistic Missile Penetration Technology ..... 97
11. Defense S&T Key Laboratory of Ballistics ..... 100
12. Defense S&T Key Laboratory of Communications Anti-Jamming Technology ..... 106
13. Defense S&T Key Laboratory of Communications Countermeasures Technology ..... 113
14. Defense S&T Key Laboratory of Complex Aviation Systems Simulation ..... 119
15. Defense S&T Key Laboratory of Complex Land Systems Simulation ..... 123
16. Defense S&T Key Laboratory of Complex Vessel Systems Simulation ..... 126
17. Defense S&T Key Laboratory of Composite Material Technology in Special Environments ..... 129
18. Defense S&T Key Laboratory of Computational Fluid Dynamics ..... 135
19. Defense S&T Key Laboratory of Computational Physics ..... 139
20. Defense S&T Key Laboratory of Diesel Engine Booster Technology ..... 143
21. Defense S&T Key Laboratory of Detonator Safety and Reliability ..... 149
22. Defense S&T Key Laboratory of Electromagnetic Compatibility (EMC) ..... 152
23. Defense S&T Key Laboratory of Electromagnetic Environment Effects ..... 157
24. Defense S&T Key Laboratory of Electromagnetic Environment Effects and Electro-Optical Engineering ..... 163
25. Defense S&T Key Laboratory of Electromechanical Engineering and Control ..... 167
26. Defense S&T Key Laboratory of Electronic Information Control ..... 171
27. Defense S&T Key Laboratory of Electronic Information Equipment Systems Research ..... 175
28. Defense S&T Key Laboratory of Electronic Measurement Technology ..... 179
29. Defense S&T Key Laboratory of Equipment Integrated Support Technology ..... 184
30. Defense S&T Key Laboratory of Explosive Combustion ..... 189
31. Defense S&T Key Laboratory of Fire Control Technology ..... 193
32. Defense S&T Key Laboratory of Fuze Dynamic Characteristics ..... 196
33. Defense S&T Key Laboratory of Gallium Arsenide Microwave and Millimeter Wave Monolithic and Modular Circuitry ..... 199
34. Defense S&T Key Laboratory of Helicopter Rotor Dynamics ..... 204
35. Defense S&T Key Laboratory of Helicopter Transmission Technology ..... 212
36. Defense S&T Key Laboratory of High-Energy Beam Processing Technology ..... 215
37. Defense S&T Key Laboratory of High-Power Microwave Electronic Vacuum Component Technology ..... 220
38. Defense S&T Key Laboratory of High-Power Microwave Technology ..... 226
39. Defense S&T Key Laboratory of High-Power Semiconductor Lasers ..... 229
40. Defense S&T Key Laboratory of Human Factors Engineering ..... 233
41. Defense S&T Key Laboratory of Hydroacoustic Countermeasure Technology ..... 238
42. Defense S&T Key Laboratory of Hydroacoustic Technology ..... 242
43. Defense S&T Key Laboratory of Hydrodynamics ..... 250
44. Defense S&T Key Laboratory of Hypersonic Ramjet Technology ..... 255
45. Defense S&T Key Laboratory of Inertial Technology ..... 261
46. Defense S&T Key Laboratory of Information System Security Technology ..... 265
47. Defense S&T Key Laboratory of Information Systems Engineering ..... 269
48. Defense S&T Key Laboratory of Infrared and Ultraviolet Technology ..... 277
49. Defense S&T Key Laboratory of Integrated Avionics Technology ..... 281

50. Defense S&T Key Laboratory of Lightweight, High-strength Structural Materials ..... 285
51. Defense S&T Key Laboratory of Liquid Rocket Engine Technology ..... 288
52. Defense S&T Key Laboratory of Low Interception Probability Signal Detection ..... 292
53. Defense S&T Key Laboratory of Marine Corrosion and Protection ..... 295
54. Defense S&T Key Laboratory of Materials Technology in Impact Environments ..... 300
55. Defense S&T Key Laboratory of Metrology and Calibration Technology ..... 305
56. Defense S&T Key Laboratory of Microsystem Technology ..... 310
57. Defense S&T Key Laboratory of Military Solid-State Laser Technology ..... 315
58. Defense S&T Key Laboratory of Military Underwater Intelligent Robotic Technology ..... 318
59. Defense S&T Key Laboratory of Millimeter-Wave Remote Sensing Technology ..... 327
60. Defense S&T Key Laboratory of Multi-Spectral Information Processing Technology ..... 331
61. Defense S&T Key Laboratory of Nano- and Microfabrication Technology ..... 335
62. Defense S&T Key Laboratory of New Ceramic Fiber and Composite Materials ..... 343
63. Defense S&T Key Laboratory of Nuclear Data ..... 347
64. Defense S&T Key Laboratory of Optoelectronic Countermeasures Technology ..... 353
65. Defense S&T Key Laboratory of Parallel and Distributed Processing ..... 357
66. Defense S&T Key Laboratory of Particle Transport and Enrichment Technology ..... 362
67. Defense S&T Key Laboratory of Plasma Physics ..... 365
68. Defense S&T Key Laboratory of Precision Guidance and Automatic Target Recognition ..... 370
69. Defense S&T Key Laboratory of Precision Hot Processing of Metals ..... 376
70. Defense S&T Key Laboratory of Radar Signal Processing ..... 380
71. Defense S&T Key Laboratory of Radio Wave Environmental Characteristics and Modeling Technology ..... 389
72. Defense S&T Key Laboratory of Reliability and Environmental Engineering Technology ..... 394
73. Defense S&T Key Laboratory of Remanufacturing Technology ..... 399
74. Defense S&T Key Laboratory of Ship Vibrational Noise ..... 404
75. Defense S&T Key Laboratory of Shockwave and Blast Physics ..... 409
76. Defense S&T Key Laboratory of Solid Rocket Engine Combustion, Thermal Structure, and Inner Flow Field ..... 413
77. Defense S&T Key Laboratory of Sonar Technology ..... 419
78. Defense S&T Key Laboratory of Space Chemical Power Technology ..... 423
79. Defense S&T Key Laboratory of Space Environmental Materials Behavior and Evaluation Technology ..... 428
80. Defense S&T Key Laboratory of Space Flight Dynamics Technology ..... 435
81. Defense S&T Key Laboratory of Space Flight Intelligent Control Technology ..... 440
82. Defense S&T Key Laboratory of Space Intelligent Control Technology ..... 445
83. Defense S&T Key Laboratory of Space Microwave Technology ..... 451
84. Defense S&T Key Laboratory of Specialized Integrated Circuits ..... 456
85. Defense S&T Key Laboratory of Strong Radiation ..... 461
86. Defense S&T Key Laboratory of Super High-Temperature Structural Composites ..... 464
87. Defense S&T Key Laboratory of Surface Physics and Chemistry ..... 469
88. Defense S&T Key Laboratory of Target and Environmental Electromagnetic Diffuse Radiation Characteristics ..... 475
89. Defense S&T Key Laboratory of Target and Environmental Optical Characteristics ..... 477

90. Defense S&T Key Laboratory of Transient Shock Technology ..... 480
91. Defense S&T Key Laboratory of Tunable Gas Lasers ..... 484
92. Defense S&T Key Laboratory of UAV Special Technology ..... 490
93. Defense S&T Key Laboratory of Underwater Information and Control ..... 496
94. Defense S&T Key Laboratory of Underwater Measurement and Control Technology ..... 503
95. Defense S&T Key Laboratory of Vacuum Technology and Physics ..... 507
96. Defense S&T Key Laboratory of Vehicle Transmission ..... 514
97. Defense S&T Key Laboratory of Vessel Integrated Power Technology ..... 519
98. Defense S&T Key Laboratory of Weapons and Equipment Systems Research ..... 525
Known Former Defense S&T Key Laboratories ..... 529
Defense S&T Key Laboratory of Flexible Manufacturing Systems Technology ..... 529
Defense S&T Key Laboratory of Pulsed Power Technology ..... 532
Defense S&T Key Laboratory of Ultra-Precision Machining Technology ..... 536
Endnotes ..... 540

## Introduction

This report represents an updated and significantly expanded revision of *The PRC State & Defense Laboratory System Part Two: Defense S&T Key Lab Directory*, which was released in early 2023. That report was in turn the second part of *The PRC State & Defense Laboratory System: An Overview,*[i] which was released in 2022 and described the general structure and organization of the PRC's state research system. Cumulatively, these reports focus on the PRC's Defense S&T Key Laboratories (DSTKLs) [国防科技重点实验室], first established in 1991 as the PRC's highest-level network of military labs. As the military counterpart to the PRC's top-level State Key Lab (SKL) system, these labs receive the most funding and conduct what the PRC considers to be its most critical military research.

In the previous edition of this report, CASI utilized a list of 60 DSTKLs circulating on the internet, apparently from a since-deleted PRC government website. Accounting for duplicates and labs since downgraded in status left a sample of 56 labs. Extensive open-source research was conducted on each of these labs, providing details on each lab's research foci, real-world applications of that research, funding, facilities and equipment, domestic and international collaborations, leadership and personnel, aliases, and any other information which may be of interest to researchers of PRC defense technology.

For this updated edition of the report, we added another 42 Defense S&T Key Labs, increasing the number of known DSTKLs by more than 40 percent. The same level of research was applied to these additional labs, bringing the total number of DSTKLs profiled in this report from 56 to 98. In addition, we recalculated the statistics presented in Part One of this report to incorporate these new labs.

Some labs contained considerably more information than others; some were very public-facing, with official websites and no shortage of laudatory state media coverage of their work, while others offered very little public information at all. Generally, university-run labs tended to be more open about their work than state-owned enterprise (SOE) labs, and military-run labs had less public information than either of these. The 42 additional labs profiled for the first time in this edition of the report tended, on the whole, to have less information publicly available (which in some cases is likely how they have managed to fly under the radar), although this was not true in all cases.

This work is intended primarily as a guide and reference work for analysts of PRC science and technology, translating detailed information on all of the PRC's known Defense S&T Key Labs and gathering it in one place for the first time. While it shows what PRC officials and researchers emphasize in terms of research priorities, it is not intended to make qualitative judgements about their progress in this research. Much of the material in this report is comprised of dense technical jargon which requires analysis by specialists in that field and which may pose translation challenges. However, we have included such information in the hope that it will provide useful insights into the state and priorities of PRC strategic research when read by analysts who

[i] Part One can be found at:
https://www.bluepathlabs.com/uploads/1/1/9/0/119002711/2022-04-11_the_prc_state___defense_laboratory_system_-_an_overview.pdf

possess the requisite knowledge. CASI hopes that this data will both provide greater insight into the inner workings and priorities of DSTKLs, and also raise awareness of these labs and their attempts to collaborate with U.S. institutions.

## Overview of Defense S&T Key Labs

The Defense S&T Key Lab system was first established in 1991 as the military counterpart to the civilian State Key Lab [国家重点实验室] system, which had been established in 1984. Collectively, the SKL and DSTKL systems represent the highest level of PRC state-sponsored S&T research,[ii] receiving high levels of funding and focusing on the PRC's greatest strategic problems in science and technology.[iii]

Officially, according to the 2003 guidelines for management of these labs, DSTKLs are primarily tasked with "carrying out applied basic research that is exploratory, innovative, and based on major key technologies, in accordance with the needs of national defense S&T and the development of weapons and equipment, centered on national defense S&T strategic objectives and the development trends of weapons and equipment development."[1] Further, they are responsible for establishing "internationally advanced and domestically leading-edge research platforms which utilize civil-military integration and advance the development of dual use technologies."[2]

As the PRC's highest national-level research institutes, the SKL and DSTKL systems sit at the top of an extraordinarily extensive network of government-sponsored labs, research centers, innovation bases, development zones, and other institutions at the national, provincial, ministerial, and municipal levels. As of November 2024, CASI counts as many as 80 categories of government research institutes in the PRC, each of which oversees as few as a dozen or as many as 1,000-plus research entities. To give an idea of how vast this network is, the city of Qingdao alone—a large city, but far from China's largest—approved construction of 119 municipal-level key labs in 2022 alone.[3]

Beginning in 2022, the PRC began a multi-year reorganization of its national-level key lab system which saw the civilian SKLs converted into a new category of "National" Key Labs [全国重点实验室], and at least some if not all of the military DSTKLs slowly being folded into this system as well. This possible abolition of the DSTKL system over the next few years constitutes a major reform of the PRC's state S&T regime and may be an attempt to further obfuscate the role of the military labs in the face of higher international scrutiny. However, the incorporation of these labs into the civilian system does not mean an end to their military research; in fact, initial evidence suggests that they may still retain their status as DSTKLs behind the scenes. This transition is described in greater detail below.

---

[ii] While there is technically a higher level of civilian lab, simply known as National Labs [国家实验室], these are small in number and do not encompass the same range of S&T topics as State Key Labs. National Labs also have a theoretical military counterpart, called Defense S&T National Labs [国防高科技国家实验室], but there is no evidence any of these labs have ever been established as of writing.

[iii] This system as a whole is described in greater detail in Part One of this project.

# Table of Contents


Introduction ..... 1

Overview of Defense S&T Key Labs ..... 2

- Number of Defense S&T Key Labs ..... 3
- Management ..... 5
- Leadership ..... 9
- Research ..... 10
- Relationship between State Key Labs and Defense S&T Key Labs ..... 15
- Collaboration with U.S. Institutions ..... 19

Notes on the Data Presented in this Directory ..... 20

- Translations of Lab Names and Attempts at Obfuscation ..... 20
- Chinese Names and Aliases ..... 21
- Research Fields ..... 21
- Lab Affiliations ..... 21
- "Key Data" Fields ..... 21
- Research Direction ..... 21
- Notable Applications ..... 22
- Notable Collaborations ..... 22
- Lab Equipment ..... 22
- Translations ..... 22
- Sources ..... 22
- Special Thanks ..... 22

Lab Data ..... 23

- List of Labs by Year Founded ..... 23
- List of Labs by Location ..... 25
- List of Labs by Parent Institution ..... 27
- List of Labs by Domain Research ..... 30
- List of Labs by Equipment Research ..... 33
- List of Labs by Functional Research ..... 36
- List of Labs with New Names Under Reorganization ..... 40

1. Defense S&T Key Laboratory of Advanced Composite Materials ..... 44
2. Defense S&T Key Laboratory of Advanced High-Temperature Structural Materials ..... 49
3. Defense S&T Key Laboratory of Aero-Engine Aerodynamics and Thermodynamics ..... 53
4. Defense S&T Key Laboratory of Aerospace Systems Simulation ..... 59
5. Defense S&T Key Laboratory of Aircraft Control and Integration Technology ..... 64
6. Defense S&T Key Laboratory of Airfoil and Blading Aerodynamics ..... 70
7. Defense S&T Key Laboratory of Antennas and Microwave Technology ..... 79
8. Defense S&T Key Laboratory of Aviation Engine High-Altitude Simulation Technology ..... 87
9. Defense S&T Key Laboratory of Aviation Plasma Dynamics ..... 93

10. Defense S&T Key Laboratory of Ballistic Missile Penetration Technology ..... 98
11. Defense S&T Key Laboratory of Ballistics ..... 101
12. Defense S&T Key Laboratory of Communications Anti-Jamming Technology ..... 107
13. Defense S&T Key Laboratory of Communications Countermeasures Technology ..... 114
14. Defense S&T Key Laboratory of Complex Aviation Systems Simulation ..... 120
15. Defense S&T Key Laboratory of Complex Land Systems Simulation ..... 124
16. Defense S&T Key Laboratory of Complex Vessel Systems Simulation ..... 127
17. Defense S&T Key Laboratory of Composite Material Technology in Special Environments ..... 130
18. Defense S&T Key Laboratory of Computational Fluid Dynamics ..... 136
19. Defense S&T Key Laboratory of Computational Physics ..... 140
20. Defense S&T Key Laboratory of Diesel Engine Booster Technology ..... 144
21. Defense S&T Key Laboratory of Detonator Safety and Reliability ..... 150
22. Defense S&T Key Laboratory of Electromagnetic Compatibility (EMC) ..... 153
23. Defense S&T Key Laboratory of Electromagnetic Environment Effects ..... 158
24. Defense S&T Key Laboratory of Electromagnetic Environment Effects and Electro-Optical Engineering ..... 164
25. Defense S&T Key Laboratory of Electromechanical Engineering and Control ..... 168
26. Defense S&T Key Laboratory of Electronic Information Control ..... 172
27. Defense S&T Key Laboratory of Electronic Information Equipment Systems Research ..... 176
28. Defense S&T Key Laboratory of Electronic Measurement Technology ..... 180
29. Defense S&T Key Laboratory of Equipment Integrated Support Technology ..... 185
30. Defense S&T Key Laboratory of Explosive Combustion ..... 190
31. Defense S&T Key Laboratory of Fire Control Technology ..... 194
32. Defense S&T Key Laboratory of Fuze Dynamic Characteristics ..... 197
33. Defense S&T Key Laboratory of Gallium Arsenide Microwave and Millimeter Wave Monolithic and Modular Circuitry .. 200
34. Defense S&T Key Laboratory of Helicopter Rotor Dynamics ..... 205
35. Defense S&T Key Laboratory of Helicopter Transmission Technology ..... 213
36. Defense S&T Key Laboratory of High-Energy Beam Processing Technology ..... 216
37. Defense S&T Key Laboratory of High-Power Microwave Electronic Vacuum Component Technology ..... 221
38. Defense S&T Key Laboratory of High-Power Microwave Technology ..... 227
39. Defense S&T Key Laboratory of High-Power Semiconductor Lasers ..... 230
40. Defense S&T Key Laboratory of Human Factors Engineering ..... 234
41. Defense S&T Key Laboratory of Hydroacoustic Countermeasure Technology ..... 239
42. Defense S&T Key Laboratory of Hydroacoustic Technology ..... 243
43. Defense S&T Key Laboratory of Hydrodynamics ..... 251
44. Defense S&T Key Laboratory of Hypersonic Ramjet Technology ..... 256
45. Defense S&T Key Laboratory of Inertial Technology ..... 262
46. Defense S&T Key Laboratory of Information System Security Technology ..... 266
47. Defense S&T Key Laboratory of Information Systems Engineering ..... 270
48. Defense S&T Key Laboratory of Infrared and Ultraviolet Technology ..... 278
49. Defense S&T Key Laboratory of Integrated Avionics Technology ..... 282

50. Defense S&T Key Laboratory of Lightweight, High-strength Structural Materials ..... 286
51. Defense S&T Key Laboratory of Liquid Rocket Engine Technology ..... 289
52. Defense S&T Key Laboratory of Low Interception Probability Signal Detection ..... 293
53. Defense S&T Key Laboratory of Marine Corrosion and Protection ..... 296
54. Defense S&T Key Laboratory of Materials Technology in Impact Environments ..... 301
55. Defense S&T Key Laboratory of Metrology and Calibration Technology ..... 306
56. Defense S&T Key Laboratory of Microsystem Technology ..... 311
57. Defense S&T Key Laboratory of Military Solid-State Laser Technology ..... 316
58. Defense S&T Key Laboratory of Military Underwater Intelligent Robotic Technology ..... 319
59. Defense S&T Key Laboratory of Millimeter-Wave Remote Sensing Technology ..... 328
60. Defense S&T Key Laboratory of Multi-Spectral Information Processing Technology ..... 332
61. Defense S&T Key Laboratory of Nano- and Microfabrication Technology ..... 336
62. Defense S&T Key Laboratory of New Ceramic Fiber and Composite Materials ..... 344
63. Defense S&T Key Laboratory of Nuclear Data ..... 348
64. Defense S&T Key Laboratory of Optoelectronic Countermeasures Technology ..... 354
65. Defense S&T Key Laboratory of Parallel and Distributed Processing ..... 358
66. Defense S&T Key Laboratory of Particle Transport and Enrichment Technology ..... 363
67. Defense S&T Key Laboratory of Plasma Physics ..... 366
68. Defense S&T Key Laboratory of Precision Guidance and Automatic Target Recognition ..... 371
69. Defense S&T Key Laboratory of Precision Hot Processing of Metals ..... 377
70. Defense S&T Key Laboratory of Radar Signal Processing ..... 381
71. Defense S&T Key Laboratory of Radio Wave Environmental Characteristics and Modeling Technology ..... 390
72. Defense S&T Key Laboratory of Reliability and Environmental Engineering Technology ..... 395
73. Defense S&T Key Laboratory of Remanufacturing Technology ..... 400
74. Defense S&T Key Laboratory of Ship Vibrational Noise ..... 405
75. Defense S&T Key Laboratory of Shockwave and Blast Physics ..... 410
76. Defense S&T Key Laboratory of Solid Rocket Engine Combustion, Thermal Structure, and Inner Flow Field ..... 414
77. Defense S&T Key Laboratory of Sonar Technology ..... 420
78. Defense S&T Key Laboratory of Space Chemical Power Technology ..... 424
79. Defense S&T Key Laboratory of Space Environmental Materials Behavior and Evaluation Technology ..... 429
80. Defense S&T Key Laboratory of Space Flight Dynamics Technology ..... 436
81. Defense S&T Key Laboratory of Space Flight Intelligent Control Technology ..... 441
82. Defense S&T Key Laboratory of Space Intelligent Control Technology ..... 446
83. Defense S&T Key Laboratory of Space Microwave Technology ..... 452
84. Defense S&T Key Laboratory of Specialized Integrated Circuits ..... 457
85. Defense S&T Key Laboratory of Strong Radiation ..... 462
86. Defense S&T Key Laboratory of Super High-Temperature Structural Composites ..... 465
87. Defense S&T Key Laboratory of Surface Physics and Chemistry ..... 470
88. Defense S&T Key Laboratory of Target and Environmental Electromagnetic Diffuse Radiation Characteristics ..... 476
89. Defense S&T Key Laboratory of Target and Environmental Optical Characteristics ..... 478

90. Defense S&T Key Laboratory of Transient Shock Technology ..... 481
91. Defense S&T Key Laboratory of Tunable Gas Lasers ..... 485
92. Defense S&T Key Laboratory of UAV Special Technology ..... 491
93. Defense S&T Key Laboratory of Underwater Information and Control ..... 497
94. Defense S&T Key Laboratory of Underwater Measurement and Control Technology ..... 504
95. Defense S&T Key Laboratory of Vacuum Technology and Physics ..... 508
96. Defense S&T Key Laboratory of Vehicle Transmission ..... 515
97. Defense S&T Key Laboratory of Vessel Integrated Power Technology ..... 520
98. Defense S&T Key Laboratory of Weapons and Equipment Systems Research ..... 526
Known Former Defense S&T Key Laboratories ..... 530
Defense S&T Key Laboratory of Flexible Manufacturing Systems Technology ..... 530
Defense S&T Key Laboratory of Pulsed Power Technology ..... 533
Defense S&T Key Laboratory of Ultra-Precision Machining Technology ..... 537
Endnotes ..... 541

## Introduction

This report represents an updated and significantly expanded revision of *The PRC State & Defense Laboratory System Part Two: Defense S&T Key Lab Directory*, which was released in early 2023. That report was in turn the second part of *The PRC State & Defense Laboratory System: An Overview,*[i] which was released in 2022 and described the general structure and organization of the PRC's state research system. Cumulatively, these reports focus on the PRC's Defense S&T Key Laboratories (DSTKLs) [国防科技重点实验室], first established in 1991 as the PRC's highest-level network of military labs. As the military counterpart to the PRC's top-level State Key Lab (SKL) system, these labs receive the most funding and conduct what the PRC considers to be its most critical military research.

In the previous edition of this report, CASI utilized a list of 60 DSTKLs circulating on the internet, apparently from a since-deleted PRC government website. Accounting for duplicates and labs since downgraded in status left a sample of 56 labs. Extensive open-source research was conducted on each of these labs, providing details on each lab's research foci, real-world applications of that research, funding, facilities and equipment, domestic and international collaborations, leadership and personnel, aliases, and any other information which may be of interest to researchers of PRC defense technology.

For this updated edition of the report, we added another 42 Defense S&T Key Labs, increasing the number of known DSTKLs by more than 40 percent. The same level of research was applied to these additional labs, bringing the total number of DSTKLs profiled in this report from 56 to 98. In addition, we recalculated the statistics presented in Part One of this report to incorporate these new labs.

Some labs contained considerably more information than others; some were very public-facing, with official websites and no shortage of laudatory state media coverage of their work, while others offered very little public information at all. Generally, university-run labs tended to be more open about their work than state-owned enterprise (SOE) labs, and military-run labs had less public information than either of these. The 42 additional labs profiled for the first time in this edition of the report tended, on the whole, to have less information publicly available (which in some cases is likely how they have managed to fly under the radar), although this was not true in all cases.

This work is intended primarily as a guide and reference work for analysts of PRC science and technology, translating detailed information on all of the PRC's known Defense S&T Key Labs and gathering it in one place for the first time. While it shows what PRC officials and researchers emphasize in terms of research priorities, it is not intended to make qualitative judgements about their progress in this research. Much of the material in this report is comprised of dense technical jargon which requires analysis by specialists in that field and which may pose translation challenges. However, we have included such information in the hope that it will provide useful insights into the state and priorities of PRC strategic research when read by analysts who

[i] Part One can be found at:
https://www.bluepathlabs.com/uploads/1/1/9/0/119002711/2022-04-11_the_prc_state___defense_laboratory_system_-_an_overview.pdf

possess the requisite knowledge. CASI hopes that this data will both provide greater insight into the inner workings and priorities of DSTKLs, and also raise awareness of these labs and their attempts to collaborate with U.S. institutions.

## Overview of Defense S&T Key Labs

The Defense S&T Key Lab system was first established in 1991 as the military counterpart to the civilian State Key Lab [国家重点实验室] system, which had been established in 1984. Collectively, the SKL and DSTKL systems represent the highest level of PRC state-sponsored S&T research,[ii] receiving high levels of funding and focusing on the PRC's greatest strategic problems in science and technology.[iii]

Officially, according to the 2003 guidelines for management of these labs, DSTKLs are primarily tasked with "carrying out applied basic research that is exploratory, innovative, and based on major key technologies, in accordance with the needs of national defense S&T and the development of weapons and equipment, centered on national defense S&T strategic objectives and the development trends of weapons and equipment development." [1] Further, they are responsible for establishing "internationally advanced and domestically leading-edge research platforms which utilize civil-military integration and advance the development of dual use technologies."[2]

As the PRC's highest national-level research institutes, the SKL and DSTKL systems sit at the top of an extraordinarily extensive network of government-sponsored labs, research centers, innovation bases, development zones, and other institutions at the national, provincial, ministerial, and municipal levels. As of November 2024, CASI counts as many as 80 categories of government research institutes in the PRC, each of which oversees as few as a dozen or as many as 1,000-plus research entities. To give an idea of how vast this network is, the city of Qingdao alone—a large city, but far from China's largest—approved construction of 119 municipal-level key labs in 2022 alone.[3]

Beginning in 2022, the PRC began a multi-year reorganization of its national-level key lab system which saw the civilian SKLs converted into a new category of "National" Key Labs [全国重点实验室], and at least some if not all of the military DSTKLs slowly being folded into this system as well. This possible abolition of the DSTKL system over the next few years constitutes a major reform of the PRC's state S&T regime and may be an attempt to further obfuscate the role of the military labs in the face of higher international scrutiny. However, the incorporation of these labs into the civilian system does not mean an end to their military research; in fact, initial evidence suggests that they may still retain their status as DSTKLs behind the scenes. This transition is described in greater detail below.

---

[ii] While there is technically a higher level of civilian lab, simply known as National Labs [国家实验室], these are small in number and do not encompass the same range of S&T topics as State Key Labs. National Labs also have a theoretical military counterpart, called Defense S&T National Labs [国防高科技国家实验室], but there is no evidence any of these labs have ever been established as of writing.

[iii] This system as a whole is described in greater detail in Part One of this project.

## Number of Defense S&T Key Labs

While the PRC has not published official figures on SKLs (now NKLs, see below) in recent years, it is believed to have established around 542 such labs as of 2020, falling short of its goal of 700 labs by that year.[4] On the military side, the number of DSTKLs is even harder to nail down, and at this point it is unclear exactly how many DSTKLs the PRC funds. Initially assuming the list of DSTKLs circulating online to be comprehensive, the research began with the assumption that the PRC currently funds approximately 56 such labs, while PRC government sources have given conflicting figures of 55[5] or 58.[6] The Australian Strategic Policy Institute (ASPI) has given a slightly higher figure of 74 as of 2009.[7]

However, further research found that the actual count of DSTKLs appears to be much higher than previously estimated, as the PRC funds dozens of DSTKLs which do not appear in any online list. As of writing,we have identified 42 additional labs that have used the "Defense S&T Key Lab" moniker, giving us a total of 98 such labs. While it is possible that some of these are being identified as DSTKLs in error (given the PRC's tendency to play fast and loose with lab titles, as is discussed below), it is obvious that many are in fact DSTKLs that have not been identified as such in official sources. For example, the PLA Rocket Force apparently oversees two DSTKLs,[8] neither of which was included in the original online list, and neither of which has been publicly named.[iv] Likewise, the National University of Defense Technology allegedly oversees seven DSTKLs, even though only three are publicly identified in the online list.[9]

Many of these "off-the-books" labs are not public-facing and offer only the scantest clues to their existence. This suggests the possibility that they are not publicly discussed due to their particularly sensitive research, making them all the more interesting. In support of this possibility, the 42 new labs were much more likely to be affiliated with either the PRC military or the Chinese Academy of Engineering Physics (CAEP), the PRC's premier institution for nuclear weapons research. However, it is just as likely that the secrecy around these labs is merely a symptom of the PRC's overall lack of transparency. Indeed, no official catalog of DSTKLs currently exists, forcing researchers to rely on a single dated list, taken from a since-deleted source, which is apparently far from comprehensive. In this environment, it is not surprising that many labs have gone uncounted.

As already stated, DSTKLs are the PRC's largest, best-funded, and highest-level defense research labs, conducting its most critical national-level military research.[v] Despite this, the existence of many of these key labs has not been described in English-language sources to this point. This has led to a major gap in our knowledge of the PRC's defense research system, one which until now we did not even know existed. With this in mind, this edition of the report provides

---

[iv] While not explicitly stated, one of these is likely a DSTKL focused on defeating adversary anti-ballistic missile systems which was revealed in a 2017 news article. See: "Chinese government reveals the Defense S&T Key Laboratory of Ballistic Missile Penetration Technology, providing much information" [中国官方曝光弹道导弹突防技术国防科技重点实验室，信息量大], *KK News*, 20 May 2017, https://kknews.cc/zh-my/military/ao8r2ln.html

[v] While DSTKLs are, as a rule, national-level labs, in recent years at least some provinces appear to be establishing provincial-level DSTKLs, adding a further dimension to the PRC's defense lab system. See, for example, "Hunan Province Department of Industry and Information Technology on the issuance of the "Hunan Provincial Defense Science and Technology Key Laboratory Management Measures" notice" [湖南省工业和信息化厅关于印发《湖南省国防科技重点实验室管理办法》的通知], *Hunan Province Department of Industry and Information Technology* [湖南省工业和信息化厅], 3 February 2018, http://fgcx.bjcourt.gov.cn:4601/law?fn=lar1550s108.txt

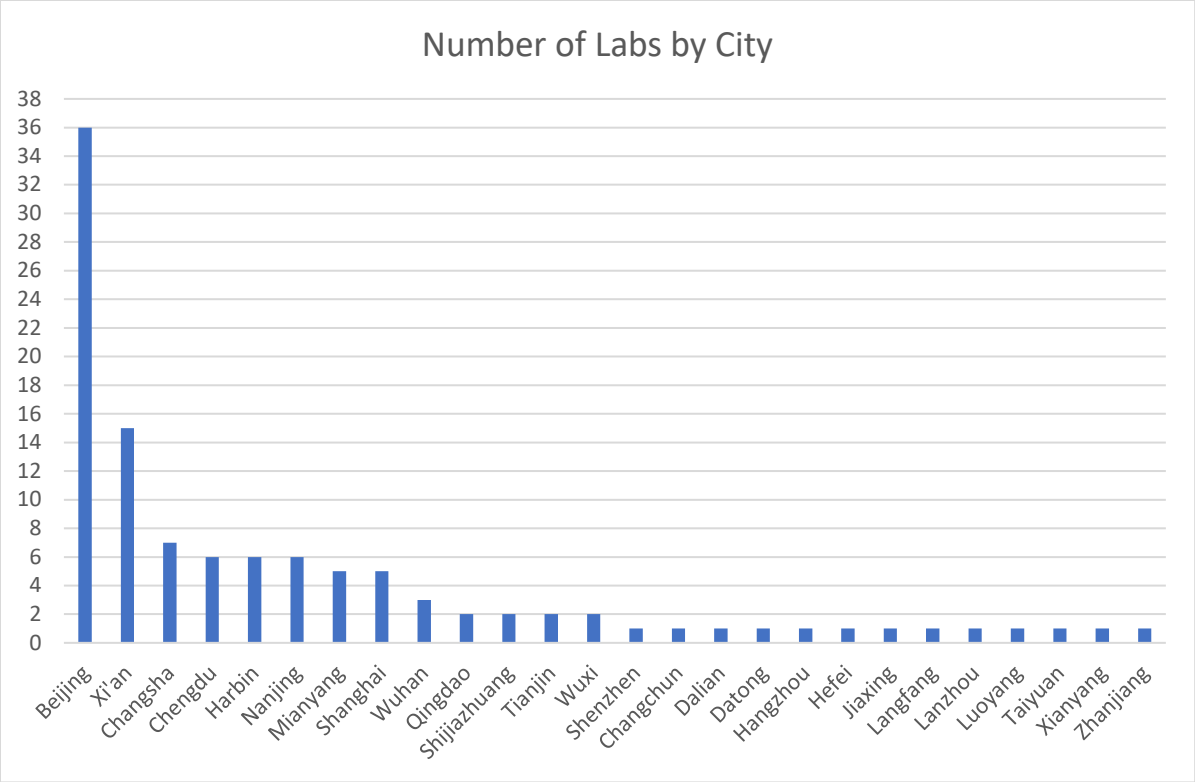
details on these 42 DSTKLs, aiming to close an important knowledge gap regarding the PRC's defense research system.

However, it is also worth noting that the identification of 98 labs is almost certainly not the final word on the matter, as there is compelling evidence that numerous additional labs remain to be discovered. For example, according to official sources, the PRC military electronics conglomerate CETC has 15 DSTKLs.[10] However, we only found 12 for this report, suggesting three more remain to be found. Likewise, CASC allegedly has 11 DSTKLs, but only 9 have been found.[11] The table below provides figures for prominent research institutes for which data could be found.

| **Prominent Institutions and Stated Number of Labs (Pre-Reform)** | | | |
|---|---|---|---|
| **Institution** | **Stated # of Labs** | **# Labs Found** | **# Remaining** |
| CETC | 15 | 12 | 3 |
| PLAA Research Acad. | 2+ ("A few" 若干) | 0 | At least 2 |
| CASC | 11 | 9 | 2 |
| AVIC | 8 | 6 | 2 |
| CAEP | 7 | 6 | 1 |
| PLA NUDT | 7 | 6 | 1 |
| PLA AMS | 3 | 2 | 1 |
| PLARF Research Acad. | 2 | 1 | 1 |
| CASIC | 8 | 8 | 0 |
| Norinco | 7 | 9 | 0 |
| CSSC | At least 9 | 9 | Unknown |
| PLAAF Research Acad. | 1 | 1 | 0 |
| PLAN Eng. University | 2 | 2 | 0 |
| TOTAL UNFOUND | At least 82 | 71 | **At least 11-13** |

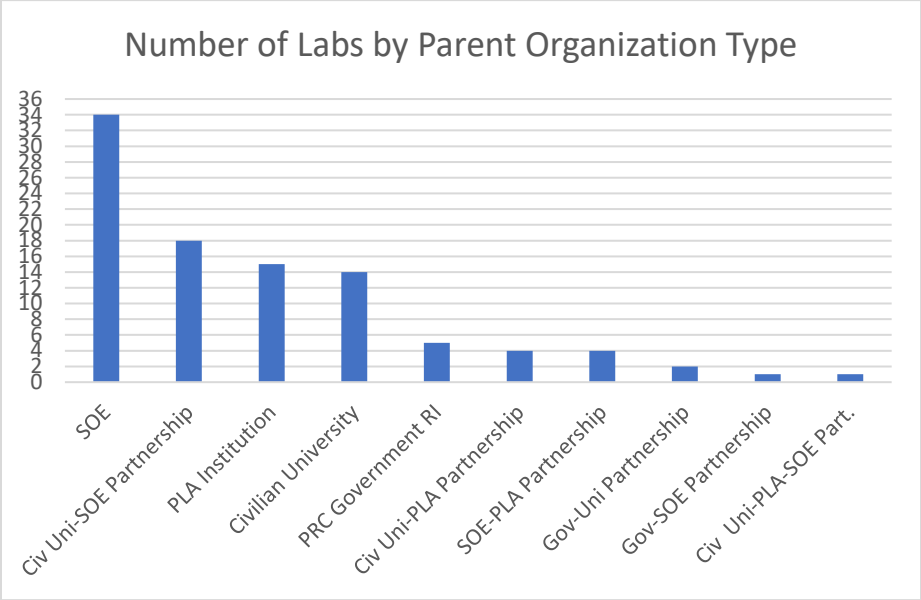
In terms of location, over one-third of labs were located in Beijing, and over half were located in just two cities, Beijing and Xi'an. In addition to being the home of Beihang University and Beijing Institute of Technology, two of the "Seven Sons of Defense" [国防七子],[vi] Beijing also hosts a large number of research institutions for state-owned conglomerates such as CETC, AVIC, AECC, CASC, CASIC, and CNNC. Xi'an also hosts a wide range of labs under Northwestern Polytechnical University (another of the Seven Sons), Xidian University, and the PLA Air Force Engineering University, as well as subsidiaries of defense conglomerates AVIC, CASC, and Norinco. Other cities hosting multiple labs included Changsha (home of the National University of Defense Technology), Harbin (home to two of the Seven Sons), Mianyang (as the home of CAEP, a major center for nuclear research), Nanjing (home to two other Seven Sons), Shanghai, Wuhan, Qingdao, Shijiazhuang, Tianjin, and Wuxi. Thirteen other cities host a single lab.

[vi] The Seven Sons of Defense are a group of seven universities which are directly subordinate to the State Administration for Science, Technology and Industry for National Defense (SASTIND) and are known for their particularly close ties to the PRC's defense establishment. They produce a disproportionately high percentage of the PRC's defense research and industrial workforce.

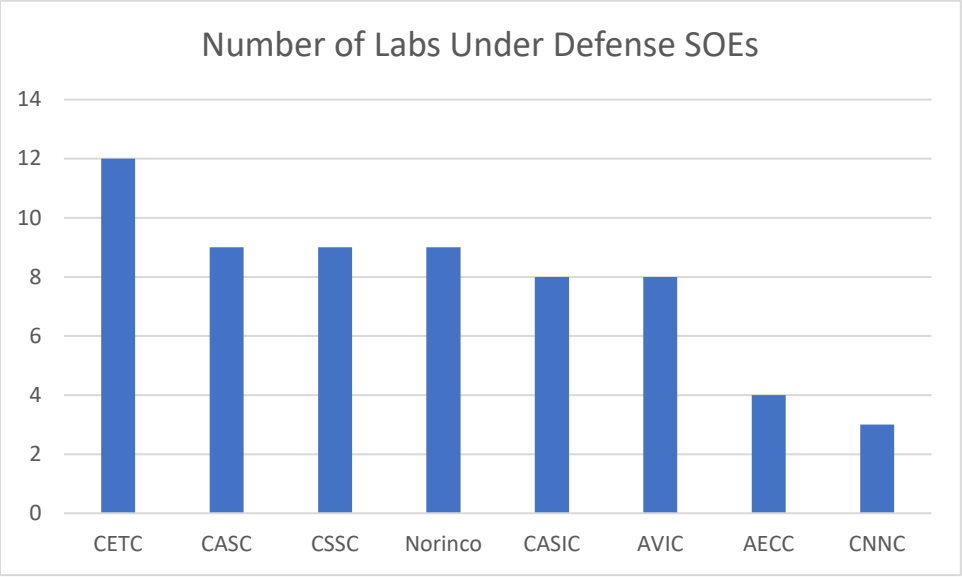



## Management

Of the 98 labs surveyed, 34 were managed solely by one of the major defense SOEs, 16 by partnerships between civilian universities and defense SOEs, 15 solely by civilian universities, 15 solely by the PLA, and five solely by a PRC government research institution. Finally, a small number of labs were jointly managed by some combination of these.

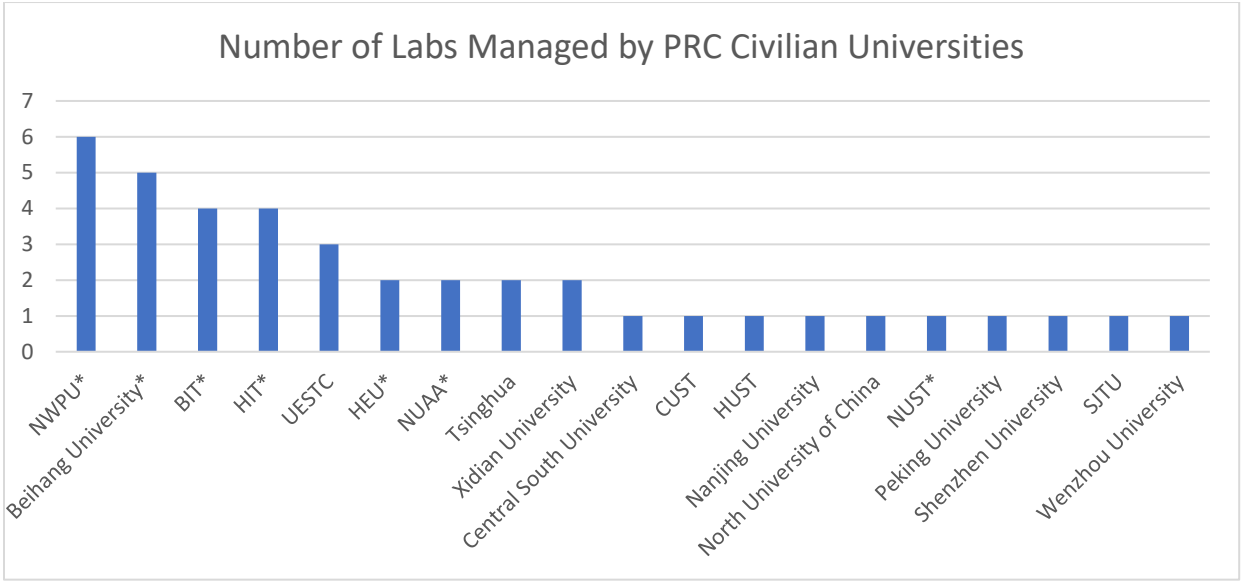


Of the defense SOEs, military electronics giant China Electronics Technology Group Corporation (CETC) had the highest number of labs found, with 12, followed by three SOEs with nine each: China Aerospace Science and Technology Corporation (CASC), China State Shipbuilding Corporation (CSSC), and China Ordnance Industries Group Corporation, also known as Norinco. China Aerospace Science and Industry Corporation (CASIC), the PRC's other major aerospace conglomerate, and the Aviation Industry Corporation of China (AVIC) each manage eight, while the Aero Engine Corporation of China (AECC) manages four. Finally, the PRC's largest nuclear corporation, the China National Nuclear Corporation (CNNC), oversees three labs related to military nuclear research.



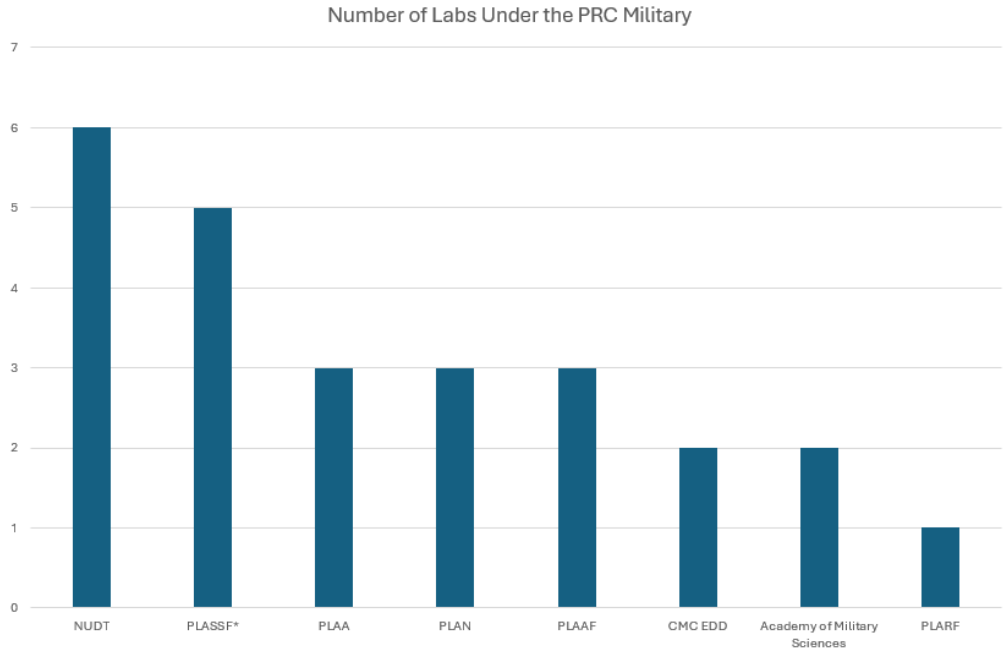

Of the PRC universities that manage DSTKLs, the Seven Sons of Defense are unsurprisingly the most prominently represented, with the remaining labs fairly evenly portioned out across a wide range of universities. Northwestern Polytechnical University leads the way with six, and Beihang, Beijing Institute of Technology, Harbin Institute of Technology, Harbin Engineering University, and Nanjing University of Aeronautics and Astronautics all manage multiple labs. The only one of the Seven Sons to not manage multiple labs is the Nanjing University of Science and Technology, which only manages one.[vii] Only two universities which are not part of the Seven Sons consortium, but are major producers of defense research in their own right, manage multiple labs: the University of Science and Technology of China manages three, and Xidian University manages two. In all, the Seven Sons account for well over half of Defense S&T Key Labs assigned to civilian universities. Notably, this figure is lower than the figure of over two-thirds that appeared in Part One of this report, which only accounted for the original 56 labs. This is the result of finding numerous additional labs under other universities. Thus, while the Seven Sons continue to dominate, this domination is not as overwhelming as initially believed.

[vii] Following the recent reforms to the DSTKL system, NUST may now co-manage a second lab, the successor to the DSTKL of Explosive Combustion. This remains unconfirmed as of writing, however.



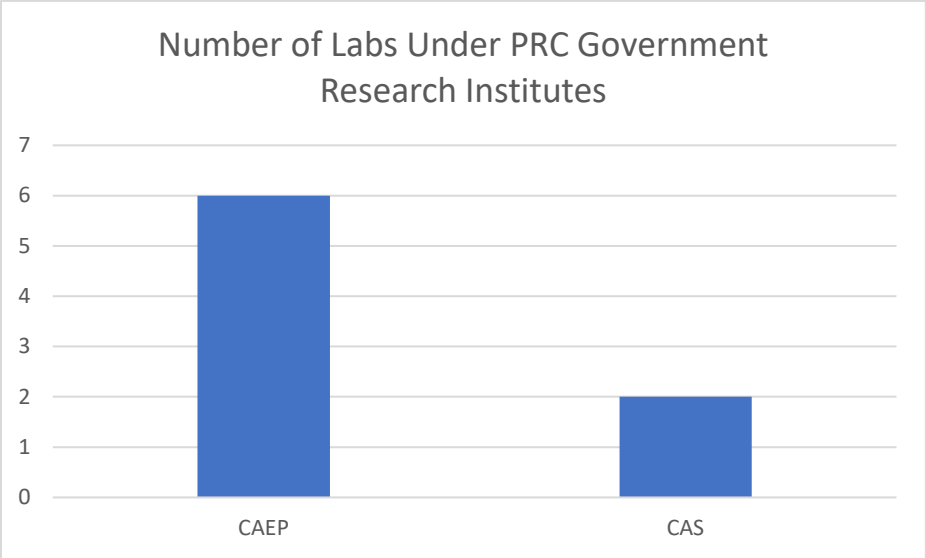

*Seven Sons of Defense

The PRC military directly manages at least 24 additional Defense S&T Key Labs. Of these, the single largest institution was the National University of Defense Technology, under which six DSTKLs were found. The PLA Strategic Support Force (PLASSF) also oversaw at least five labs as part of its network of research institutes. These labs were presumably scattered across the various new arms that replaced the PLASSF when it was abolished in early 2024. Smaller numbers of labs are scattered across the four services, as well as the Central Military Commission's (CMC) Equipment Development Department (EDD) and the Academy of Military Sciences.




*The PLASSF has since been broken into three new arms

Finally, eight labs are subordinate to two PRC government research institutions. Six of these are under the Chinese Academy of Engineering Physics (CAEP), the primary research institute for the PRC's nuclear weapons program. The Chinese Academy of Sciences (CAS) may oversee two more, the DSTKLs of Infrared and Ultraviolet Technology and Microsystem Technology, although the status of these labs is ambiguous (see entries on these labs for more).




Oversight for all DSTKLs is provided jointly by the PRC State Council State Administration for Science, Technology and Industry for National Defense (SASTIND) and the PLA CMC's EDD.[viii] Of these two organizations, SASTIND appears to be preeminent, as DSTKL guidelines suggest that it plays a more prominent day to day role in lab management and is solely responsible for some functions, such as approval of lab directors.[12]

Institutions wishing to establish a DSTKL must submit an application to SASTIND and the EDD, demonstrating that the proposed lab will fill a requirement in the PRC's defense needs as laid out by these two organizations. Institutions must also show that they possess infrastructure and expertise in the field that will allow them to conduct research at an "internationally advanced and domestically leading-edge" level. Following initial approval, labs typically undergo a probationary period of around two years, during which it is already conducting research, before receiving final approval.[13] In some cases, this probationary period has lasted significantly longer than two years,[ix] suggesting some labs struggle to gain final approval.

Ongoing oversight is provided by a SASTIND pool of experts, who are responsible for overseeing each lab's development strategy, planning, and project demonstrations.[x] SASTIND is tasked with conducting "regular" evaluations at unspecified intervals, and labs that fail these

[viii] Prior to recent reforms which saw the replacement of these organizations by SASTIND and the EDD, these tasks were carried out by the former Commission for Science, Technology and Industry for National Defense (COSTIND) and the PLA General Armaments Department (GAD), respectively.
[ix] Two labs, the DSTKL of Complex Vessel Systems Simulation and the DSTKL of Composite Material Technology in Special Environments, may have taken as long as 8 years to receive approval.
[x] The guidelines are unclear if there is a single expert pool overseeing all labs, or individual expert pools for each lab.

evaluations are given an unspecified period of time to rectify their shortcomings or risk losing their status.[14] [xi] However, DSTKL guidelines state that annual inspections are not conducted by SASTIND, but via self-reporting by the parent institutions, possibly disincentivizing negative evaluations.

Besides self-reporting, there are other small pieces of evidence that may suggest a lax oversight system. First, despite threats to revoke lab credentials, only a single instance of this ever actually happening was found, in 2006, when three DSTKLs were suddenly demoted. Civilian SKLs, on the other hand, regularly have their credentials revoked upon failing to meet standards; for example, between 2014 and 2018, three SKLs reportedly lost their credentials.[15] In light of this information, it seems highly unlikely that not a single DSTKL has failed in 18 years. Rather, the pattern of three labs being failed at once followed by no labs failing for 18 years suggests a brief attempt at more stringent enforcement that did not stick. Further, DSTKLs are allegedly established to fulfill "urgent needs" in defense weaponry and equipment.[16] While their work has undoubtedly evolved over time, it is difficult to believe that the PLA's "urgent needs" of over 30 years ago are still the same as its urgent needs of today. Despite this, none of the labs established in the early 1990s have been abolished or downgraded. Even if no lab has failed to meet requirements, a healthy and dynamic system would likely see labs regularly being phased out and replaced, if only due to changing requirements. Taken collectively, this may suggest a sclerotic system with a lack of accountability and inefficient allocation of resources.

## Leadership

DSTKLs are led by a director (approved by SASTIND), followed by one to three deputy directors (who sometimes also serve as directors of subordinate lab branches). Given the pole position of DSTKLs at the top of the PRC's research ecosystem, the position of director is highly prestigious and signifies that the individual is one of the (if not *the*) top Chinese academics in this field. DSTKL directors have typically already been elected as academicians to the Chinese Academy of Sciences (CAS) or the Chinese Academy of Engineering (CAE),[xii] signifying a high level of career achievement. They have also often pursued graduate studies in the U.S. or Europe.

Each lab also has an academic committee of 15-20 experts in the field (with no more than one-third coming from the parent institution), which is overseen by a separate academic committee director. The academic committee oversees the lab's annual research plans, training, exchanges, and major academic activities. Academic committee members typically serve in three-year stints, and at least one-third must be replaced each term.[17]

---

[xi] Guidelines for the newer provincial DSTKLs are more specific, stating that labs that fail evaluations two years in a row will lose their status. See, for example, "Hunan Province Department of Industry and Information Technology on the issuance of the "Hunan Provincial Defense Science and Technology Key Laboratory Management Measures" notice" [湖南省工业和信息化厅关于印发《湖南省国防科技重点实验室管理办法》的通知], *Hunan Province Department of Industry and Information Technology* [湖南省工业和信息化厅], 3 February 2018, http://fgcx.bjcourt.gov.cn:4601/law?fn=lar1550s108.txt

[xii] While there is no data for the DSTKL system, as of 2019 there were 393 CAS and 271 CAE academicians in the State Key Lab system. This accounted for 47.8% and 29.7% of the total number of academicians of the two academies, respectively. See: "One word, one change: more than 150 national key laboratories reorganized and renamed within a year" [一字之差，一场变革：一年内超 150 个国家重点实验室重组更名], *SouthCN.com,* 12 July 2023, https://news.southcn.com/node_64549305f1/34cb753b9d.shtml

To give an example of an academic committee, the Defense S&T Key Lab of Liquid Rocket Engine Technology featured committee members from industry, academia, and the military, including CASC, CETC, AECC, the PLA National University of Defense Technology, Nanjing University of Aeronautics and Astronautics, and Beihang University.[18]

Finally, most labs have a kind of emeritus position filled by a (typically elderly) leading light in the field, who oftentimes founded or revolutionized this field in China. For example, the Defense S&T Key Lab of Remanufacturing Technology founder Xu Binshi [徐滨士], a CAE academician and retired PLA major general, is referred to as the "Father of Chinese Remanufacturing." These emeritus directors retain unofficial positions as philosophical directors of sorts, whose examples and guidance are referred to and followed by the lab.

In addition to these leadership personnel, this directory also includes any other key personnel who are worth noting for their research, achievements, or history (e.g. work or study in the U.S.).

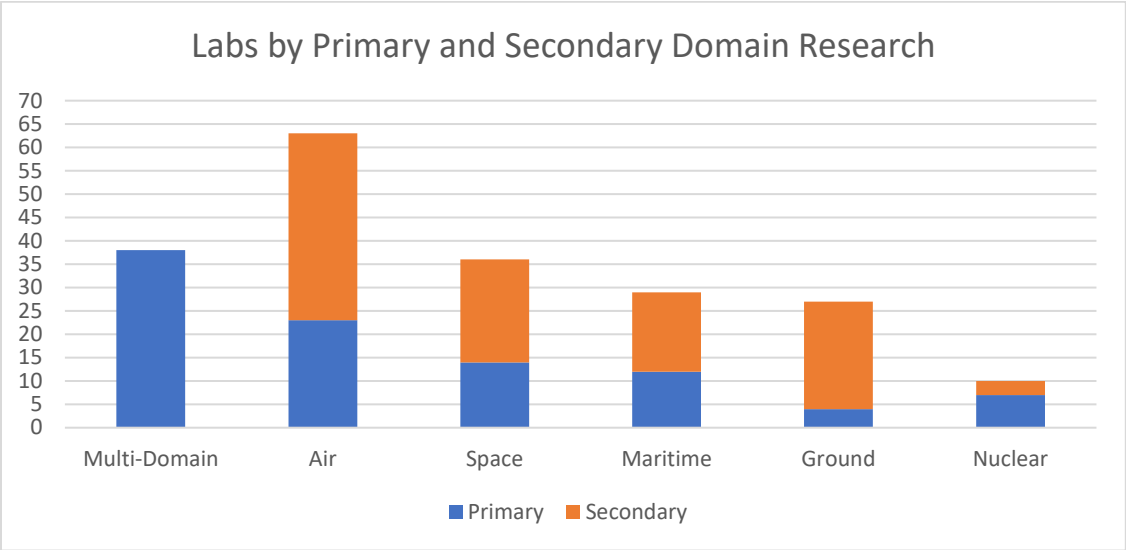
## Research

While DSTKLs are officially tasked with *applied basic* research,[xiii] and on the whole appear to focus more heavily on basic and early-stage applied research, all DSTKLs carry out a combination of basic and applied research according to their missions. That is, some DSTKLs are heavily theoretical in their output, while others aid in design of finished products, with most falling somewhere within this continuum. As highlighted in Part One of the report, while the labs profiled here encompass a wide range of research foci, they are disproportionately focused on a relatively limited number of fields. These include (but are not limited to) aircraft, unmanned aerial vehicles (UAVs), space vehicles, rocket launch, ballistic and non-ballistic missiles, new materials, and various aspects of the electromagnetic spectrum, suggesting that these are priority areas for the PRC's defense S&T. A 2018 document establishing provincial-level DSTKLs in Hunan Province largely confirms this, claiming that national-level priorities for defense S&T innovation include air and space vehicles, missile and rocket launch, new materials, electronic weapons and equipment, nuclear weaponry and military nuclear power, ships, and munitions, all of which are prominently represented in this sample of DSTKLs.[19]

Data was compiled on the research foci of the 98 surveyed labs. These have been broken down into a domain focus (air, space, maritime, ground, or nuclear), equipment focus (aircraft, UAVs, missiles, etc.), and functional focus (acoustics, electromagnetics, propulsion, etc.). These were also broken down into a "primary" focus and "secondary" foci, to show both the number of labs primarily focusing on a specific area as well as all labs conducting at least some research in that area. While these categorizations will inevitably be somewhat subjective and limited by what

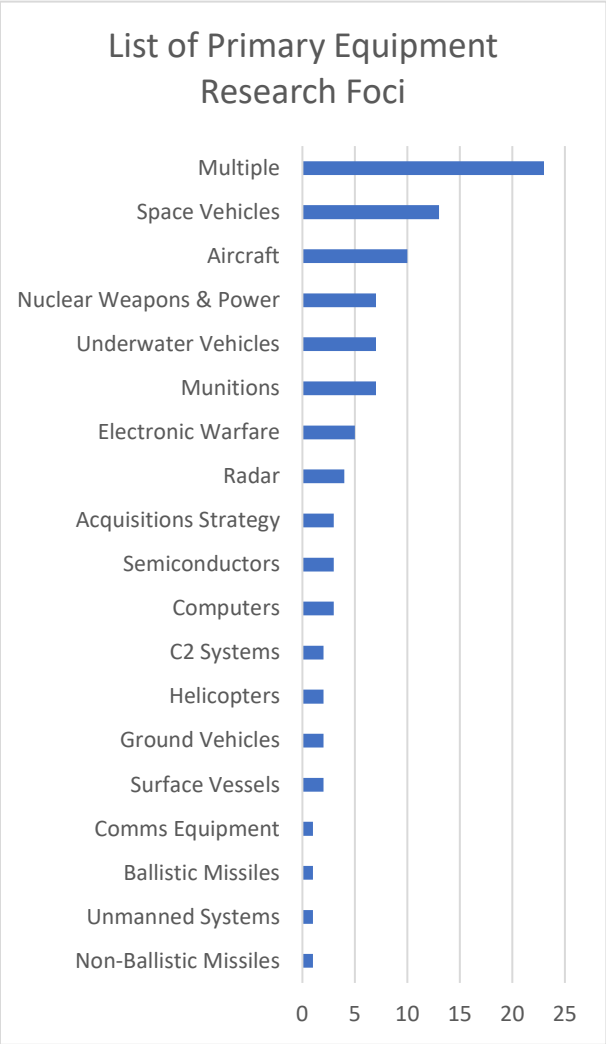
[xiii] The PRC has further split the concept of applied research into two categories: the first is *applied basic research*, which is directed at specific practical applied goals or objectives for obtaining new knowledge of applied principles (mechanisms, laws). The second is *applied technical research*, which is directed at specific practical applied goals or objectives to obtain new applied technical knowledge. See Ji Chengyi [计承宜], ""An analysis of the concept of applied basic research" [关于应用基础研究概念的剖析], National Natural Science Foundation of China [国家自然科学基金], 1991, shorturl.at/joBKV

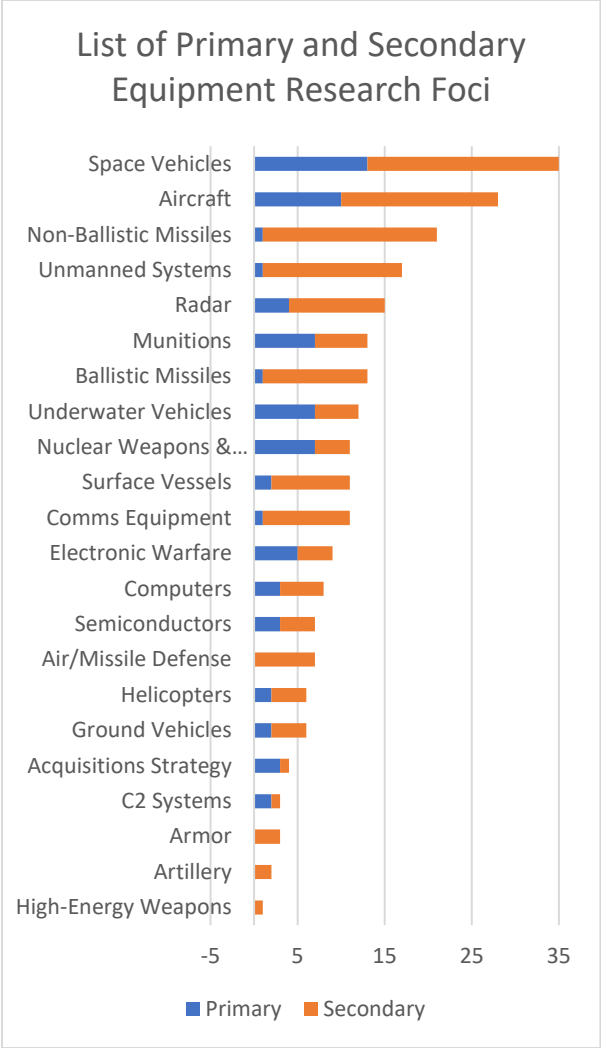
information is publicly available, these breakdowns provide insight into what the PRC has chosen to prioritize in its national-level defense research.



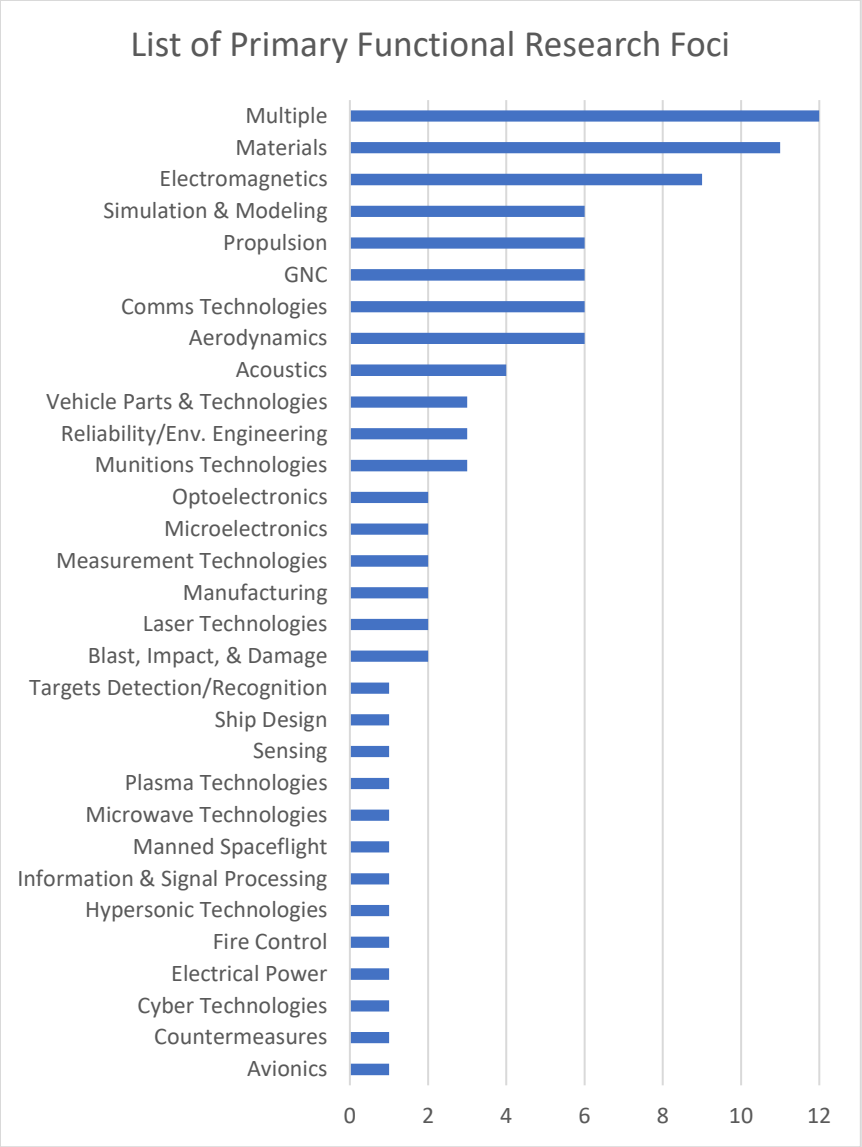

Of the 98 labs surveyed, the greatest number were primarily focused on multi-domain research, meaning that they focus on two or more domains, or research that applies to no one domain in particular. Of labs focusing primarily on one domain, aerospace research was by far the most prominent. This is not particularly surprising, given how many of the most critical technologies in future warfare, including space vehicles, ballistic and non-ballistic missiles, space and aviation propulsion, and UAVs, reside in this sector. Many of these, such as aircraft propulsion, also pose significant challenges for the PLA, while others, such as ballistic missiles, are critical to the way it plans to conduct warfare. It is thus no surprise to see the PRC allocating significant resources to this domain.

For greater precision, aerospace was split into air (aeronautics) and space research. Aeronautical research was found to be the most common research domain, with 23 labs primarily dedicated to this area. A further 40 labs conduct research in the air domain as a secondary part of their research. Space comes in second, with 14 labs, as well as a further 22 conducting at least some space research. Maritime was third, with 12 primary research labs and 17 conducting at least some maritime research. The ground domain had the fewest number of labs primarily dedicated to it, with only four, but a further 23 conduct at least some ground warfare research. Seven labs conduct primarily nuclear research. Interestingly, of the original 56 labs originally included in this report, none conducted primarily nuclear research, as all seven come from the newer list of 42 labs for the updated edition. This may indicate the PRC downplaying or hiding its nuclear research—which it may consider particularly sensitive—by not including any of these labs on the official list from which the original 56 were drawn.

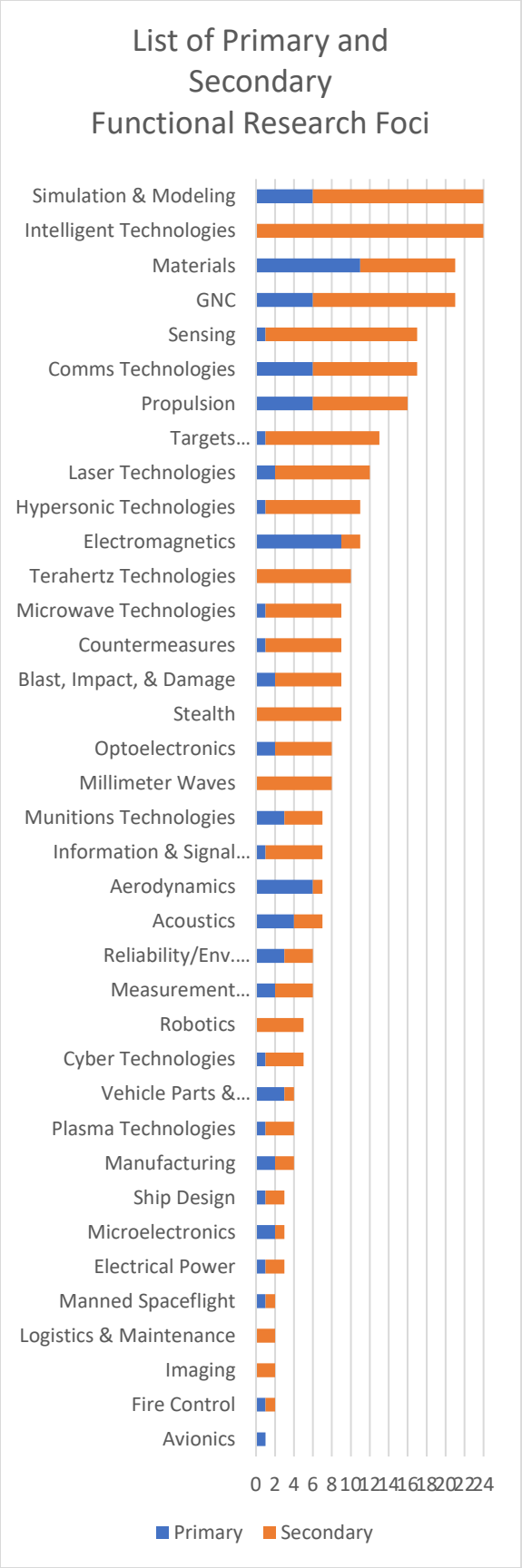



In terms of equipment, 23 labs researched multiple types of equipment. The single most researched type of equipment was space vehicles, with 13 labs primarily focused on this area, followed by aircraft with 10. Other major primary research areas included nuclear weaponry and power, underwater vehicles, munitions, electronic warfare, and radar. When secondary research foci were included, space vehicles and aircraft remain the top two. However, several other foci come to prominence, including ballistic and non-ballistic missiles, with at least 13 and 21 labs, respectively, conducting some research on those topics, unmanned systems with 17, surface vessels with 11, and communications equipment with 11. While many of these lack a large number of labs focusing primarily on them, they do appear to be areas of widespread secondary interest across a high number of labs.




In terms of functional research foci, the single most prominent research interest was in advanced materials with 11 labs, followed by electromagnetics with nine, and several foci with six each, including simulation and modeling; propulsion; guidance, navigation and control (GNC); communications technologies; and aerodynamics. When secondary research interests were factored in, simulation and modeling joined with intelligent technologies as the two most popular foci. Sensing, target detection and recognition, laser technologies, hypersonic technologies, and terahertz technologies also took on greater prominence.


List of Primary and Secondary Functional Research Foci
Simulation & Modeling
Intelligent Technologies
Materials
GNC
Sensing
Comms Technologies
Propulsion
Targets...
Laser Technologies
Hypersonic Technologies
Electromagnetics
Terahertz Technologies
Microwave Technologies
Countermeasures
Blast, Impact, & Damage
Stealth
Optoelectronics
Millimeter Waves
Munitions Technologies
Information & Signal...
Aerodynamics
Acoustics
Reliability/Env....
Measurement...
Robotics
Cyber Technologies
Vehicle Parts &...
Plasma Technologies
Manufacturing
Ship Design
Microelectronics
Electrical Power
Manned Spaceflight
Logistics & Maintenance
Imaging
Fire Control
Avionics
0 2 4 6 8 10 12 14 16 18 20 22 24
Primary
Secondary

## Relationship between State Key Labs and Defense S&T Key Labs

One important facet of the SKL and DSTKL systems is that the boundary between the two is highly porous, in some cases to the point that there is no meaningful distinction between them. While ostensibly civilian, many SKLs engage in significant military research. For example, all military bio research at this level appears to be under the SKL system. Likewise, DSTKLs apply their dual-use research to civilian fields such as civil aviation and nuclear power. Rather than being a black and white system, in which some labs are clearly military and some are clearly civilian, most of these labs exist in a gray continuum, dabbling in both military and civilian research as instructed according to national needs. Sharing of resources such as facilities, scientific instruments, data, and experimental materials between civilian and military research platforms is a key part of the PRC's strategy of Military-Civil Fusion (MCF). As outlined in Part One of this project, in 2018 the Ministry of Science and Technology (MOST), National Development and Reform Commission (NDRC), SASTIND, and the CMC EDD announced measures to promote resource sharing across a wide range of national scientific research facilities, including between SKLs and DSTKLs. Such integration closely binds military and civilian labs, making differentiation difficult and complicating the efforts of U.S. companies, research institutions, and regulatory agencies trying to prevent intellectual property and advanced technology from being transferred to the PLA.

The boundary between military and civilian is further complicated by the way military labs will often play fast and loose with their official names. Numerous naming conventions, including "Defense S&T Key Lab" [国防科技重点实验室], "State Key Lab" [国家重点实验室], "State-Level Key Lab" [国家级重点实验室], "Key Lab" [重点实验室], and now "National Key Lab" [全国重点实验室] (see below), are used seemingly interchangeably, often even by the labs themselves. For example, the Defense S&T Key Lab of Radar Signal Processing, profiled in this report, has referred to itself in various sources as the *National Laboratory of Radar Signal Processing*, the *National Key Laboratory of Radar Signal Processing*, or the *Key Laboratory of Science and Technology on Radar Signal Processing*. Notably, none of these include "Defense S&T," which is almost never translated into English.

Other labs are ambiguous in status for other reasons. A national-level key laboratory dedicated to research on microsystems, officially known as the "Key Laboratory of Science and Technology on Micro-System" (*sic*), is referred to sporadically as a DSTKL in public sources, but is more often referred to as an SKL, and its subordination to the Chinese Academy of Sciences would be unusual for a DSTKL. Is such a lab an SKL or a DSTKL? Absent any official confirmation and in the presence of conflicting information, we are reduced to informed guesses about which labs belong in which category. For this reason, it is important for U.S. and Western research institutions to not trust a PRC research lab simply because it is officially categorized as "civilian," when this distinction is functionally meaningless.

Most recently, the gap between the civilian and military arms of the system has been further degraded by reforms which have seen a significant number of DSTKLs seemingly merged into the civilian system. Beginning around 2022, the SKL system was replaced by the similar "National

Key Lab" (NKL) [全国重点实验室] system, with all former SKLs now renamed accordingly. Functionally, NKLs play the same role as the SKLs they are replacing, but the NKL system is intended to better clarify and coordinate the role and layout of the civilian national-level labs, as well as refocusing on the PRC's biggest technological needs and "chokepoints" [卡脖子]. It also solves problems such as a lack of full-time research personnel (labs would tend to draw part-time personnel who were primarily affiliated with the lab's parent institution and credentialed at multiple research institutions), leading to mixed loyalties and unclear ownership of intellectual property derived from discoveries.[20] Collectively, these measures are intended to solve ongoing problems in the PRC key lab system, including a lack of major original results, cultivation of talent, and poor management.[21] The name change to "National" Key Lab is intended as both an "ultimatum" to the labs, who will be abolished if they fail to sufficiently reform, and a symbol of this upgraded lab system.[22]

Per one source, part of this reform involves the setting of clearer goals for labs. For example, one NKL focused on grass and seed development set a goal of developing ten new varieties of pasture grass and ten varieties of grass for ecological restoration in the coming years.[23] As Alex Stone outlined in *China's Model of Science: Rationale, Players, Issues*, one of the most pressing problems in PRC S&T efforts is overly stringent top-down planning, which makes spontaneous discoveries and innovation much more difficult. This is because researchers tend to be consumed with hitting their targets to maintain funding.[24] If this source is accurate, the setting of more such top-down targets would represent a step in the wrong direction for the PRC research system.

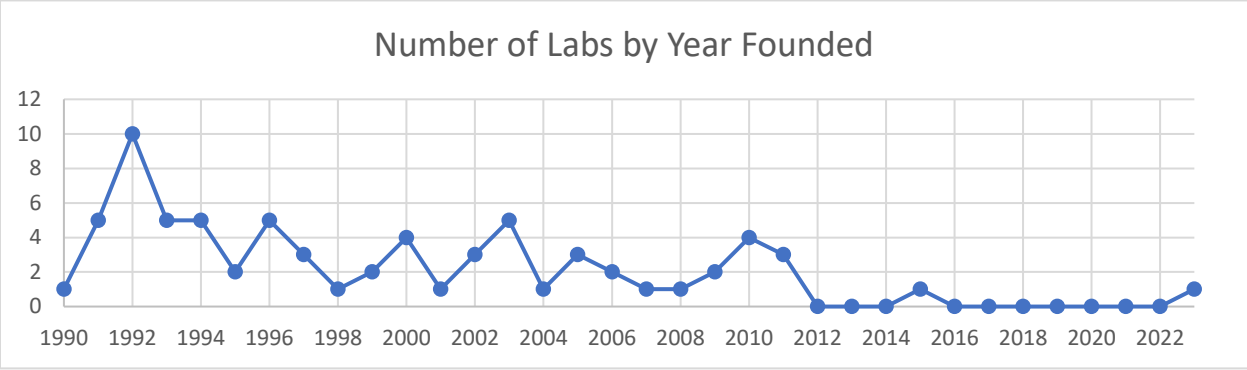
Most significantly for the purposes of this report, it appears that many, though not all, Defense S&T Key Labs have been incorporated into this NKL system over the past two years. However, there is no evidence that they have ceased or even altered their research to focus less on military fields. For example, the Defense S&T Key Laboratory of Vessel Integrated Power Technology has changed its name to the "National Key Laboratory of Electromagnetic Energy" [电磁能技术全国重点实验室],[25] but continues to be subordinate to the PLA Naval Engineering University and conduct research on railgun technology.[26] Similarly, the Defense S&T Key Lab of Space Intelligent Control Technology was renamed to the "National Key Lab of Space Intelligent Control Technology" in 2023, but continues to fund SASTIND projects in 2024, indicating a continued military role.[27]

This raises the question of why some DSTKLs are now officially dropping their "Defense S&T" [国防科技] moniker in favor of the civilian "National" [全国]. For now, PRC sources are mum. It is unclear if this represents a complete folding of one system into the other, as not all labs have taken on this new moniker,[xiv] and official documents continue to refer to the role of DSTKLs in national strategies. However, it could be an attempt to further obfuscate and erode barriers between the civilian and military systems. As U.S. and Western governments pay more attention to PRC research institutions and their possible military connections, it is possible DSTKLs may be finding it harder to operate internationally and may be attempting to whitewash their military ties by folding themselves into the ostensibly civilian system. An official press release from one

[xiv] As of writing, 43 of 98 labs have shown likely evidence of reorganization.

CASC subsidiary is telling: it refers to its subsidiary DSTKL, the Defense S&T Key Lab of Space Flight Intelligent Control Technology, by its new civilian name, the "National Key Lab of Space Flight Intelligent Control Technology." However, it then proudly states that in a recent assessment, this lab was ranked as the number one lab in the *Defense S&T Key Lab* system, indicating it is still classified as a DSTKL despite its new name, and suggesting the system still continues as normal behind the scenes. Further, the source makes clear that the lab was re-approved in 2023 as a Defense S&T Key Lab by SASTIND. Thus, despite changing its name to the new NKL system, this lab still appears to be a DSTKL overseen by SASTIND.[28] In another example, the DSTKL of Aircraft Control and Integration Technology was reorganized into a new NKL, the "National Key Lab of Aircraft Control and Integration Technology." However, in official announcements it continues to use the official logo for the DSTKL system, suggesting it is still viewed as a DSTKL.[29]

One data point against the continued central role of Defense S&T Key Labs going forward is the fact that so few new labs appear to have been established in recent years. A founding date was found for 71 labs. After an initial spate of 15 labs established in the first two years of the DSTKL system's operations,[xv] it fell into a fairly predictable pattern, establishing between one and five labs per year every year between 1992 and 2011. However, after 2011, this number suddenly dropped off precipitously. The available data shows only two labs established over the next 12 years, one in 2015 and one in 2023. While the dataset is incomplete (30 known labs had no public founding date), the trend in the available data is clear: DSTKLs were established much more rarely after around 2011. The reason for this is entirely unclear (in the same time period, dozens of civilian SKLs were established), but, combined with the ongoing conversion of some DSTKLs into civilian NKLs, this could point to a gradual abolishment and folding of DSTKLs into the civilian system. More research will be necessary before the fate of the Defense S&T Key Lab system can be made clear.




Such obfuscation will make products such as this report all the more important to help work out which labs are actually civilian, and which are only pretending to be. Further, rather than whitewashing these labs by placing them within the civilian system, it may be more appropriate for U.S. and allied officials and scholars to view the entire civilian NKL system as tainted and

[xv] This includes one lab which opened its doors a bit early in December 1990.

suspect, and act accordingly. A list of labs which are known to have been reorganized as of writing is provided in “Lab Data” below.

## Collaboration with U.S. Institutions

In the course of this research, we found significant evidence of collaboration between these defense labs and universities, companies, and research institutions in the United States, as well as in Europe, Australia, Japan, and others.[xvi] This collaboration ranged from one-off visits, research papers, fellowships, and conference participation and co-hosting, all the way up to official, long-term institutional cooperation.

To give just a few of the many examples of such cooperation detailed in this directory, the Defense S&T Key Lab of Antennas and Microwave Technology, which conducts research into advanced military radars, claims to have cooperative relationships with the University of California, University of Pennsylvania, MIT, and others, gave an honorary professorship to an employee of IBM, conducted academic exchanges with Duke and Penn State, and had at least one of its researchers studying at a U.S. university as recently as 2019. Another advanced radar DSTKL, the Defense S&T Key Lab of Radar Signal Processing, has established a joint research center with Syracuse University under a national plan specifically aimed at encouraging tech transfer; has hosted conferences with speakers from Columbia, NYU, University of California, Bell Labs, and others; and has hosted scholar exchanges and guest lecturers from the University of California, University of Florida, Boeing, and others. Likewise, the Defense S&T Key Lab of Communications Anti-Jamming Technology, dedicated to research on military communications equipment, claims to have joint graduate training agreements with Princeton and Columbia, as well as schools in Canada, the U.K., Australia, and Switzerland. It also claims to have worked with Intel, Siemens, Nokia, Philips, and other international corporations.

By far the most common form of contact between PRC defense lab researchers and their U.S. and Western counterparts, however, was in academic conference participation and co-hosting. Such participation often led to U.S. and Western researchers being brought to the PRC to speak on strategic and dual-use technologies, or at least rubbing shoulders with PRC military and defense S&T experts, allowing ample opportunity for transfer of technical knowledge. One particularly egregious example was the International Conference on Defence Technology, in which multiple DSTKLs teamed up with Norinco and a U.K. researcher from Imperial College to host a conference on the latest trends in military technology, including military artificial intelligence (AI), stealth, and quantum science. Western researchers came to the PRC to discuss topics such as armor and armor-piercing munitions, rocket propulsion, and composite materials.[xvii]

Most conferences are not nearly so blatant, however. More often, they are more akin to a 2022 conference hosted by the Defense S&T Key Lab of Aviation Engine High-Altitude Simulation, which teamed up with military aerospace conglomerates CASC and AECC to co-host a conference on the seemingly benign topic of cleaner and more efficient aircraft engine technology. Any whiff of a military connection was played down (e.g., the lab removed the "Defense" portion of its name in conference materials), and it attracted researchers from General

[xvi] While this directory focuses primarily on the U.S., further information is available about other states' cooperation with these labs upon request.
[xvii] For more on this conference, see the author's piece at Jamestown China Brief: Matthew Bruzzese, "PRC Transfer of Military and Dual-Use Technology: the Case of the International Conference on Defence Technology," *China Brief*, 24(12), 7 June 2024, https://jamestown.org/program/prc-transfer-of-military-and-dual-use-technology-the-case-of-the-international-conference-on-defense-technology/

Electric, the Southwest Research Institute, Texas A&M's Turbo Lab, Pratt & Whitney, Safran, Piaggio Aerospace, Airbus, Imperial College London, and others.[30] While universities and research institutes have taken strides in recent years to be more circumspect in their research collaboration with PRC entities, the frequency with which Western researchers continue to participate in conferences with military or dual-use applications indicates they may be an ongoing blind spot through which the PRC continues to gather important technical knowledge of strategic import.

In some cases, the research also revealed the use of U.S., European, and Japanese equipment by these labs, possibly in violation of export controls. Despite this, the labs often openly boast about their access to cutting-edge foreign equipment, listing it on their websites. For example, despite its presence on the U.S. Commerce Department Entity List since 2001, numerous labs under Northwestern Polytechnical University (NWPU) in Xi'an list out their bounty of U.S. and other foreign equipment on their websites, in some cases even specifying its national origin and year of acquisition (making clear that this equipment was acquired post-2001). Thus, we know, for example, that the DSTKL of Underwater Information and Control at NWPU, which conducts research into underwater warfare, apparently has access to numerous pieces of U.S.-origin high-tech equipment, including a research unmanned underwater vehicle (UUV) that is also used by the U.S. military.

## Notes on the Data Presented in this Directory

### Translations of Lab Names and Attempts at Obfuscation

All lab names given in this directory are direct translations of their names from the original Chinese. While "official" English names were found for some labs, these names often have little to no connection to the lab's actual Chinese name, and are often much more vague as to the lab's true purpose. Most importantly, English translations of lab names almost always remove any mention of "defense," or any mention of explicitly military technologies. As noted previously, this is almost certainly intentional and designed to obfuscate the lab's military purposes to an English-speaking audience, minimizing scrutiny and lowering barriers to foreign cooperation. Further, the "official" English names often translate awkwardly (e.g. "Science and Technology on Plasma Dynamics Laboratory"), and sometimes casually change depending on the source (as in the example of the DSTKL of Radar Signal Processing, which has variously called itself the "National Key Laboratory of Science and Technology on Radar Signal Processing," the "National Laboratory of Radar Signal Processing," and the "National Key Laboratory of Radar Signal Processing" in English), leaving some doubt as to how "official" they even are. Thus, this directory uses direct translations of the labs' names from their original Chinese. Unlike U.S. research institutions, which have names like "Oak Ridge" that give no clue as to the lab's work, most PRC research institutions have highly utilitarian and literal names which give useful insight into their missions and how the PRC views them. For these reasons, this report uses literal translations of the Chinese names, although "official" English names, where found, are also provided.

In addition, this report lists any new names the labs have taken on as of the end of 2024, as they are gradually folded into the civilian NKL system. Official English names are provided when known; when not known, a literal translation is provided in apostrophes.

### Chinese Names and Aliases

As noted in Part One of the report, Chinese state labs tend to play fast and loose with their names in Chinese as well as English, switching between using the characters for "Defense," "Key," and "State/National" seemingly interchangeably. The labs will oftentimes use slight variations on their names in both Chinese and English. Thus, any lab names which appear similar to, but not exactly the same as, the lab's "official" name are worthy of further investigation. This report endeavors to capture all of these slight name variations, where they occur, in the "Known Aliases" section. Further, it provides the "Defense" version of each name as the "Official" Chinese name, even when this is not the most commonly used name, while noting where this is the case. For example, the DSTKL of Computational Fluid Dynamics [国家计算流体力学国防科技重点实验室] is more frequently, though not always, called the *National* Laboratory of Computational Fluid Dynamics [国家计算流体力学实验室] in Chinese. Once again, without any kind of official list from Chinese sources, we are left to guess what is actually a DSTKL and what is not.

### Research Fields

Research fields listed in this directory were determined for each lab in three ways, and in descending order of specificity: first, by determining the lab's domain or research field in the most general sense (air, space, maritime, ground, or nuclear), then determining which specific technology or piece of equipment its research focuses on (e.g. aircraft, UAVs, missiles), and finally its functional research area (e.g. propulsion, aerodynamics, stealth). These categories are somewhat subjective and limited to publicly available information, but give a good idea of a lab's general area of focus.

### Lab Affiliations

This section lists all known parent institutions responsible for managing the lab, including any aliases. State-owned research institutions will generally have both a full name and a more generic numerical identifier. For example, AECC's Beijing Institute of Aeronautical Materials is also known as the 621st Research Institute. Both are given, with preference for the full name. In the case of universities, the term *xueyuan* [学院] is typically translated interchangeably as either "School" or "College." This report uses the official English translation wherever it could be found.

### "Key Data" Fields

This section contains information on the lab's date of establishment, official start of operations, funding, physical size, and number of personnel, when this information was forthcoming.

### Research Direction

Most labs have an official "research direction" [研究方向], a short list of research areas which summarize the lab's primary research foci, which are listed here, along with any other notable research areas.

### Notable Applications

This section lists any real-world applications of the lab's research that were found, with an emphasis on the defense sector. It varies in specificity: in some cases, it was possible to trace the lab's work to a specific piece of defense equipment, (e.g. "this lab's research into carbon composites was applied to braking technology for the J-10 combat aircraft"), while in other cases it was only possible to discern general applications (e.g. "this lab's research contributes to a wide range of rocket, missile, and ammunition propellants").

### Notable Collaborations

This section lists any particularly interesting collaborations between this lab and other institutions. It is not meant to be an exhaustive list of all collaborations. Rather, it focuses primarily on any work with military, defense industry, or defense research partners, as well as research with major PRC corporations. There is also a dedicated subsection for international collaboration. This often involves hosting for visits or study, individual, or institutional research collaboration; conference co-hosting; or alleged long-term institutional partnerships between these labs and U.S. or allied universities, companies, or research institutions.

### Lab Equipment

This section lists any equipment or facilities the lab is known to possess, along with any publicly available technical specifications. Particular emphasis was given to possession of equipment from U.S., E.U., or Japanese companies which may violate export controls.

### Translations

This report has made every effort to be accurate and consistent with Chinese translations.

### Sources

Unfortunately, sources frequently disappear from the Chinese-language internet over time. This was, for instance, the fate of the original list of 60 Defense S&T Key Labs which kicked off this project. This problem has only been exacerbated by Google's decision to end its practice of caching websites indexed in its search engine, which was often the only way to access websites that had disappeared.

### Special Thanks

The author would like to give special thanks to BPL analyst Devon Johannessen, who provided invaluable research support for several of these labs.

# Lab Data

## List of Labs by Year Founded

| YEAR | # | *DEFENSE S&T KEY LABORATORY OF…* |
|---|---|---|
| **1990** | 1 | Shockwave and Blast Physics (Established in December 1990, possibly the first DSTKL) |
| **1991** | 5 | Ballistics<br>Helicopter Rotor Dynamics<br>Plasma Physics<br>Radar Signal Processing<br>Solid Rocket Engine Combustion, Thermal Structure, and Inner Flow Field |
| **1992** | 10 | Aero-Engine Aerodynamics and Thermodynamics<br>Airfoil and Blading Aerodynamics<br>Antennas and Microwave Technology<br>Computational Physics<br>Electromechanical Engineering and Control<br>High Power Microwave Electronic Vacuum Component Technology<br>Hydroacoustic Technology<br>Precision Guidance and Automatic Target Recognition<br>Ultra-precision Machining Technology<br>Vehicle Transmission |
| **1993** | 5 | Electromagnetic Compatibility<br>Electronic Information Control<br>High Energy Beam Processing Technology<br>Radio Wave Environmental Characteristics and Modeling Technology<br>Underwater Information and Control |
| **1994** | 5 | Advanced Composite Materials<br>Communications Anti-Jamming Technology<br>Explosive Combustion<br>Military Solid-State Laser Technology<br>Tunable Gas Lasers |
| **1995** | 2 | Computational Fluid Dynamics<br>Space Microwave Technology |
| **1996** | 5 | High-Power Semiconductor Lasers<br>Nano- and Microfabrication Technology<br>Precision Hot Processing of Metals<br>Sonar Technology<br>Strong Radiation |
| **1997** | 3 | Aerospace Systems Simulation<br>Aviation Engine High-Altitude Simulation Technology<br>Marine Corrosion and Protection |
| **1998** | 1 | New Ceramic Fiber and Composite Materials |
| **1999** | 2 | Fire Control Technology<br>Pulsed Power Technology |
| **2000** | 4 | Composite Material Technology in Special Environments<br>Remanufacturing Technology<br>Space Environmental Materials Behavior and Evaluation Technology<br>Super High Temperature Structural Composite |
| **2001** | 1 | UAV Special Technology |
| **2002** | 3 | Complex Vessel Systems Simulation<br>Diesel Engine Booster Technology<br>Military Underwater Intelligent Robotic Technology |
| **2003** | 5 | Electromagnetic Environment Effects<br>Metrology and Calibration Technology<br>Nuclear Data<br>Space Flight Intelligent Control Technology<br>Surface Physics and Chemistry |
| **2004** | 1 | Microsystem Technology |
| **2005** | 3 | Communications Countermeasures Technology<br>Lightweight, High-strength Structural Materials<br>Multispectral Information Processing Technology |
| **2006** | 2 | Advanced High-Temperature Structural Materials<br>Information Systems Engineering |
| **2007** | 1 | Vessel Integrated Power Technology |
| **2008** | 1 | Reliability & Environmental Engineering Technology |
| **2009** | 2 | Integrated Avionics Technology<br>Space Intelligent Control Technology |

| | | |
|---|---|---|
| **2010** | 4 | Aviation Plasma Dynamics<br>Electromagnetic Environment Effects and Electro-Optical Engineering<br>Inertial Technology<br>Space Flight Dynamics Technology |
| **2011** | 3 | Human Factors Engineering<br>Materials Technology in Impact Environments<br>Ship Vibrational Noise |
| **2012** | 0 | |
| **2013** | 0 | |
| **2014** | 0 | |
| **2015** | 1 | Liquid Rocket Engine Technology |
| **2016-2022** | 0 | |
| **2023** | 1 | Infrared and Ultraviolet Technology (possibly abandoned and reorganized as NKL) |
| **U/I** | 30 | Aircraft Control and Integration Technology (Final approval 2010)<br>Ballistic Missile Penetration Technology<br>Complex Aviation Systems Simulation<br>Complex Land Systems Simulation<br>Detonator Safety and Reliability<br>Electronic Information Equipment Systems Research<br>Electronic Measurement Technology (2002)<br>Equipment Integrated Support Technology<br>Flexible Manufacturing Systems Technology<br>Fuze Dynamic Characteristics<br>Gallium Arsenide Microwave and Millimeter Wave Monolithic and Modular Circuitry<br>Helicopter Transmission Technology (Final Approval 2018)<br>High-Power Microwave Technology<br>Hydroacoustic Countermeasure Technology<br>Hydrodynamics<br>Hypersonic Ramjet Technology<br>Information System Security Technology<br>Low Interception Probability Signal Detection<br>Millimeter Wave Remote Sensing Technology<br>Optoelectronic Countermeasures Technology<br>Parallel and Distributed Processing (Final Approval 2011)<br>Particle Transport and Enrichment Technology<br>Space Chemical Power Technology<br>Specialized Integrated Circuits<br>Target and Environmental Electromagnetic Diffuse Radiation Characteristics<br>Target and Environmental Optical Characteristics<br>Transient Shock Technology<br>Underwater Measurement and Control Technology<br>Vacuum Technology and Physics<br>Weapons and Equipment Systems Research |

## List of Labs by Location

| CITY | # | *DEFENSE S&T KEY LAB OF…* |
|---|---|---|
| **BEIJING** | 36 | Advanced Composite Materials<br>Advanced High-Temperature Structural Materials<br>Aero-Engine Aerodynamics and Thermodynamics<br>Aerospace Systems Simulation<br>Aircraft Control and Integration Technology<br>Ballistic Missile Penetration Technology<br>Complex Aviation Systems Simulation<br>Complex Land Systems Simulation<br>Complex Vessel Systems Simulation<br>Computational Fluid Dynamics<br>Computational Physics<br>Electronic Information Equipment Systems Research<br>Fuze Dynamic Characteristics*<br>High Energy Beam Processing Technology<br>High Power Microwave Electronic Vacuum Component Technology*<br>Human Factors Engineering<br>Hydroacoustic Countermeasure Technology*<br>Hypersonic Ramjet Technology*<br>Inertial Technology<br>Information System Security Technology<br>Materials Technology in Impact Environments<br>Metrology and Calibration Technology<br>Military Solid-State Laser Technology<br>Millimeter Wave Remote Sensing Technology<br>Nano- and Microfabrication Technology*<br>Nuclear Data<br>Radio Wave Environmental Characteristics and Modeling Technology<br>Reliability & Environmental Engineering Technology<br>Remanufacturing Technology<br>Space Flight Intelligent Control Technology<br>Space Intelligent Control Technology<br>Target and Environmental Electromagnetic Diffuse Radiation Characteristics<br>Target and Environmental Optical Characteristics<br>Transient Shock Technology<br>Vehicle Transmission<br>Weapons and Equipment Systems Research |
| **XI'AN** | 15 | Airfoil and Blading Aerodynamics<br>Antennas and Microwave Technology<br>Aviation Plasma Dynamics<br>Detonator Safety and Reliability<br>Electromechanical Engineering and Control<br>Explosive Combustion<br>Fuze Dynamic Characteristics*<br>Liquid Rocket Engine Technology<br>Radar Signal Processing<br>Solid Rocket Engine Combustion, Thermal Structure, and Inner Flow Field<br>Space Flight Dynamics Technology<br>Space Microwave Technology<br>Super High Temperature Structural Composites<br>UAV Special Technology<br>Underwater Information and Control |
| **CHANGSHA** | 7 | Equipment Integrated Support Technology<br>Hypersonic Ramjet Technology*<br>Information Systems Engineering<br>Lightweight, High-strength Structural Materials<br>New Ceramic Fiber and Composite Materials<br>Parallel and Distributed Processing<br>Precision Guidance and Automatic Target Recognition* |
| **CHENGDU** | 6 | Aviation Engine High-Altitude Simulation Technology<br>Communications Anti-Jamming Technology<br>Electronic Information Control<br>High Power Microwave Electronic Vacuum Component Technology* |

| | | |
|---|---|---|
| | | Low Interception Probability Signal Detection<br>Strong Radiation |
| **HARBIN** | 6 | Composite Material Technology in Special Environments<br>Hydroacoustic Technology<br>Military Underwater Intelligent Robotic Technology<br>Precision Hot Processing of Metals<br>Space Environmental Materials Behavior and Evaluation Technology<br>Tunable Gas Lasers |
| **NANJING** | 6 | Antennas and Microwave Technology<br>Ballistics<br>Electromagnetic Environment Effects and Electro-Optical Engineering<br>Gallium Arsenide Microwave and Millimeter Wave Monolithic and Modular Circuitry<br>Helicopter Rotor Dynamics<br>Helicopter Transmission Technology |
| **MIANYANG** | 5 | High-Power Microwave Technology<br>Hypersonic Ramjet Technology*<br>Plasma Physics<br>Shockwave and Blast Physics<br>Surface Physics and Chemistry |
| **SHANGHAI** | 5 | Hydroacoustic Countermeasure Technology*<br>Infrared and Ultraviolet Technology<br>Integrated Avionics Technology<br>Microsystem Technology<br>Nano- and Microfabrication Technology* |
| **WUHAN** | 3 | Electromagnetic Compatibility<br>Multi-spectral Information Processing Technology<br>Vessel Integrated Power Technology |
| **QINGDAO** | 2 | Electronic Measurement Technology*<br>Marine Corrosion and Protection |
| **SHIJIAZHUANG** | 2 | Electromagnetic Environment Effects<br>Specialized Integrated Circuits |
| **TIANJIN** | 2 | Diesel Engine Booster Technology*<br>Particle Transport and Enrichment Technology |
| **WUXI** | 2 | Hydrodynamics<br>Ship Vibrational Noise |
| **SHENZHEN** | 1 | Precision Guidance and Automatic Target Recognition* |
| **CHANGCHUN** | 1 | High-Power Semiconductor Lasers |
| **DALIAN** | 1 | Underwater Measurement and Control Technology |
| **DATONG** | 1 | Diesel Engine Booster Technology* |
| **HANGZHOU** | 1 | Sonar Technology |
| **HEFEI** | 1 | Antennas and Microwave Technology |
| **JIAXING** | 1 | Communications Countermeasures Technology |
| **LANGFANG** | 1 | Optoelectronic Countermeasures Technology |
| **LANZHOU** | 1 | Vacuum Technology and Physics |
| **LUOYANG** | 1 | Fire Control Technology |
| **TAIYUAN** | 1 | Electronic Measurement Technology* |
| **XIANYANG** | 1 | Space Chemical Power Technology |
| **ZHANJIANG** | 1 | Hydroacoustic Countermeasure Technology* |

**Lab headquartered in multiple cities*

# List of Labs by Parent Institution

| PARENT INSTITUTION | # | *DEFENSE S&T KEY LAB OF…* | SUBORINDATE INSTITUTION | PARTNER(S) |
|---|---|---|---|---|
| **STATE OWNED ENTERPRISES** | | | | |
| **CETC** | 12 | Antennas and Microwave Technology* | 14 RI, 38 RI | Xidian U. |
| | | Communications Countermeasures Technology | 36 RI | |
| | | Electronic Information Control | 29 RI | |
| | | Electronic Measurement Technology* | 41 RI | NUC |
| | | Gallium Arsenide Microwave and Millimeter Wave… | 55 RI | |
| | | High Power Microwave Electronic Vacuum…* | 12 RI | UESTC |
| | | Information Systems Engineering* | 28 RI | NUDT, CASIC |
| | | Infrared and Ultraviolet Technology* | 11 RI | CAS, Norinco |
| | | Military Solid-State Laser Technology | 11 RI | |
| | | Optoelectronic Countermeasures Technology | 53 RI | |
| | | Radio Wave Environmental Characteristics… | 22 RI | |
| | | Specialized Integrated Circuits | 13 RI | |
| **CASC** | 9 | Liquid Rocket Engine Technology | 11RI | |
| | | Reliability & Environmental Engineering Technology* | 511 RI, BISE | Beihang |
| | | Solid Rocket Engine Combustion, Thermal Structure…* | 41 RI | NWPU |
| | | Space Chemical Power Technology | 42 RI | |
| | | Space Env. Materials Behavior and Evaluation...* | 510 RI | HIT |
| | | Space Flight Intelligent Control Technology | 12 RI | |
| | | Space Intelligent Control Technology | 502 RI | |
| | | Space Microwave Technology | CAST Xi'an | |
| | | Vacuum Technology and Physics | 510 RI | |
| **CSSC** | 9 | Electromagnetic Compatibility | 701 RI | |
| | | Hydroacoustic Countermeasure Technology | 726 RI | |
| | | Hydrodynamics* | CSSRC | HEU |
| | | Marine Corrosion and Protection | 725 RI | |
| | | Ship Vibrational Noise* | 701, 702 RI | PLAN |
| | | Sonar Technology | 715 RI | |
| | | Underwater Information and Control* | 705 RI | NWPU |
| | | Underwater Measurement and Control Technology | 760 RI | |
| | | Vessel Integrated Power Technology* | 712 RI | PLAN |
| **NORINCO** | 9 | Detonator Safety and Reliability | 213 RI | |
| | | Diesel Engine Booster Technology | 70 RI | |
| | | Electromechanical Engineering and Control* | 212 RI | BIT |
| | | Explosive Combustion | 204 RI | |
| | | Fuze Dynamic Characteristics* | 212 RI | BIT |
| | | Infrared and Ultraviolet Technology* | 211 RI | CAS, CETC |
| | | Materials Technology in Impact Environments* | 52 RI | BIT |
| | | Transient Shock Technology* | 208 RI | Nanjing U. |
| | | Vehicle Transmission* | 201 RI | BIT |
| **CASIC** | 8 | Aerospace Systems Simulation | BSC, 2ACA 2DEP | |
| | | Hypersonic Ramjet Technology* | 31 RI | NUDT, |
| | | Inertial Technology* | 33 RI | PLASSF^ |
| | | Information Systems Engineering* | 17 RI | Beihang |
| | | Metrology and Calibration Technology* | 203 RI | NUDT, CETC |
| | | Millimeter Wave Remote Sensing Technology | 25 RI | AVIC, CNNC |
| | | Target and Env. Electromagnetic Diffuse Radiation… | 207 RI | |
| | | Target and Env. Optical Characteristics | | |
| **AVIC** | 7 | Aircraft Control and Integration Technology* | 618 RI | Beihang |
| | | Airfoil and Blading Dynamics | 1st Aircraft Inst. | NWPU |
| | | Fire Control Technology | 613 RI | |
| | | Helicopter Rotor Dynamics* | 602 RI | NUAA |
| | | High Energy Beam Processing Technology | MTI (fmr. 625 RI) | |
| | | Integrated Avionics Technology | 615 RI | |
| | | Metrology and Calibration Technology* | 304 RI | CASIC, CNNC4 |
| | | UAV Special Technology* | CADI | NWPU, AFEU |
| **AECC** | 4 | Advanced Composite Materials | 621 RI | |
| | | Advanced High-Temperature Structural Materials | 621 RI | |
| | | Aviation Engine High-Altitude Simulation Technology | 624 RI | |
| | | Helicopter Transmission Technology* | 608 RI | NUAA |
| **CNNC** | 3 | Metrology and Calibration Technology* | CIAE | CASIC, AVIC |
| | | Nuclear Data | CIAE | |
| | | Particle Transport and Enrichment Technology* | RIPCENI | Tsinghua |

| | | | | |
|---|---|---|---|---|
| **CIVILIAN UNIVERSITIES** | | | | |
| **BEIHANG UNIVERSITY** | 5 | Aero-Engine Aerodynamics and Thermodynamics<br>Aircraft Control and Integration Technology*<br>Computational Fluid Dynamics*<br>Inertial Technology*<br>Reliability & Environmental Engineering Technology* | | <br>AVIC<br>PLASSF^<br>CASIC<br>CASC |
| **NORTHWESTERN POLYTECHNICAL UNIVERSITY (NWPU)** | 5 | Airfoil and Blading Aerodynamics*<br>Solid Rocket Engine Combustion, Thermal Structure…*<br>Space Flight Dynamics Technology*<br>Super High Temperature Structural Composites<br>UAV Special Technology* | | AVIC<br>CASC<br>PLASSF^<br><br>AFEU, AVIC |
| **BEIJING INSTITUTE OF TECHNOLOGY (BIT)** | 4 | Electromechanical Engineering and Control*<br>Fuze Dynamic Characteristics*<br>Materials Technology in Impact Environments*<br>Vehicle Transmission* | | Norinco<br>Norinco<br>Norinco<br>Norinco |
| **HARBIN INSTITUTE OF TECHNOLOGY (HIT)** | 4 | Composite Material Technology in Special Environments<br>Precision Hot Processing of Metals<br>Space Env. Materials Behavior and Evaluation…*<br>Tunable Gas Lasers | | <br><br>CASC |
| **UNIVERSITY OF ELECTRONIC S&T OF CHINA (UESTC)** | 3 | Communications Anti-Jamming Technology<br>High Power Microwave Electronic Vacuum…*<br>Strong Radiation* | | <br>CETC<br>CAEP |
| **HARBIN ENGINEERING UNIVERSITY (HEU)** | 2 | Hydroacoustic Technology<br>Military Underwater Intelligent Robotic Technology | | |
| **NANJING UNIVERSITY OF AERONAUTICS AND ASTRONAUTICS (NUAA)** | 2 | Helicopter Rotor Dynamics*<br>Helicopter Transmission Technology* | | AVIC<br>AECC |
| **TSINGHUA UNIVERSITY** | 2 | Human Factors Engineering*<br>Particle Transport and Enrichment Technology* | | PLA EDD<br>CNNC |
| **XIDIAN UNIVERSITY** | 2 | Precision Guidance and Automatic Target Recognition*<br>Radar Signal Processing | | CETC |
| **CENTRAL SOUTH UNIVERSITY (CSU)** | 1 | Lightweight, High-strength Structural Materials | | |
| **CHANGCHUN UNIVERSITY OF S&T (CUST)** | 1 | High-Power Semiconductor Lasers | | |
| **HUAZHONG UNIVERSITY OF S&T (HUST)** | 1 | Multi-spectral Information Processing Technology | | |
| **NANJING UNIVERSITY** | 1 | Transient Shock Technology* | | Norinco |
| **NORTH UNIVERSITY OF CHINA (NUC)** | 1 | Electronic Measurement Technology* | | CETC |
| **NANJING UNIVERSITY OF S&T (NUST)** | 1 | Ballistics | | |
| **PEKING UNIVERSITY (PKU)** | 1 | Nano- and Microfabrication Technology* | | SJTU |
| **SHENZHEN UNIVERSITY** | 1 | Precision Guidance and Automatic Target Recognition* | | NUDT |
| **SHANGHAI JIAO TONG UNIVERSITY (SJTU)** | 1 | Nano- and Microfabrication Technology* | | PKU |
| **WENZHOU UNIVERSITY** | 1 | Plasma Physics* | | CAEP |
| **MILITARY INSTITUTIONS** | | | | |
| **NATIONAL UNIVERSITY OF DEFENSE TECHNOLOGY (NUDT)** | 6 | Equipment Integrated Support Technology<br>Hypersonic Ramjet Technology*<br>Information Systems Engineering*<br>New Ceramic Fiber and Composite Materials<br>Parallel and Distributed Processing<br>Precision Guidance and Automatic Target Recognition | | <br>CASIC,<br>PLASSF^<br>CASIC, CETC |
| **PLA STRATEGIC SUPPORT FORCE (PLASSF)**[xviii] | 5 | Computational Fluid Dynamics*<br>Electronic Information Equipment Systems Research<br>Hypersonic Ramjet Technology*<br>Low Interception Probability Signal Detection<br>Space Flight Dynamics Technology* | CARDC<br>Space Eng. U.<br>CARDC<br>57 RI<br>BACC | Beihang<br><br>NUDT, CASIC<br><br>NWPU |
| **PLA ARMY (PLAA)** | 3 | Electromagnetic Env. Effects<br>Electromagnetic Env. Effects and Electro-Optical Eng.<br>Remanufacturing Technology | Army Eng. U.<br>Army Eng. U.<br>Armor Academy | |
| **PLA NAVY (PLAN)** | 3 | Complex Vessel Systems Simulation<br>Ship Vibrational Noise*<br>Vessel Integrated Power Technology* | Research Acad.<br>Naval Eng. U.<br>Naval Eng. U. | <br>CSSC<br>CSSC |

[xviii] The PLASSF was reorganized into three component arms in 2024.

| | | | | |
|---|---|---|---|---|
| **CMC EQUIPMENT DEVELOPMENT DEPARTMENT (EDD)** | 2 | Complex Land Systems Simulation<br>Human Factors Engineering* | CASRT | Tsinghua |
| **ACADEMY OF MILITARY SCIENCES (AMS)** | 2 | Information System Security Technology<br>Weapons and Equipment Systems Research | Inst. of Sys. Eng.<br>Inst. of Sys. Eng. | |
| **PLA AIR FORCE (PLAAF)** | 3 | Aviation Plasma Dynamics<br>Complex Aviation Systems Simulation<br>UAV Special Technology* | Air Force Eng. U.<br>Research Acad.<br>Air Force Eng. U. | <br><br>NWPU, AVIC |
| **PLA ROCKET FORCE (PLARF)** | 1 | Ballistic Missile Penetration Technology | Research Acad. | |
| **GOVERNMENT RESEARCH INSTITUTIONS** | | | | |
| **CHINESE ACADEMY OF ENGINEERING PHYSICS (CAEP)** | 6 | Computational Physics<br>High-Power Microwave Technology<br>Plasma Physics*<br>Shockwave and Blast Physics<br>Strong Radiation*<br>Surface Physics and Chemistry | IAPCM<br>IAE<br>LFRC (8th Acad.)<br>IFF (1st Acad.)<br>IAE or ILP<br>IMR | <br><br>Wenzhou U.<br><br>UESTC |
| **CHINESE ACADEMY OF SCIENCES (CAS)** | 2 | Infrared and Ultraviolet Technology*<br>Microsystem Technology | SITP<br>SIMIT | CETC, Norinco |

*Jointly managed lab

^Following PLASSF reorganization in 2024, current subordination unknown

## List of Labs by Domain Research[xix]

| DOMAIN | PRIMARY RESEARCH AREA | # | SECONDARY RESEARCH AREA | # | TOTAL |
|---|---|---|---|---|---|
| **AIR** | Advanced Composite Materials<br>Advanced High-Temperature Structural Materials<br>Aero-Engine Aerodynamics and Thermodynamics<br>Aerospace Systems Simulation<br>Aircraft Control and Integration Technology<br>Airfoil and Blading Aerodynamics<br>Aviation Engine High-Altitude Simulation Tech.<br>Aviation Plasma Dynamics<br>Ballistic Missile Penetration Technology<br>Fire Control Technology<br>Helicopter Rotor Dynamics<br>Helicopter Transmission Technology<br>High Energy Beam Processing Technology<br>High Power Microwave Electronic Vacuum…<br>Integrated Avionics Technology<br>Millimeter Wave Remote Sensing Technology<br>Multi-spectral Information Processing Technology<br>Optoelectronic Countermeasures Technology<br>Precision Guidance and Automatic Target Rec…<br>Radar Signal Processing<br>Super High Temperature Structural Composites<br>Target and Env. Electromagnetic Diffuse…<br>UAV Special Technology | 23 | Antennas and Microwave Technology<br>Ballistics<br>Communications Anti-Jamming Tech.<br>Complex Aviation Systems Simulation<br>Complex Land Systems Simulation<br>Complex Vessel Systems Simulation<br>Composite Material Tech. in Special Env.<br>Computational Fluid Dynamics<br>Electromagnetic Compatibility<br>Electromagnetic Environment Effects<br>Electromagnetic Env. Eff. and Electro…<br>Electromechanical Engineering and Control<br>Electronic Information Control<br>Equipment Integrated Support Technology<br>Explosive Combustion<br>Fuze Dynamic Characteristics<br>Gallium Arsenide Microwave and Mil...<br>High-Power Microwave Technology<br>High-Power Semiconductor Lasers<br>Human Factors Engineering<br>Hypersonic Ramjet Technology<br>Inertial Technology<br>Information Systems Engineering<br>Lightweight, High-strength Structural…<br>Liquid Rocket Engine Technology<br>Materials Technology in Impact Env.<br>Metrology and Calibration Technology<br>Microsystem Technology<br>New Ceramic Fiber and Composite Mat.<br>Radio Wave Env. Characteristics…<br>Reliability & Environmental Engineering…<br>Remanufacturing Technology<br>Solid Rocket Engine Combustion…<br>Space Chemical Power Technology<br>Space Flight Dynamics Technology<br>Space Flight Intelligent Control Tech.<br>Specialized Integrated Circuits<br>Target and Env. Optical Characteristics<br>Underwater Measurement and Control…<br>Weapons and Equipment Systems Research | 40 | 63 |
| **SPACE** | Composite Material Technology in Special Env.<br>Computational Fluid Dynamics<br>Electronic Information Equipment Systems…<br>Human Factors Engineering<br>Inertial Technology<br>Liquid Rocket Engine Technology<br>Reliability & Environmental Engineering Tech.<br>Solid Rocket Engine Combustion…<br>Space Environmental Materials Behavior…<br>Space Flight Dynamics Technology<br>Space Intelligent Control Technology<br>Space Microwave Technology<br>Tunable Gas Lasers<br>Vacuum Technology and Physics | 14 | Advanced Composite Materials<br>Aircraft Control and Integration Tech.<br>Communications Anti-Jamming Tech.<br>Complex Aviation Systems Simulation<br>Electromagnetic Environment Effects<br>Electronic Measurement Technology<br>Explosive Combustion<br>High Energy Beam Processing Technology<br>Hypersonic Ramjet Technology<br>Information Systems Engineering<br>Lightweight, High-strength Structural…<br>Metrology and Calibration Technology<br>Military Solid-State Laser Technology<br>Millimeter Wave Remote Sensing Tech.<br>Nano- and Microfabrication Technology<br>New Ceramic Fiber and Composite Mat.<br>Parallel and Distributed Processing<br>Radio Wave Env. Characteristics…<br>Space Chemical Power Technology<br>Space Flight Intelligent Control Tech.<br>Super High Temp. Structural Composites<br>Underwater Measurement and Control… | 22 | 36 |

[xix] Following further data refinements, this list and the other two research lists differ slightly in some categories from the data presented in Part One of the report. The overall findings in Part One of the report remain unchanged.

| | | | | | |
|---|---|---|---|---|---|
| **GROUND** | Complex Land Systems Simulation<br>Diesel Engine Booster Technology<br>Transient Shock Technology<br>Vehicle Transmission | 4 | Antennas and Microwave Technology<br>Ballistics<br>Communications Anti-Jamming Tech.<br>Detonator Safety and Reliability<br>Electromagnetic Compatibility<br>Electromagnetic Environment Effects<br>Electromechanical Engineering and Control<br>Electronic Information Control<br>Electronic Measurement Technology<br>Explosive Combustion<br>Fire Control Technology<br>Fuze Dynamic Characteristics<br>Gallium Arsenide Microwave and Mil…<br>High-Power Microwave Technology<br>High-Power Semiconductor Lasers<br>Information Systems Engineering<br>Materials Technology in Impact Env.<br>Microsystem Technology<br>Multi-spectral Information Processing<br>Remanufacturing Technology<br>Specialized Integrated Circuits<br>Target and Env. Optical Characteristics<br>Weapons and Equipment Systems Research | 23 | 27 |
| **MARITIME** | Complex Vessel Systems Simulation<br>Electromagnetic Compatibility<br>Hydroacoustic Countermeasure Technology<br>Hydroacoustic Technology<br>Hydrodynamics<br>Marine Corrosion and Protection<br>Military Underwater Intelligent Robotic Tech.<br>Ship Vibrational Noise<br>Sonar Technology<br>Underwater Information and Control<br>Underwater Measurement and Control Technology<br>Vessel Integrated Power Technology | 12 | Airfoil and Blading Aerodynamics<br>Antennas and Microwave Technology<br>Communications Anti-Jamming Tech.<br>Diesel Engine Booster Technology<br>Electronic Information Control<br>Electronic Measurement Technology<br>Equipment Integrated Support Technology<br>Fire Control Technology<br>Fuze Dynamic Characteristics<br>High-Power Microwave Technology<br>Human Factors Engineering<br>Materials Technology in Impact Env.<br>Radio Wave Env. Characteristics…<br>Reliability & Environmental Engineering…<br>Remanufacturing Technology<br>Specialized Integrated Circuits<br>Weapons and Equipment Systems Research | 17 | 29 |
| **NUCLEAR** | Computational Physics<br>Nuclear Data<br>Particle Transport and Enrichment Technology<br>Plasma Physics<br>Shockwave and Blast Physics<br>Strong Radiation<br>Surface Physics and Chemistry | 7 | Lightweight, High-strength Structural…<br>Metrology and Calibration Technology<br>Parallel and Distributed Processing | 3 | 10 |
| **MULTI-DOMAIN** | Antennas and Microwave Technology<br>Ballistics<br>Communications Anti-Jamming Technology<br>Communications Countermeasures Technology<br>Complex Aviation Systems Simulation<br>Detonator Safety and Reliability<br>Electromagnetic Environment Effects<br>Electromagnetic Environment Effects and Electro…<br>Electromechanical Engineering and Control<br>Electronic Information Control<br>Electronic Measurement Technology<br>Equipment Integrated Support Technology<br>Explosive Combustion<br>Fuze Dynamic Characteristics<br>Gallium Arsenide Microwave and Millimeter…<br>High-Power Microwave Technology<br>High-Power Semiconductor Lasers<br>Hypersonic Ramjet Technology<br>Information System Security Technology<br>Information Systems Engineering<br>Infrared and Ultraviolet Technology<br>Lightweight, High-strength Structural Materials<br>Low Interception Probability Signal Detection | 38 | | | 38 |

| | | | | | |
|---|---|---|---|---|---|
| | Materials Technology in Impact Environments<br>Metrology and Calibration Technology<br>Microsystem Technology<br>Military Solid-State Laser Technology<br>Nano- and Microfabrication Technology<br>New Ceramic Fiber and Composite Materials<br>Parallel and Distributed Processing<br>Precision Hot Processing of Metals<br>Radio Wave Environmental Characteristics…<br>Remanufacturing Technology<br>Space Chemical Power Technology<br>Space Flight Intelligent Control Technology<br>Specialized Integrated Circuits<br>Target and Environmental Optical Characteristics<br>Weapons and Equipment Systems Research | | | | |

## List of Labs by Equipment Research

| EQUIPMENT | PRIMARY RESEARCH AREA | # | SECONDARY RESEARCH AREA | # | TOTAL |
|---|---|---|---|---|---|
| **ACQUISITIONS STRATEGY** | Complex Aviation Systems Simulation<br>Complex Land Systems Simulation<br>Complex Vessel Systems Simulation | 3 | Weapons and Equipment Systems Research | 1 | 4 |
| **AIRCRAFT** | Advanced Composite Materials<br>Advanced High-Temperature Structural…<br>Aero-Engine Aerodynamics…<br>Aircraft Control and Integration Tech.<br>Airfoil and Blading Aerodynamics<br>Aviation Engine High-Altitude Sim…<br>Aviation Plasma Dynamics<br>High Energy Beam Processing Tech.<br>Integrated Avionics Technology<br>Super High Temp. Structural Composites | 10 | Complex Aviation Systems Simulation<br>Complex Vessel Systems Simulation<br>Composite Material Tech. in Special Env.<br>Computational Fluid Dynamics<br>Electromagnetic Compatibility<br>Electromagnetic Environment Effects<br>Electromagnetic Env. Effects and Electro…<br>Equipment Integrated Support Technology<br>Fire Control Technology<br>Human Factors Engineering<br>Hypersonic Ramjet Technology<br>Lightweight, High-strength Structural Mat.<br>Metrology and Calibration Technology<br>Multi-spectral Information Processing Tech.<br>New Ceramic Fiber and Composite Materials<br>Reliability & Environmental Engineering…<br>Remanufacturing Technology<br>Weapons and Equipment Systems Research | 18 | 28 |
| **AIR/MISSILE DEFENSE** | | 0 | Aerospace Systems Simulation<br>Complex Aviation Systems Simulation<br>Complex Land Systems Simulation<br>Electronic Information Control<br>Precision Guidance and Automatic Target Rec.<br>Space Flight Intelligent Control Technology<br>Target and Env. Optical Characteristics | 7 | 7 |
| **ARMOR** | | 0 | Complex Land Systems Simulation<br>Materials Technology in Impact Environments<br>Transient Shock Technology | 3 | 3 |
| **ARTILLERY** | | 0 | Complex Land Systems Simulation<br>Target and Env. Optical Characteristics | 2 | 2 |
| **BALLISTIC MISSILES** | Ballistic Missile Penetration Technology | 1 | Aerospace Systems Simulation<br>Complex Land Systems Simulation<br>Electronic Measurement Technology<br>Fuze Dynamic Characteristics<br>Inertial Technology<br>Liquid Rocket Engine Technology<br>Optoelectronic Countermeasures Technology<br>Solid Rocket Engine Combustion…<br>Space Chemical Power Technology<br>Space Flight Intelligent Control Technology<br>Target and Env. Electromagnetic Diffuse…<br>Weapons and Equipment Systems Research | 12 | 13 |
| **C2 SYSTEMS** | Information Systems Engineering<br>Weapons and Equipment Systems Res… | 2 | Microsystem Technology | 1 | 3 |
| **COMMS EQUIPMENT** | Communications Anti-Jamming Tech. | 1 | Communications Countermeasures Tech.<br>Electromagnetic Compatibility<br>Gallium Arsenide Microwave and Mil…<br>Microsystem Technology<br>Radio Wave Env. Char. and Modeling…<br>Sonar Technology<br>Space Microwave Technology<br>Specialized Integrated Circuits<br>Tunable Gas Lasers<br>Underwater Information and Control | 10 | 11 |
| **COMPUTERS** | Electronic Information Equipment…<br>Information System Security Technology<br>Parallel and Distributed Processing | 3 | Complex Vessel Systems Simulation<br>Electromagnetic Compatibility<br>Information Systems Engineering<br>Nano- and Microfabrication Technology<br>Optoelectronic Countermeasures Technology | 5 | 8 |
| **ELECTRONIC WARFARE EQUIPMENT** | Electromagnetic Environment Effects<br>Electromagnetic Env. Eff. and Electro...<br>Electronic Information Control<br>High-Power Microwave Technology | 5 | Aerospace Systems Simulation<br>Communications Countermeasures Tech.<br>Target and Environmental Optical Char.<br>UAV Special Technology | 4 | 9 |

| | | | | | |
|---|---|---|---|---|---|
| | Low Interception Probability Signal Det… | | | | |
| **GROUND VEHICLES** | Diesel Engine Booster Technology<br>Vehicle Transmission | 2 | Complex Land Systems Simulation<br>Electromagnetic Environment Effects<br>Fire Control Technology<br>Remanufacturing Technology | 4 | 6 |
| **HELICOPTERS** | Helicopter Rotor Dynamics<br>Helicopter Transmission Technology | 2 | Advanced Composite Materials<br>Airfoil and Blading Aerodynamics<br>Equipment Integrated Support Technology<br>Fire Control Technology | 4 | 6 |
| **HIGH-ENERGY WEAPONS** | | 0 | Vessel Integrated Power Technology | 1 | 1 |
| **MISSILES (NON-BALLISTIC)** | Precision Guidance and Auto. Target… | 1 | Aerospace Systems Simulation<br>Aircraft Control and Integration Technology<br>Complex Aviation Systems Simulation<br>Electromechanical Engineering and Control<br>Electronic Information Control<br>Explosive Combustion<br>Hydrodynamics<br>Hypersonic Ramjet Technology<br>Inertial Technology<br>Information Systems Engineering<br>Materials Technology in Impact Environments<br>Millimeter Wave Remote Sensing Technology<br>Multi-spectral Information Processing Tech.<br>New Ceramic Fiber and Composite Materials<br>Optoelectronic Countermeasures Technology<br>Space Chemical Power Technology<br>Space Flight Dynamics Technology<br>Space Flight Intelligent Control Technology<br>Super High Temp. Structural Composites<br>Target and Env. Electromagnetic Diffuse… | 20 | 21 |
| **MUNITIONS** | Ballistics<br>Detonator Safety and Reliability<br>Electromechanical Eng. and Control<br>Explosive Combustion<br>Fuze Dynamic Characteristics<br>Materials Technology in Impact Env.<br>Transient Shock Technology | 7 | Electromagnetic Environment Effects<br>Electronic Measurement Technology<br>High-Power Semiconductor Lasers<br>Hydrodynamics<br>Lightweight, High-strength Structural Mat.<br>Shockwave and Blast Physics | 6 | 13 |
| **NUCLEAR WEAPONS & POWER** | Computational Physics<br>Nuclear Data<br>Particle Transport and Enrichment Tech.<br>Plasma Physics<br>Shockwave and Blast Physics<br>Strong Radiation<br>Surface Physics and Chemistry | 7 | Lightweight, High-strength Structural Mat.<br>Metrology and Calibration Technology<br>Parallel and Distributed Processing<br>Super High Temp. Structural Composites | 4 | 11 |
| **RADAR** | Antennas and Microwave Technology<br>High Power Microwave Electronic…<br>Millimeter Wave Remote Sensing Tech.<br>Radar Signal Processing | 4 | Complex Aviation Systems Simulation<br>Electromagnetic Compatibility<br>Electromagnetic Environment Effects<br>Electronic Information Control<br>Electronic Measurement Technology<br>Gallium Arsenide Microwave and Mil…<br>New Ceramic Fiber and Composite Materials<br>Precision Guidance and Automatic Target Rec.<br>Radio Wave Environmental Char…<br>Specialized Integrated Circuits<br>Target and Environmental Optical Char… | 11 | 15 |
| **SEMICONDUC-TORS** | Gallium Arsenide Microwave and Mil…<br>High-Power Semiconductor Lasers<br>Specialized Integrated Circuits | 3 | Military Solid-State Laser Technology<br>Nano- and Microfabrication Technology<br>Optoelectronic Countermeasures Technology<br>Precision Hot Processing of Metals | 4 | 7 |
| **SPACE VEHICLES** | Composite Material Tech. in Special Env.<br>Computational Fluid Dynamics<br>Human Factors Engineering<br>Inertial Technology<br>Liquid Rocket Engine Technology<br>Reliability & Env. Engineering Tech.<br>Solid Rocket Engine Combustion…<br>Space Environmental Materials Behavior...<br>Space Flight Dynamics Technology<br>Space Intelligent Control Technology | 13 | Advanced Composite Materials<br>Aircraft Control and Integration Technology<br>Complex Aviation Systems Simulation<br>Electromagnetic Environment Effects<br>Electronic Information Equipment Systems…<br>Electronic Measurement Technology<br>Explosive Combustion<br>High Energy Beam Processing Technology<br>Hypersonic Ramjet Technology<br>Information Systems Engineering | 22 | 35 |

| | | | | | |
|---|---|---|---|---|---|
| | Space Microwave Technology<br>Tunable Gas Lasers<br>Vacuum Technology and Physics | | Lightweight, High-strength Structural Mat.<br>Metrology and Calibration Technology<br>Military Solid-State Laser Technology<br>Millimeter Wave Remote Sensing Technology<br>Nano- and Microfabrication Technology<br>New Ceramic Fiber and Composite Materials<br>Parallel and Distributed Processing<br>Radio Wave Environmental Characteristics…<br>Space Chemical Power Technology<br>Space Flight Intelligent Control Technology<br>Super High Temp. Structural Composites<br>Underwater Measurement and Control Tech. | | |
| **SURFACE VESSELS** | Marine Corrosion and Protection<br>Vessel Integrated Power Technology | 2 | Complex Vessel Systems Simulation<br>Diesel Engine Booster Technology<br>Electromagnetic Compatibility<br>Fire Control Technology<br>Hydrodynamics<br>Reliability & Environmental Engineering…<br>Ship Vibrational Noise<br>Underwater Measurement and Control Tech.<br>Weapons and Equipment Systems Research | 9 | 11 |
| **UNDERWATER VEHICLES** | Hydroacoustic Countermeasure Tech.<br>Hydroacoustic Technology<br>Military Underwater Intelligent Robotic…<br>Ship Vibrational Noise<br>Sonar Technology<br>Underwater Information and Control<br>Underwater Measurement and Control… | 7 | Airfoil and Blading Aerodynamics<br>Complex Vessel Systems Simulation<br>Equipment Integrated Support Technology<br>Hydrodynamics<br>Multi-spectral Information Processing Tech. | 5 | 12 |
| **UNMANNED SYSTEMS** | UAV Special Technology | 1 | Advanced Composite Materials<br>Aircraft Control and Integration Technology<br>Airfoil and Blading Aerodynamics<br>Aviation Engine High-Altitude Simulation…<br>Ballistics<br>Complex Aviation Systems Simulation<br>Electromagnetic Environment Effects<br>Equipment Integrated Support Technology<br>Fire Control Technology<br>Hydroacoustic Countermeasure Technology<br>Information System Security Technology<br>Information Systems Engineering<br>Integrated Avionics Technology<br>Multi-spectral Information Processing Tech.<br>Space Flight Intelligent Control Technology<br>Underwater Measurement and Control Tech. | 16 | 17 |
| **MULTIPLE** | Aerospace Systems Simulation<br>Communications Countermeasures Tech.<br>Electronic Measurement Technology<br>Equipment Integrated Support Technology<br>Fire Control Technology<br>Hydrodynamics<br>Hypersonic Ramjet Technology<br>Infrared and Ultraviolet Technology<br>Lightweight, High-strength Structural Mat.<br>Metrology and Calibration Technology<br>Microsystem Technology<br>Military Solid-State Laser Technology<br>Multi-spectral Information Processing…<br>Nano- and Microfabrication Technology<br>New Ceramic Fiber and Composite Mat.<br>Optoelectronic Countermeasures Tech.<br>Precision Hot Processing of Metals<br>Radio Wave Environmental Char…<br>Remanufacturing Technology<br>Space Chemical Power Technology<br>Space Flight Intelligent Control Tech.<br>Target and Env. Electromagnetic Diffuse...<br>Target and Environmental Optical Char. | 23 | | | 23 |

## List of Labs by Functional Research

| RESEARCH | PRIMARY RESEARCH AREA | # | SECONDARY RESEARCH AREA | # | TOTAL |
|---|---|---|---|---|---|
| **ACOUSTICS** | Hydroacoustic Countermeasure Technology<br>Hydroacoustic Technology<br>Ship Vibrational Noise<br>Sonar Technology | 4 | Equipment Integrated Support Technology<br>Military Underwater Intelligent Robotic…<br>Underwater Measurement and Control Tech. | 3 | 7 |
| **AERO-DYNAMICS** | Airfoil and Blading Aerodynamics<br>Aviation Plasma Dynamics<br>Ballistics<br>Computational Fluid Dynamics<br>Helicopter Rotor Dynamics<br>Hypersonic Ramjet Technology | 6 | Aero-Engine Aerodynamics and Thermo… | 1 | 7 |
| **AVIONICS** | Integrated Avionics Technology | 1 | | 0 | |
| **BLAST, IMPACT & DAMAGE** | Shockwave and Blast Physics<br>Transient Shock Technology | 2 | Ballistics<br>Detonator Safety and Reliability<br>Explosive Combustion<br>Fuze Dynamic Characteristics<br>Materials Technology in Impact Env.<br>Space Chemical Power Technology<br>Space Environmental Materials Behavior… | 7 | 9 |
| **COMMS TECHNOLOGIES** | Communications Anti-Jamming Tech.<br>Communications Countermeasures Tech.<br>Electronic Information Equipment…<br>Information Systems Engineering<br>Low Interception Probability Signal…<br>Tunable Gas Lasers | 6 | Electromagnetic Compatibility<br>Electromagnetic Env. Effects and Electro…<br>Hydroacoustic Technology<br>Information System Security Technology<br>Microsystem Technology<br>Radio Wave Env. Characteristics…<br>Sonar Technology<br>Space Environmental Materials Behavior…<br>Space Microwave Technology<br>Specialized Integrated Circuits<br>Underwater Information and Control | 11 | 17 |
| **COUNTER-MEASURES** | Ballistic Missile Penetration Technology | 1 | Aerospace Systems Simulation<br>Communications Countermeasures Tech.<br>Complex Aviation Systems Simulation<br>Electronic Information Control<br>Fire Control Technology<br>Optoelectronic Countermeasures Technology<br>Space Microwave Technology<br>Target and Env. Electromagnetic Diffuse… | 8 | 9 |
| **CYBER TECHNOLOGIES** | Information System Security Technology | 1 | Complex Vessel Systems Simulation<br>Electronic Information Equipment…<br>Information Systems Engineering<br>Low Interception Probability Signal… | 4 | 5 |
| **ELECTRICAL POWER** | Vessel Integrated Power Technology | 1 | Advanced High-Temp. Structural Materials<br>Vacuum Technology and Physics | 2 | 3 |
| **ELECTRO-MAGNETICS** | Electromagnetic Compatibility<br>Electromagnetic Environment Effects<br>Electromagnetic Env. Effects and Electro…<br>Electronic Measurement Technology<br>High Power Microwave Electronic…<br>High-Power Microwave Technology<br>Infrared and Ultraviolet Technology<br>Radio Wave Env. Characteristics…<br>Space Microwave Technology | 9 | Antennas and Microwave Technology<br>Electronic Information Control | 2 | 11 |
| **FIRE CONTROL** | Fire Control Technology | 1 | Antennas and Microwave Technology | 1 | 2 |
| **GUIDANCE, NAVIGATION & CONTROL (GNC)** | Aircraft Control and Integration Tech.<br>Inertial Technology<br>Space Flight Dynamics Technology<br>Space Flight Intelligent Control Technology<br>Space Intelligent Control Technology<br>Underwater Information and Control | 6 | Aerospace Systems Simulation<br>Ballistics<br>Helicopter Rotor Dynamics<br>High-Power Semiconductor Lasers<br>Hydroacoustic Technology<br>Integrated Avionics Technology<br>Metrology and Calibration Technology<br>Military Underwater Intelligent Robotic…<br>Multi-spectral Information Processing Tech.<br>Precision Guidance and Automatic Target…<br>Radio Wave Env. Characteristics…<br>Sonar Technology<br>Target and Env. Optical Characteristics | 15 | 21 |

| | | | | | |
|---|---|---|---|---|---|
| | | | UAV Special Technology<br>Underwater Measurement and Control Tech. | | |
| **HYPERSONIC TECHNOLOGIES** | Hypersonic Ramjet Technology | 1 | Aero-Engine Aerodynamics…<br>Aircraft Control and Integration Technology<br>Aviation Engine High-Altitude Simulation…<br>Complex Aviation Systems Simulation<br>Computational Fluid Dynamics<br>Explosive Combustion<br>New Ceramic Fiber and Composite Materials<br>Space Flight Dynamics Technology<br>Space Flight Intelligent Control Technology<br>Super High Temp Structural Composites | 10 | 11 |
| **IMAGING** | | 0 | Multi-spectral Information Processing Tech.<br>Radar Signal Processing | 2 | 2 |
| **INFORMATION & SIGNAL PROCESSING** | Radar Signal Processing | 1 | Communications Anti-Jamming Technology<br>Information Systems Engineering<br>Multi-spectral Information Processing Tech.<br>Precision Guidance and Automatic Target…<br>Sonar Technology<br>Underwater Information and Control | 6 | 7 |
| **INTELLIGENT TECHNOLOGIES** | | 0 | Aerospace Systems Simulation<br>Aircraft Control and Integration Technology<br>Aviation Engine High-Altitude Simulation…<br>Communications Anti-Jamming Technology<br>Communications Countermeasures Tech.<br>Complex Aviation Systems Simulation<br>Composite Material Technology in Special…<br>Computational Physics<br>Electronic Information Control<br>Electronic Information Equipment Systems...<br>Equipment Integrated Support Technology<br>Information System Security Technology<br>Information Systems Engineering<br>Integrated Avionics Technology<br>Microsystem Technology<br>Military Underwater Intelligent Robotic…<br>Millimeter Wave Remote Sensing Tech.<br>Multi-spectral Information Processing Tech.<br>Precision Guidance and Automatic Target…<br>Precision Hot Processing of Metals<br>Radar Signal Processing<br>Space Flight Intelligent Control Technology<br>Space Intelligent Control Technology<br>Weapons and Equipment Systems Research | 24 | 24 |
| **LASER TECHNOLOGIES** | Military Solid-State Laser Technology<br>Particle Transport and Enrichment Tech. | 2 | High Energy Beam Processing Technology<br>High-Power Semiconductor Lasers<br>Materials Technology in Impact Env.<br>Multi-spectral Information Processing Tech.<br>Optoelectronic Countermeasures Technology<br>Plasma Physics<br>Shockwave and Blast Physics<br>Strong Radiation<br>Target and Env. Optical Characteristics<br>Tunable Gas Lasers | 10 | 12 |
| **LOGISTICS & MAINTENANCE** | | 0 | Equipment Integrated Support Technology<br>Weapons and Equipment Systems Research | 2 | 2 |
| **MANNED SPACEFLIGHT** | Human Factors Engineering | 1 | Space Flight Dynamics Technology | 1 | 2 |
| **MANUFACT-URING** | High Energy Beam Processing Technology<br>Remanufacturing Technology | 2 | Aerospace Systems Simulation<br>Composite Material Technology… | 2 | 4 |
| **MATERIALS** | Advanced Composite Materials<br>Advanced High-Temp. Structural Materials<br>Composite Material Technology…<br>Lightweight, High-strength Structural Mat.<br>Marine Corrosion and Protection<br>Materials Technology in Impact Env.<br>New Ceramic Fiber and Composite Mat.<br>Precision Hot Processing of Metals<br>Space Environmental Materials Behavior… | 11 | Computational Physics<br>Equipment Integrated Support Technology<br>Helicopter Rotor Dynamics<br>High Energy Beam Processing Technology<br>High-Power Semiconductor Lasers<br>Hypersonic Ramjet Technology<br>Nano- and Microfabrication Technology<br>Shockwave and Blast Physics<br>Specialized Integrated Circuits | 10 | 21 |

| | | | | | |
|---|---|---|---|---|---|
| | Super High Temp. Structural Composites<br>Surface Physics and Chemistry | | Vacuum Technology and Physics | | |
| **MEASUREMENT TECHNOLOGIES** | Metrology and Calibration Technology<br>Nuclear Data | 2 | Electromagnetic Compatibility<br>Space Flight Intelligent Control Technology<br>Space Microwave Technology<br>Tunable Gas Lasers | 4 | 6 |
| **MICRO-ELECTRONICS** | Microsystem Technology<br>Nano- and Microfabrication Technology | 2 | Electronic Measurement Technology | 1 | 3 |
| **MICROWAVE TECHNOLOGIES** | Antennas and Microwave Technology | 1 | Aerospace Systems Simulation<br>Electromagnetic Compatibility<br>Electronic Measurement Technology<br>Gallium Arsenide Microwave and Mil…<br>High Power Microwave Electronic Vac...<br>Precision Guidance and Automatic Target…<br>Space Microwave Technology<br>Strong Radiation | 8 | 9 |
| **MILLIMETER WAVE TECHNOLOGIES** | | 0 | Aerospace Systems Simulation<br>Electronic Information Control<br>Electronic Measurement Technology<br>Gallium Arsenide Microwave and Mil…<br>High Power Microwave Electronic Vac…<br>Infrared and Ultraviolet Technology<br>Millimeter Wave Remote Sensing Tech.<br>Precision Guidance and Automatic Target… | 8 | 8 |
| **MUNITIONS TECHNOLOGIES** | Detonator Safety and Reliability<br>Electromechanical Engineering and Control<br>Fuze Dynamic Characteristics | 3 | Electromagnetic Environment Effects<br>Explosive Combustion<br>Shockwave and Blast Physics<br>Transient Shock Technology | 4 | 7 |
| **OPTO-ELECTRONICS** | Optoelectronic Countermeasures Tech.<br>Target and Env. Optical Characteristics | 2 | Electromagnetic Env. Effects and Electro…<br>High-Power Semiconductor Lasers<br>Microsystem Technology<br>Military Solid-State Laser Technology<br>Space Env. Materials Behavior and Eval…<br>Tunable Gas Lasers | 6 | 8 |
| **PLASMA TECHNOLOGIES** | Plasma Physics | 1 | Aviation Plasma Dynamics<br>Ballistics<br>High Energy Beam Processing Technology | 3 | 4 |
| **PROPULSION** | Aero-Engine Aerodynamics…<br>Aviation Engine High-Altitude Sim...<br>Aviation Plasma Dynamics<br>Explosive Combustion<br>Liquid Rocket Engine Technology<br>Solid Rocket Engine Combustion… | 6 | Advanced High-Temp. Structural Materials<br>Equipment Integrated Support Technology<br>High Energy Beam Processing Technology<br>Hypersonic Ramjet Technology<br>New Ceramic Fiber and Composite Materials<br>Space Chemical Power Technology<br>Super High Temp. Structural Composites<br>UAV Special Technology<br>Vacuum Technology and Physics<br>Vessel Integrated Power Technology | 10 | 16 |
| **RELIABILITY & ENV. ENG.** | Equipment Integrated Support Technology<br>Reliability & Environmental Engineering…<br>Vacuum Technology and Physics | 3 | Human Factors Engineering<br>Shockwave and Blast Physics<br>Space Environmental Materials Behavior… | 3 | 6 |
| **ROBOTICS** | | 0 | Communications Anti-Jamming Technology<br>Equipment Integrated Support Technology<br>Helicopter Rotor Dynamics<br>Military Underwater Intelligent Robotic…<br>Nano- and Microfabrication Technology | 5 | 5 |
| **SENSING** | Millimeter Wave Remote Sensing Tech. | 1 | Aircraft Control and Integration Technology<br>Electronic Measurement Technology<br>Hydroacoustic Technology<br>Information Systems Engineering<br>Infrared and Ultraviolet Technology<br>Microsystem Technology<br>Military Underwater Intelligent Robotic…<br>Multi-spectral Information Processing Tech.<br>Nano- and Microfabrication Technology<br>Optoelectronic Countermeasures Technology<br>Precision Guidance and Automatic Target…<br>Space Microwave Technology<br>Target and Env. Electromagnetic Diffuse…<br>Target and Env. Optical Characteristics<br>Tunable Gas Lasers | 16 | 17 |

| | | | | | |
|---|---|---|---|---|---|
| | | | Underwater Measurement and Control Tech. | | |
| **SHIP DESIGN** | Hydrodynamics | 1 | Electronic Measurement Technology<br>Marine Corrosion and Protection | 2 | 3 |
| **SIMULATION & MODELING** | Aerospace Systems Simulation<br>Complex Land Systems Simulation<br>Complex Vessel Systems Simulation<br>Computational Physics<br>Parallel and Distributed Processing<br>Weapons and Equipment Systems Research | 6 | Aviation Engine High-Altitude Simulation…<br>Ballistics<br>Complex Aviation Systems Simulation<br>Composite Material Technology…<br>Computational Fluid Dynamics<br>Electromagnetic Environment Effects<br>Electromechanical Engineering and Control<br>Electronic Information Control<br>Fire Control Technology<br>Materials Technology in Impact Env.<br>Nuclear Data<br>Optoelectronic Countermeasures Technology<br>Radar Signal Processing<br>Radio Wave Env. Characteristics…<br>Reliability & Environmental Engineering…<br>Shockwave and Blast Physics<br>Space Env. Materials Behavior and Eval…<br>UAV Special Technology | 18 | 24 |
| **STEALTH TECHNOLOGIES** | | 0 | Advanced Composite Materials<br>Antennas and Microwave Technology<br>Airfoil and Blading Dynamics<br>Aviation Engine High-Altitude Simulation…<br>Aviation Plasma Dynamics<br>Electronic Information Control<br>New Ceramic Fiber and Composite Materials<br>Target and Env. Optical Characteristics<br>UAV Special Technology | 9 | 9 |
| **TARGET DETECTION & RECOGNITION** | Precision Guidance and Automatic Target... | 1 | Fire Control Technology<br>Hydroacoustic Technology<br>Information Systems Engineering<br>Microsystem Technology<br>Military Underwater Intelligent Robotic…<br>Millimeter Wave Remote Sensing Tech.<br>Multi-spectral Information Processing Tech.<br>Optoelectronic Countermeasures Technology<br>Radar Signal Processing<br>Sonar Technology<br>Target and Env. Optical Characteristics<br>Underwater Measurement and Control Tech. | 13 | 14 |
| **TERAHERTZ TECHNOLOGIES** | | 0 | Communications Anti-Jamming Technology<br>Electromagnetic Env. Effects…<br>Electronic Measurement Technology<br>High Power Microwave Electronic Vac...<br>Infrared and Ultraviolet Technology<br>Precision Guidance and Automatic Target…<br>Space Microwave Technology<br>Specialized Integrated Circuits<br>Strong Radiation<br>Tunable Gas Lasers | 10 | 10 |
| **VEHICLE PARTS & TECH** | Diesel Engine Booster Technology<br>Helicopter Transmission Technology<br>Vehicle Transmission | 3 | Remanufacturing Technology | 1 | 4 |
| **MULTIPLE** | Aviation Plasma Dynamics<br>Complex Aviation Systems Simulation<br>Electronic Information Control<br>Gallium Arsenide Microwave and Mil…<br>High-Power Semiconductor Lasers<br>Military Underwater Intelligent Robotic…<br>Multi-spectral Information Processing Tech.<br>Specialized Integrated Circuits<br>Strong Radiation<br>Target and Env. Electromagnetic Diffuse…<br>UAV Special Technology<br>Underwater Measurement and Control… | 12 | | | 12 |

## List of Labs with New Names Under Reorganization

| DSTKL | NEW NAME |
|---|---|
| Defense S&T Key Lab of Advances Composite Materials | None |
| Defense S&T Key Lab of Advanced High-Temperature Structural Materials | None |
| Defense S&T Key Lab of Aero-Engine Aerodynamics and Thermodynamics | None |
| Defense S&T Key Lab of Aerospace Systems Simulation | None |
| Defense S&T Key Lab of Aircraft Control and Integration Tech | National Key Lab of Aircraft Control and Integration Tech* |
| Defense S&T Key Lab of Airfoil and Blading Aerodynamics | National Key Lab of Aircraft Configuration Design |
| Defense S&T Key Lab of Antennas and Microwave Tech | National Key Lab of Radar Detection and Perception* |
| Defense S&T Key Lab of Aviation Engine High-Altitude Simulation Tech | None |
| Defense S&T Key Lab of Aviation Plasma Dynamics | None |
| Defense S&T Key Lab of Ballistic Missile Penetration Tech | None |
| Defense S&T Key Lab of Ballistics | National Key Lab of Transient Physics* |
| Defense S&T Key Lab of Communications Anti-Jamming Tech | National Key Lab of Wireless Communications |
| Defense S&T Key Lab of Communications Countermeasures Tech | National Key Lab of Electromagnetic Space Security |
| Defense S&T Key Lab of Complex Aviation Systems Simulation | National Key Lab of Complex Aviation Systems Simulation*^ |
| Defense S&T Key Lab of Complex Land Systems Simulation | None |
| Defense S&T Key Lab of Complex Vessel Systems Simulation | None |
| Defense S&T Key Lab of Composite Material Tech in Special Environments | None |
| Defense S&T Key Lab of Computational Fluid Dynamics | None |
| Defense S&T Key Lab of Computational Physics | National Key Lab of Computational Physics* |
| Defense S&T Key Lab of Diesel Engine Booster Tech | None |
| Defense S&T Key Lab of Detonator Safety and Reliability | None |
| Defense S&T Key Lab of Electromagnetic Compatibility | National Key Lab of Maritime Equipment Electromagnetic Effects and Security*^ |
| Defense S&T Key Lab of Electromagnetic Environment Effects | None |
| Defense S&T Key Lab of Electromagnetic Environment Effects and Electro-Optical Engineering | None |
| Defense S&T Key Lab of Electromechanical Engineering and Control | None |
| Defense S&T Key Lab of Electronic Information Control | None |
| Defense S&T Key Lab of Electronic Information Equipment Systems Research | None |
| Defense S&T Key Lab of Electronic Measurement Tech | National Key Lab of Electronic Testing Tech* |
| Defense S&T Key Lab of Equipment Integrated Support Tech | National Key Lab of Equipment Condition Sensing and Rapid Support*^ |
| Defense S&T Key Lab of Explosive Combustion | National Key Lab of Energetic Materials*^ |
| Defense S&T Key Lab of Fire Control Tech | None |
| Defense S&T Key Lab of Fuze Dynamic Characteristics | None |
| Defense S&T Key Lab of Gallium Arsenide Microwave and Millimeter Wave Monolithic and Modular Circuitry | National Key Lab of Solid State Microwave Devices and Circuits*^ |
| Defense S&T Key Lab of Helicopter Rotor Dynamics | National Key Lab of Helicopter Dynamics* |
| Defense S&T Key Lab of Helicopter Transmission Tech | None |
| Defense S&T Key Lab of High-Energy Beam Processing Tech | None |
| Defense S&T Key Lab of High-Power Microwave Electronic Vacuum Component Tech | National Key Lab of Microwave Electronic Vacuum Components*^ |
| Defense S&T Key Lab of High-Power Microwave Tech | None |
| Defense S&T Key Lab of High-Power Semiconductor Lasers | None |
| Defense S&T Key Lab of Human Factors Engineering | National Key Lab of Human Factors Engineering* |
| Defense S&T Key Lab of Hydroacoustic Countermeasure Tech | National Key Lab of Underwater Acoustic Antagonizing*^ |
| Defense S&T Key Lab of Hydroacoustic Tech | National Key Lab of Hydroacoustic Tech* |
| Defense S&T Key Lab of Hydrodynamics | National Key Lab of Hydrodynamics* |
| Defense S&T Key Lab of Hypersonic Ramjet Tech | None |
| Defense S&T Key Lab of Inertial Tech | None |
| Defense S&T Key Lab of Information System Security Tech | None |
| Defense S&T Key Lab of Information Systems Engineering | National Key Lab of Information Systems Engineering* |
| Defense S&T Key Lab of Infrared and Ultraviolet Tech | National Key Lab of Infrared Sensing* |
| Defense S&T Key Lab of Integrated Avionics Tech | National Key Lab of Integrated Avionics and Systems Integration*^ |
| Defense S&T Key Lab of Lightweight, High-strength Structural Materials | None |
| Defense S&T Key Lab of Liquid Rocket Engine Tech | National Key Lab of Aerospace Liquid Propulsion* |
| Defense S&T Key Lab of Low Interception Probability Signal Detection | None |
| Defense S&T Key Lab of Marine Corrosion and Protection | National Key Lab of Marine Corrosion and Protection* |
| Defense S&T Key Lab of Materials Tech in Impact Environments | None |
| Defense S&T Key Lab of Metrology and Calibration Tech | None |
| Defense S&T Key Lab of Microsystem Tech | None |
| Defense S&T Key Lab of Military Solid-State Laser Tech | None |
| Defense S&T Key Lab of Military Underwater Intelligent Robotic Tech | National Key Lab of Intelligent Marine Vehicle Tech* |

| | |
|---|---|
| Defense S&T Key Lab of Millimeter-Wave Remote Sensing Tech | None |
| Defense S&T Key Lab of Multi-Spectral Information Processing Tech | National Key Lab of Multispectral Information Intelligent Processing Tech* |
| Defense S&T Key Lab of Nano- and Microfabrication Tech | National Key Lab of Advanced Micro and Nano Manufacture Tech |
| Defense S&T Key Lab of New Ceramic Fiber and Composite Materials | None |
| Defense S&T Key Lab of Nuclear Data | None |
| Defense S&T Key Lab of Optoelectronic Countermeasures Tech | None |
| Defense S&T Key Lab of Parallel and Distributed Processing | None |
| Defense S&T Key Lab of Particle Transport and Enrichment Tech | National Key Lab of Particle Transport and Enrichment Tech* |
| Defense S&T Key Lab of Plasma Physics | National Key Lab of Plasma Physics*^ |
| Defense S&T Key Lab of Precision Guidance and Automatic Target Recognition | National Key Lab of Automatic Target Recognition (ATR) |
| Defense S&T Key Lab of Precision Hot Processing of Metals | None |
| Defense S&T Key Lab of Radar Signal Processing | National Key Lab of Radar Signal Processing |
| Defense S&T Key Lab of Radio Wave Environmental Characteristics and Modeling Tech | None |
| Defense S&T Key Lab of Reliability and Environmental Engineering Tech | National Key Lab of Reliability and Environmental Engineering Tech |
| Defense S&T Key Lab of Remanufacturing Tech | None |
| Defense S&T Key Lab of Ship Vibrational Noise | None |
| Defense S&T Key Lab of Shockwave and Blast Physics | National Key Lab of Shockwave and Blast Physics* |
| Defense S&T Key Lab of Solid Rocket Engine Combustion, Thermal Structure, and Inner Flow Field | National Key Lab of Solid Propulsion* |
| Defense S&T Key Lab of Sonar Tech | None |
| Defense S&T Key Lab of Space Chemical Power Tech | None |
| Defense S&T Key Lab of Space Environmental Materials Behavior and Evaluation Tech | National Key Lab of Space Environment and Material Effects* |
| Defense S&T Key Lab of Space Flight Dynamics Tech | None |
| Defense S&T Key Lab of Space Flight Intelligent Control Tech | National Key Lab of Space Flight Intelligent Control Tech* |
| Defense S&T Key Lab of Space Intelligent Control Tech | National Key Lab of Space Intelligent Control Tech* |
| Defense S&T Key Lab of Space Microwave Tech | National Key Lab of Microwave Communications* |
| Defense S&T Key Lab of Specialized Integrated Circuits | National Key Lab of Solid State Microwave Devices and Circuits* |
| Defense S&T Key Lab of Strong Radiation | None |
| Defense S&T Key Lab of Super High-Temperature Structural Composites | None |
| Defense S&T Key Lab of Surface Physics and Chemistry | None |
| Defense S&T Key Lab of Target and Environmental Electromagnetic Diffuse Radiation Characteristics | None |
| Defense S&T Key Lab of Target and Environmental Optical Characteristics | None |
| Defense S&T Key Lab of Transient Shock Tech | National Key Lab of Transient Shock* |
| Defense S&T Key Lab of Tunable Gas Lasers | None |
| Defense S&T Key Lab of UAV Special Tech | National Key Lab of Unmanned Flight Vehicle Tech* |
| Defense S&T Key Lab of Underwater Information and Control | National Key Lab of Underwater Information and Control* |
| Defense S&T Key Lab of Underwater Measurement and Control Tech | None |
| Defense S&T Key Lab of Vacuum Tech and Physics | None |
| Defense S&T Key Lab of Vehicle Transmission | None |
| Defense S&T Key Lab of Vessel Integrated Power Tech | National Key Lab of Electromagnetic Energy |
| Defense S&T Key Lab of Weapons and Equipment Systems Research | None |

*Literal Translation, official English name unknown
^Unconfirmed

**Abbreviations**

| | |
|---|---|
| AECC | Aero Engine Corporation of China |
| AUV | Autonomous Underwater Vehicle |
| AVIC | Aviation Industry Corporation of China |
| BACC | Beijing Aerospace Control Center (PLASSF) |
| BAMTRI | Beijing Aeronautical Manufacturing Technology Research Institute (AVIC) |
| BIAM | Beijing Institute of Aeronautical Materials (AECC) |
| BIRM | Beijing Institute of Radio Metrology and Measurement (CASIC) |
| BISEE | Beijing Institute of Spacecraft Environment Engineering (CASC) |
| BIT | Beijing Institute of Technology |
| BPEI | Beijing Precision Engineering Institute for Aircraft Industry (AVIC) |
| CAE | Chinese Academy of Engineering |
| CAEP | China Academy of Engineering Physics |
| CALT | China Academy of Launch Vehicle Technology |
| CARDC | China Aerodynamics Research and Development Center (PLA AMS) |
| CAS | Chinese Academy of Sciences |
| CASC | China Aerospace Science and Technology Corporation |
| CASIC | China Aerospace Science and Industry Corporation |
| CAST | China Academy of Space Technology (CASC) |
| CETC | China Electronics Technology Group Corporation |
| CHRDI | China Helicopter Research and Development Institute (AVIC) |
| CIAE | China Institute of Atomic Energy (CNNC) |
| CIMM | Changcheng Institute of Metrology & Measurement (AVIC) |
| CMC | Central Military Commission |
| CNNC | China National Nuclear Corporation |
| COSTIND | Commission for Science, Technology and Industry for National Defense |
| CRIRP | China Research Institute of Radio Wave Propagation (CETC) |
| CSSC | China State Shipbuilding Corporation |
| CSU | Central South University |
| CUST | Changchun University of Science and Technology |
| DSTKL | Defense S&T Key Laboratory |
| EMC | Electromagnetic Compatibility |
| EMP | Electromagnetic Pulse |
| EW | Electronic Warfare |
| FACRI | Xi'an Flight Automatic Control Research Institute (AVIC) |
| GAD | PLA General Armaments Department |
| GNC | Guidance, Navigation, and Control |
| GSD | PLA General Staff Department |
| HEU | Harbin Engineering University |
| HIT | Harbin Institute of Technology |
| HUST | Huazhong University of Science and Technology |
| IFV | Infantry Fighting Vehicle |
| ISR | Intelligence, Surveillance, and Reconnaissance |

| | |
|---|---|
| LSMRI | Luoyang Ship Material Research Institute (CSSC) |
| MCF | Military-civil Fusion |
| MCRI | Xi'an Modern Chemistry Research Institute (Norinco) |
| MIIT | Ministry of Industry and Information Technology |
| MOST | Ministry of Science and Technology |
| MRAP | Mine-Resistant Ambush Protected Vehicle |
| MTI | Manufacturing Technology Institute (AVIC) |
| NEU | PLA Naval Engineering University |
| NJUST | Nanjing University of Science and Technology |
| NSFC | National Natural Science Foundation of China |
| Norinco | China Ordnance Industries Group Corporation |
| NUAA | Nanjing University of Aeronautics and Astronautics |
| NUC | North University of China |
| NUDT | National University of Defense Technology |
| NWPU | Northwestern Polytechnical University |
| PLA | People's Liberation Army |
| PLAA | PLA Army |
| PLAAF | PLA Air Force |
| PLAN | PLA Navy |
| PLARF | PLA Rocket Force |
| PLASSF | PLA Strategic Support Force |
| RI | Research Institute |
| SASTIND | State Administration of Science, Technology and Industry for National Defense |
| SEEE | School of Electrical and Electronic Engineering (HUST) |
| SLBM | Sea-launched ballistic missile |
| SWIEE | Southwest Institute of Electronic Equipment (CETC) |
| SOE | State-owned Enterprise |
| TT&C | Telemetry, Tracking, and Command/Control |
| UAV | Unmanned Aerial Vehicle |
| UESTC | University of Electronic Science and Technology of China |
| UUV | Unmanned Underwater Vehicle |

## 1. Defense S&T Key Laboratory of Advanced Composite Materials

**Official English Name:** National Key Laboratory of Advanced Composites (LAC)

**Chinese Name:** 先进复合材料国防科技重点实验室

**Post-2024 Name**: No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Air
- *Secondary: Space*

Equipment:

- Aircraft
- *Secondary: Helicopters, Space Vehicles, Unmanned Systems*

Functional Field:

- Materials
- *Secondary: Stealth Technologies*

**Affiliations:**

- Aero Engine Corporation of China (AECC) [中国航空发动机集团][xx]
    - Beijing Institute of Aeronautical Materials (BIAM) [北京航空材料研究院]
        - *a.k.a. AECC 621st Research Institute [621 研究所]*

**Key Data:**

- Established: 1994
- Total Funding: Unknown
- Personnel: Unknown[31]
- Official start of operations: 1996
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research into resin, ceramic matrix, and metal matrix composite materials to create aerospace materials with improved performance, including reduced weight and superior

[xx] BIAM appears to have been transferred in recent years from AVIC to AECC. Most online sources still associate it with AVIC, but its official website and more recent sources state AECC.

toughness, durability, and heat resistance.[32] The lab officially began operations in 1996, and was expanded (via approval of COSTIND), possibly to its current Defense S&T Key Lab status, in 2004.[33]

The lab's parent institution, the Beijing Institute of Aeronautical Materials (a.k.a. the 621st RI), was established in 1956 as the PRC's first institution devoted to high-temp structural materials. Its advanced materials are utilized in the engines and other parts of aircraft and helicopters.[34] It was added to the U.S. Commerce Department Entity List for export control in December 2020.[35]

**Further Information:**

- This lab released a book in 2006 about its achievements for the first ten years written by (former?) director Yi Xiaosu, *Advanced Composite Materials Technology, Research, and Development* [先进复合材料技术研究与发展]. Yi Xiaosu also wrote a large two-volume set of books in English on composite materials engineering.[36]
- The BIAM website speaks of a similarly named S&T Key Lab of Advanced Composite Materials [先进复合材料科技重点实验室] (without the word "Defense") which is presumed to be the same lab. If so, it may go by the internal name of "28th Research Office" [第二十八研究室].[37]

**Research Direction:**

1. Resin matrix composites [树脂基复合材料]
2. Ceramic matrix composites [陶瓷基复合材料]
3. Metal matrix composites [金属基复合材料][38]

*Other Notable Research Areas:*

- High temperature structural ceramic matrix composites
- Nanoceramic composites
- Laminated ceramic composites
- Self-toughened Si3N4 ceramics
- Continuous fiber reinforced ceramic matrix composites
- Ceramic composite powder preparation technology
- Ceramic parts net proximity molding technology
- Ceramic substrate preparation technology
- Functional and smart materials
- Positive temperature coefficient (PTC) ceramic materials
- Piezoelectric ceramics and smart structures
- Advanced thermosetting and thermoplastic resin systems and composites
- Advanced composite liquid molding technologies
- Non-hot press tank molding technologies
- Structural/functional integrated composites

- Composite material automation technology
- High-performance continuous fibers and their composites
- Structurally/functionally integrated aluminum matrix composites
- Particle-reinforced aluminum matrix composites prepared by stirring method and its precision casting process technology
- Synthesis methods of functional composite ceramic powders
- Self-toughened silicon nitride high-temperature structural ceramic materials
- Broadband wave-transparent ceramic radome materials
- Precision molding technology for gel injection molding of ceramic parts
- Extrusion molding and preparation technology of multi-purpose thin-walled honeycomb ceramics
- Material physical and chemical properties characterization
- Theoretical and experimental analysis of material microstructure, properties and failure
- Liquid forming processes numerical simulation and online testing[39]

**Notable Applications:**

- This lab's composites have been used in PRC advanced fighter aircraft, large transport aircraft, helicopters, new UAVs, and early warning aircraft. It has developed aerospace composites for aircraft primary structures, control rudders, propellers, engines, and S-shaped inlets for UAVs.[40] [xxi]
- This lab has developed resin matrix composites with good radar absorption properties for use on stealth aircraft.[41]
- This lab may have produced the return capsule hatch door for the Shenzhou manned spacecraft.[42]
- Yi Xiaosu has worked to create ESTM fabric, an advanced aerospace fabric which dramatically improves damage tolerance of liquid-formed composites. The U.S. equivalent, an epoxy resin called RTM6, is embargoed to China, forcing China to develop an indigenous equivalent.[43]
- Yi Xiaosu developed a new reinforced fabric based on inter-layering structuring [层间结构化] which was applied to the KJ-2000 early warning aircraft and reduced fatigue on parts. The U.K.'s University of Manchester was also involved in testing.[44]
- Lab Director Chen Xiangbao announced in 2017 that the J-20 fighter would soon have an indigenous engine, implying this lab is involved somehow in the J-20 engine project. However, it is possible Chen is simply making the announcement on behalf of AECC or BIAM as a senior executive, rather than as a representative of this lab.[45]
- Composites developed by this lab were allegedly used in the indigenous C919 large passenger aircraft, including design and manufacturing techniques of tougher, more damage tolerant materials, including epoxy resins, bismaleimide, polyphenylbenzoxazine

[xxi] Further information about specific materials is available upon request.

and polyimide resin-based aerospace composites. These have been marketed to international buyers as well.[46]

- Yi Xiaosu led a team to develop highly conductive composite materials for aircraft. One advantage of these materials is resilience to lightning strikes. The materials have been used on civilian aircraft such as the AG300, AG600, SR2X, and SF50.[47]

**Leadership and Key Personnel:**

- Director: Either Chen Xiangbao [陈祥宝] or Yi Xiaosu [益小苏][48]
    - Both individuals have been described as the lab's Director.
    - Chen Xiangbao is a CAE Academician, BIAM Deputy Director, and Director of the PLA Equipment Development Department Advanced Materials Technology experts group [先进材料技术专业组]. Chen's advances have been utilized in PRC UAVs, fighters, and transport aircraft, including high temperature resistant and high toughness composite materials, low temperature curing high performance composite materials, structural absorbing integrated composite materials, composite materials manufacturing process simulation optimization, automatic lay-up technology, and improved resin matrix composite materials.
    - Yi Xiaosu did his graduate work in Germany. His focus is on high-performance structural composite materials, functional composite materials, materials process and engineering, and polymeric materials.
- Deputy Director: Bao Jianwen [包建文][49]

**Notable Collaborations:**

*Domestic*

- This lab is associated with the Composite Materials and Applications Lab [复合材料及应用研究室] at BIAM, which is involved in wide-scale production of civilian products such as parts for X-ray machines, blood vessel machines, and CT equipment.[50]
- This lab has done work with Shanghai Jiao Tong University on green composites and recycling of composite materials.[51]

*International*

- Parent institution BIAM claims to have extensive international relationships, including with U.S. company Kirkhill-TA, Airbus (France/Germany), SECMA (France), and SELL (Germany). It is unclear to what extent BIAM's 2020 addition to the Entity List for export control will affect its international relationships.[52]
- Yi Xiaosu's team signed a research agreement with Airbus in 2017 to develop composite materials with good conductivity.[53]

- A new reinforced fabric based on inter-layering structuring [层间结构化], which was later applied to the PLA's KJ-2000 early warning aircraft, was tested by the University of Manchester in the U.K.[54]
- This lab participated in a Super-Light Composite Material Wing/Bridge [超轻复合材料机翼/桥梁] competition in 2009, which was sponsored by U.S. company Boeing.[55]
- Yi Xiaosu was also Director of the Asia-Australia Composites Council.[56]
- Yi Xiaosu took part in a 2018 Sino-German High-end Manufacturing Summit [2018 中德高端制造峰会].[57]

**Lab Equipment:**

None found

**Address**:

None found, possibly co-located with BIAM at No. 8 Hangcai Avenue, Haidian District, Beijing[58]

**Known Aliases:**

- National Key Laboratory of Advanced Composite Materials [先进复合材料国家重点实验室]
- Science and Technology on Advanced Composites Laboratory [先进复合材料重点实验室]
- S&T Key Laboratory of Advanced Composite Materials [先进复合材料科技重点实验室]
- BIAM 28th Research Office [第二十八研究室]
    - Presumed to be the same lab

## 2. Defense S&T Key Laboratory of Advanced High-Temperature Structural Materials

**Official English Name:** Unknown

**Chinese Name:** 先进高温结构材料国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Air

Equipment:

- Aircraft

Functional Field:

- Materials
- *Secondary*: *Electrical Power, Propulsion*

**Affiliations:**

- Aero Engine Corporation of China (AECC) [中国航空发动机集团][xxii]
    - Beijing Institute of Aeronautical Materials (BIAM) [北京航空材料研究院]
        - *a.k.a. AECC 621st Research Institute [621 研究所]*

**Key Data:**

- Established: 2006
- Total Funding: Unknown
- Personnel: nearly 100 researchers[59]
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research into the development of structural materials capable of operating under high temperatures, complex stresses, and corrosive environments. Research areas include casting, forging, injection molding, alloy deformation, and powder metallurgy. The lab's

[xxii] BIAM appears to have been transferred in recent years from AVIC to AECC. Most online sources still associate it with AVIC, but its official website and more recent sources state AECC.

research is critical to the creation of high-temperature alloys used in aero-engines for its parent organization, the Beijing Institute of Aeronautical Materials. It is also a key lab tasked with breaking the foreign stranglehold on gas turbine blades and nozzles. Beside this, the lab's research is also applied in the civilian fields of shipping, electronics, oil drilling, and nuclear power. [60]

The lab's parent institution, the Beijing Institute of Aeronautical Materials (a.k.a. the 621st Research Institute), was established in 1956 as the PRC's first institution devoted to high-temp structural materials. Its advanced materials are utilized in the engines and other parts of aircraft and helicopters.[61] It was added to the U.S. Commerce Department Entity List for export control in December 2020.[62]

**Further Information:**

- The lab has a Powder Turbine Disc Research and Applications Technical Engineering Center [粉末涡轮盘研究与应用技术工程中心] which is a leading institution for manufacturing aerosolized powder and near-size forming technology. It is engaged in powder metallurgy for high temperature alloys, high-speed steel, die steel, stainless steel, low-alloy steel, binary alloys, titanium alloys, and other special high-quality metal materials and parts manufacturing. [63] [xxiii]
- A source from 2011 stated that the PRC's gas turbine technology is 20-30 years behind other countries' and still has much catching up to do. BIAM created the "Advanced High Temperature Alloy Precision Formed Parts High Technology Industrialization Demonstration Project" [先进高温合金精密成型件高技术产业化示范工程] in 2006 to break the foreign stranglehold on gas turbine blades and nozzles, so that the PRC would no longer have to rely on imports.[64]
- In 2012, BIAM released a book based on the basic research of this lab, called *Advanced High Temperature Structural Materials and Technology*, available for online purchase.[65]

**Research Direction:**

1. High-temperature structural material casting and applications [铸造高温结构材料及应用]
2. High-temperature structural material injection molding and high-temperature alloy deformation applications [喷射成形高温结构材料及变形高温合金应用]
3. High temperature powder structural material applications [粉末高温结构材料应用]
4. Mechanical properties and testing technology for high-temperature structural materials [高温结构材料力学性能测试技术][66]

[xxiii] A list of specific materials manufactured by this Center is available upon request.

**Notable Applications:**

- High-temperature alloy turbine blades and turbine discs developed by this lab have been key to the PRC's development of advanced aero-engines. Perhaps most notably, this lab was involved in the development of both the DD6 and DD9 single-crystal high-temperature alloys (although the DD6 was first developed in the 1990s before the creation of this lab, so the lab's exact role in development of the former is unclear). These single-crystal alloys are critical to the development of advanced aircraft engines and are considered a "crown jewel" of aero-engine development that only a select few countries have mastered. The DD6 has been used in the WS-10 engine (utilized by combat aircraft like the J-10, J-11, J-15, and J-16) and WS-20 engine (utilized by the Y-20), while the more advanced DD9 is used in the WS-15 (utilized by the J-20) and WS-13 (utilized by the J-31 and J-17).[67] As of 2022, the lab has also developed a DD10 alloy.[68]
- This lab created a corrosion-resistant alloy, DZ466, which is comparable to U.S. company General Electric's DS GTD111.[69]

**Leadership and Key Personnel:**

- Director: Zhang Guoqing [张国庆][70]
    - Oversees several unidentified Sino-European aerospace cooperation projects.
- Deputy Directors: Li Jiarong [李嘉荣]; Xiao Chengbo [肖程波]; Guo Zhonglou [桂忠楼][71]
- Standing Deputy Director: Tang Dingzhong [唐定中][72]

**Notable Collaborations:**

*Domestic*

- The lab has worked, or at least engaged in some form of broad coordination, on new materials research with PRC company AT&M (Antai) [安泰科技].[73]
- Other labs working in the area of single crystal high-temperature alloys for aircraft turbines include the CAS Institute of Metals, and particularly its Department of High-Temperature Alloy Research [中国科学院金属研究所高温合金研究部], and Shaanxi Liangshi [陕西炼石].[74]

*International*

- One source from 2011 shows BIAM collaborating with an unidentified French organization.[75]
- For further information on BIAM cooperation internationally, see the “International Collaborations” section for the Defense S&T Key Laboratory of Advanced Composite Materials.

**Lab Equipment:**

None found

**Address**:

None found, possibly co-located with BIAM at No. 8 Hangcai Avenue, Haidian District, Beijing[76]

**Known Aliases:**

- National Key Laboratory of Advanced High Temperature Structural Materials [先进高温结构材料国家级重点实验室]
- Key Laboratory of Advanced High Temperature Structural Materials [先进高温结构材料重点实验室]
- National Key Laboratory of Science and Technology on Advanced High Temperature Structural Materials
- Science and Technology on Advanced High Temperature Structural Materials Laboratory

## 3. Defense S&T Key Laboratory of Aero-Engine Aerodynamics and Thermodynamics

**Official English Name:** National Key Laboratory on Aero-Engine Thermodynamics (AEL)[77]

**Chinese Name:** 航空发动机气动热力国防科技重点实验室

**Post-2024 Name**: No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Air

Equipment:

- Aircraft

Functional Field:

- Propulsion
- *Secondary: Aerodynamics, Hypersonic Technologies*

**Affiliations:**

- Beihang University [北京航空航天大学]
    - School of Energy and Propulsion Engineering [能源与动力工程学院]

**Key Data:**

- Established: 1992
- Total Funding: 22.06m RMB
- Personnel: Unknown[78]
- Official start of operations: 1995
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research on aerodynamics and related thermal research for aircraft engines.[79]

**Further Information:**

- In 2023, the lab, along with Beihang University and the Beihang Aero-Enging Institute [航空发动机研究院], established a Luoyang Experimental Base [洛阳实验基地] in Yiyang County, Luoyang. The base is located at the Yiyang County Advanced Manufacturing Development Zone [宜阳县先进制造业开发区]. The base is affiliated with Zhongchen S&T Equipment Co. [中宸科技装备有限公司].[80]

**Research Direction:**

1. Flow coupling mechanisms of aero-engine compression systems [航空发动机压缩系统流动耦合机理]
2. Exploring new concepts and principles for aero-engine aerodynamic and thermal force [航空发动机气动热力新概念原理探索]
3. Internal flow mechanisms of compressors and turbines under non-constant conditions [非定常条件下压气机及涡轮内部流动机理]
4. High-performance combustion mechanisms [高性能燃烧机理]
5. Advanced aero-engine cooling mechanisms [航空发动机先进冷却机理][81]

*Other Notable Research Areas:*

- Inherent non-constant aerodynamic thermodynamics of impellers
- Non-linear turbulent flow, vortex and fluctuating hydrodynamics
- Real flow in impellers
- High-performance liquid mist combustion science
- Fundamental research of rotational heat transfer
- High performance liquid mist combustion[82]

In 2019, this lab's research fund was interested in funding the following topics:

1. Research on oil-electric hybrid-based all-electric propulsion power system configurations and turbine power generation systems for new concept micro-scale aero-engine technology
2. Numerical simulation techniques for variable cross-sectional pipe flow with non-constant excitation for advanced aero-engine pressurization technology
3. High-frequency absorption spectroscopy of non-constant temperature of cyclonic flames for diagnosis and control of aero-engine cyclonic combustion instability
4. Graphene surface microstructures coupled with pulsating airflow to enhance blade cooling technology for aero-engine blade cooling design technology
5. Design and process study of a miniature permanent magnet rotary motor based on MEMS three-dimensional coil for new concept micro-scale aero-engine technology[83]

**Notable Applications**:

- Research by Zou Zhengping [邹正平] into unidentified aircraft turbine engine components, including advances in weight reduction and component size, improving thrust-to-weight ratio and turbine blade number reduction.[84]
- Researcher Chen Maozhang [陈懋章] seems to be involved in some unidentified fashion with the development of the Taihang [太行] aircraft engine, used in the Y-20 heavy transport aircraft. Additionally, images on Chen's team homepage show what looks like a military helicopter and at least two types of space planes.[85]
- Cheng Maozhang's team, under both this lab and the Beihang National Aerospace S&T Lab [航空科学与技术国家实验室], has made several strides in aero-engine technology, including:
    - A "low-speed, large-size compressor experimental device and rotor flow field dynamic measurement technology" allowing for research on the internal flow mechanism of compressors. This project won a 1st Class National S&T Progress Award in 1993.
    - A "pressure engine processor magazine with curved twist spoiler" which has been utilized in multiple types of combat aircraft and eliminates mid-air engine stalling and other failures in the air. This award won a 2nd Class National Technical Invention Award in 1999.
    - A "small and large blade axial flow compressor technology" with 15% higher pressurization ratio than the U.S. F-22 fighter aircraft and providing support for the next generation of high thrust-to-weight engines. This won a 2nd Class National Technical Invention Award in 2011.
    - A "turning turbine design technology" with an internal flow organization method of counter-rotating turbines and counter-rotating turbine aerodynamic design technology, with significantly reduced weight and length. This will provide the turbine engines for the PRC's 4th generation of aircraft.
    - Hypersonic pre-cooling aero-engine technology, including design breakthroughs in heat exchange and high-temperature alloy array microfine tube low melt corrosion brazing process technology.[86]

**Leadership and Key Personnel:**

- (Possibly current, as of 2022) Director: Xu Guoqiang [徐国强][87]
- (likely former) Director: Tao Zhi [陶智][88]
    - Studied at Strathclyde University in U.K.
    - Not a Communist Party member
    - CPPCC Representative (possibly as minor political party member) and Beihang Vice President
- Academic Committee Director: Cheng Ronghui [程荣][89]
    - Senior engineer [总师] at AECC

    - Chief scientist [首席科学家] at Taihang National Lab [太行国家实验室]
- Deputy Directors: Gao Ge [高歌]; Li Qiushi [李秋实]; Lu Lifeng [陆利蓬][90]
    - Li Qiushi was a visiting scholar to MIT 2007-2008

*Key Personnel*:

- Zhao Yongjun [赵拥军][91]
    - Researches aero-engine performance, fault diagnosis and health management, system simulation and multidisciplinary optimization.
    - PhD from Georgia Institute of Technology in U.S.
    - Worked at both the GIT Aerospace Systems Design Lab and U.S. company General Electric.
- Zou Zhengping [邹正平][92]
    - Research into improved aero-engine design and improved cooperation between academia and industry, as well as likely research into hypersonic space planes.
- Chen Maozhang [陈懋章]
    - Involved in development of Taihang aircraft engine and several other notable advances in aircraft engines (see "Notable Applications" section).

**Notable Collaborations:**

*Domestic*

- This lab is associated with the Advanced Aero-Engine Collaborative Innovation Center [先进航空发动机协同创新中心], a 2013 collaboration between Beihang and AVIC that was part of the first batch of 14 Ministry of Education collaboration and innovation centers.[93] [xxiv]
- This lab provided "academic support" to the China Aerospace Third Professional Information Network's 37th Technical Exchange Conference and the 1st Joint Conference on Air and Space Propulsion in 2016, primarily organized by CASC, with support from several other institutions including the PLA Rocket Force Engineering University. Other participants included a wide range of CASC, CASIC, and other subsidiaries, the Naval Engineering College, and the Air Force Engineering University.[94]
- A team under Academician Chen Maozhang [陈懋章] at Beihang is subordinate to both this lab and the Beihang National Aerospace S&T Lab [航空科学与技术国家实验室], and is a major part of the Ministry of Education's 2011 AeroEngine Collaboration Center [教育部 2011 航空发动机协同中心]. It has over 70 affiliated researchers. See Notable Applications for more information.[95]

[xxiv] A complete list of organizations is available upon request.

*International*

- In 2024, this lab co-organized the 9th National Young Scholar Meeting on Combustion Research [第九届全国青年燃烧学术会议], along with the Chinese Society of Engineering Thermophysics [中国工程热物理学会], Beihang University, and others. Other researchers involved in organizing came from PLA Space Engineering University, PLA Air Force Engineering University, National University of Defense Technology, CAEP, Nanjing University of Science and Technology, Beijing Institute of Technology, Harbin Engineering University, and Northwestern Polytechnical University. Among the PRC participants, personnel from military institutions such as NUDT, the Academy of Military Sciences, Air Force Engineering University, and others (including one from PLA Unity 32178, an apparent research organization), military research and industrial organizations such as CAEP, AVIC, and AECC, and the Seven Sons of Defense, were heavily represented. Known foreign participants came from the U.S. (Case Western Reserve), U.K. (University of Nottingham Ningbo), Singapore (National University of SIngapore, Nanyang Technological University), and Ireland (National University of Ireland Galway). Topics focused on various types of aerospace propulsion, including solid rockets and hypersonic propulsion.[96]
- A French expert in aero-engines and longtime senior engineer at U.S. company General Electric has given guest lectures at this lab and has been named an honorary professor at Beihang.[97]
- The Department of Thermal Engineering [热能工程系], which oversees this lab, claims to have partnerships with multiple western academic institutions, including U.S. institutions Princeton, Purdue University, University of Connecticut, and Georgia Institute of Technology, as well as Oxford University in the U.K. and Ecole Centrale in France. A professor from Princeton has been named as an honorary professor, and a professor from Purdue has established a Sino-foreign joint combustion basic research team.[98]

**Lab Equipment:**

Lab equipment includes:

- Transonic fan test bench
- Medium-speed large-size compressor experimental device
- Full-ring rotating turbine blade external heat transfer test bench[99]

**Address**:

None found, possibly co-located with Beihang University at No. 37 Xueyuan Road, Haidian District, Beijing [北京市海淀区学院路 37 号]

Second location at or near No. 28 Dongfang Street, Gu'an County, Langfang, Hebei Province [河北省廊坊市固安县东方街 28 号附近][100]

The lab has its own three-story building, as well as a second research area at Beihang's "Southern Campus" (possibly a reference to the lab's secondary facility in the city of Langfang).[101]

**Website**:

https://web.archive.org/web/20181012112026/http://sepe.buaa.edu.cn/xygk/xssz/gjzdsys/index.htm

**Known Aliases:**

- National Key Laboratory of Science and Technology on Aero-Engine Aero-thermodynamics [航空发动机气动热力国家级重点实验室]
- National Defense Key Laboratory on Aero-Engine Aero-thermodynamics [航空发动机气动热力国防重点实验室]
- National Key Laboratory on Aero-engines
- National Key Laboratory of Aero-engine

## 4. Defense S&T Key Laboratory of Aerospace Systems Simulation

**Official English Name:** Unknown

**Chinese Name:** 航天系统仿真国防科技重点实验室

**Post-2024 Name**: No evidence of name chance as of January 2025

**Research Focus:**

Domain:

- Air

Equipment:

- Multiple (Air/Missile Defense, Ballistic Missiles, Electronic Warfare, Non-Ballistic Missiles)

Functional Field:

- Simulation and Modeling
- *Secondary: Countermeasures, GNC, Intelligent Technologies, Manufacturing, Microwave Technologies, Millimeter Wave Technologies*

**Affiliations:**

- China Aerospace Science and Industry Corporation (CASIC) [中国航天科工集团]
    - Beijing Simulation Center [北京仿真中心]
    - CASIC 2nd Academy, 2nd Department [二院二部][102]

**Key Data:**

- Established: 1997
- Total Funding: Unknown
- Personnel: 65[103]
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

The Defense S&T Key Laboratory of Aerospace Systems Simulation claims to be the only Defense S&T Key Lab focused on simulation technology. It is responsible for research into realistic simulation and modeling technology for missile guidance, control, and countermeasures, as well as a wide range of other strategic uses, including air and missile defense, space defense, AI and intelligent warfare, and electronic warfare.

This lab was probably known as the Defense S&T Key Laboratory of Missile Control Systems Simulation [导弹控制系统仿真国防科技重点实验室] until around 2011, when it changed to its current name (see "Further Information" for more). Today, it is much more commonly known in Chinese as the "Key Laboratory of Aerospace Systems Simulation" [航天系统仿真重点实验室], usually (but not always) omitting "Defense S&T" from the beginning of its name.

The lab's parent institution, the Beijing Simulation Center, was established in 1996, and is focused on development of simulations for aerospace systems to advance the PRC's weapons and equipment development.[104]

**Further Information:**

- *Evidence for the lab's change of name in 2011*: Besides the similar names, the former Missile Control Systems Simulation Lab disappeared from public sources around 2011, and the Aerospace Systems Simulation Lab first appeared in public sources around 2012. The Aerospace Systems Simulation lab is occasionally referred to as being a Defense S&T Key Lab, and continues to do work on missile guidance and control, indicating overlapping missions.[105] Finally, Ma Jing and Tao Yuhui are associated with both labs.[106]

**Research Direction:**

No formal research direction found, but primary research areas include:

6. Missile control simulation technology [导弹武器控制系统仿真总体技术]
7. Microwave and millimeter wave guidance simulation technologies [微波、毫米波寻的制导仿真技术]
8. Simulation applications software and integrated, comprehensive simulation environments [仿真应用软件及一体化综合仿真环境]
9. Missile guidance system accuracy and confidence simulations [导弹制导系统仿真精度与置信度]
10. System simulation technology for precision guided weapons development [精确制导武器研制的系统仿真技术]
11. Semi-physical simulations of microwave-millimeter wave guidance seeking [在微波/毫米波寻的制导半实物仿真]
12. Simulation of offensive and defense countermeasures [攻防对抗仿真]
13. Multi-disciplinary virtual prototyping [多学科虚拟样机]
14. RF semi-physical simulations of complex ground and sea clutter/interference [复杂的地海杂波/干预射频半实物仿真]

15. Self-developed platforms for distributed simulation software support and virtual prototype support software [自主研发了分布仿真软件支撑平台和虚拟样机支撑软件平台][107]

**Notable Applications:**

- This lab's research is primarily used in simulations and modeling for a wide range of military uses. This includes missile guidance systems, ballistic missile defenses, networked air defense system survivability, space defenses, intelligence, electronic warfare, AI and automation, and civilian technologies like intelligent manufacturing and industrial internet.[108]
- One project under this lab researched simulation of AI countermeasures in cognitive electronic warfare.[109]

**Leadership and Key Personnel:**

- Director: Tang Mingnan [唐明南][110]
- Honorary 2022 Academic Committee Director: Li Bohu [李伯虎][111]

**Notable Collaborations:**

*Domestic*

- This lab is associated with the China Simulation Federation's Aerospace Systems Simulation Experts Committee [中国仿真学会航空航天系统仿真专业委员会][112]
- This lab has hosted an annual conference, the China Targeting and Environmental Modeling and Simulation Technology Conference [中国目标与环境建模仿真技术大会], since 2015.
    - The 2015 conference was focused on RF targeting and environmental modeling and simulation, and also discussed environmental modeling and simulation for jamming countermeasures and simulation of precision guided equipment in military operations in a complex environment, among many other topics.[113]
    - The fourth conference in 2018 featured several PLA and military-industrial participants, including the PLAAF Research Institute, CASC 8th Academy 8th Department, CMC Equipment Development Department Simulation Pre-research Specialist Team, Academy of Military Science Evaluation and Demonstration Center , PLARF Research Academy Construction Development Institute, PLAN Test and Training Base, PLAN Research Academy Surface Warfare Institute, AVIC China Air-to-air Missile Research Institute, and others. The theme was "Complex opto-electronic targets, jamming, and environmental characteristics modeling and simulation technology" [复杂光电目标、干扰与环境特性建模仿

真技术], including development of a new generation of advanced defensive weapons systems under complex battlefield environments.[114]

- The fifth conference in 2019 was co-hosted with the University of Electronic Science and Technology of China and featured personnel of PLA Base 29 (CARDC), a PLAAF Test and Training Base, CASC, CASIC (including 4th Academy 17th RI), AVIC, CSSC, Norinco, CETC, Hubei Anxin Intelligent Technology Co. [湖北安心智能科技有限公司等产业公司], Shenyang Dongrui S&T Co. [沈阳东睿科技有限公司], and several universities. The topic was "Complex target, jamming, and environmental characteristics modeling and simulation technology [复杂目标、干扰与环境特性建模仿真技术]. One topic of discussion with military implications was ground and sea clutter/interference modeling and simulation.[115]
- The sixth conference in 2020 had the theme of Advanced Electronic Countermeasures Technology / Photoelectric Detection Target and Simulation Technology [先进电子对抗技术/光电探测目标与仿真技术]. Topics included the strategic importance of electromagnetic compatibility and electromagnetic security to the success of informatized and intelligentized operations, microwave millimeter wave integrated circuits, and new challenges in modeling and simulation of warfare systems for things like joint warfare and cyber warfare. It featured participants from CASIC and the National Defense University Joint Operations College [国防大学联合作战学院].[116]

- This lab has taken part in several other noteworthy conferences with military institutions:
  - The 2010 China Guidance, Navigation, and Control Academic Conference [2010 中国制导、导航与控制学术会议] (CGNC2010). Other notable participants included multiple AVIC institutions, the PLAAF Equipment Research Academy Aviation Equipment Institute [空军装备研究院航空装备研究所], Air Force Engineering University, Naval Aviation Engineering College, and the National University of Defense Technology.[117]
  - A major 2016 VR/AR summit that featured major players in both government and industry, indicating the lab's interest in simulation extends to these fields.[118]
  - The 2017 Simulation Technology Exchange [2017 年仿真技术学术交流会], alongside personnel of the PLAN, PLAAF, and PLARF Research Academies.[119]
  - The 2018 China Simulation Conference [2018 年中国仿真大会] which also featured personnel of CASC 1st, 5th, and 8th Academies, CASIC 2nd and 3rd Academies, Baidu, and the National Defense University (including Major General Hu Xiaofeng [胡晓峰], a well-known thought-leader in the area of military AI and wargames), among other universities and institutions.[120]
  - A 2021 conference on photo-electric detection technology [光电探测技术]. Topics included infrared, terahertz, laser, quantum, microwave, space, and intelligent detection technologies, all with military uses. The summit claimed to be international, but no names of international participants were given.[121]

**Lab Equipment:**

None found

**Address**:

CASIC's 2nd Department Building #75, Beijing[122]

**Known Aliases:**

- Key Laboratory of Aerospace Systems Simulation [航天系统仿真重点实验室]
    - This is the much more common name. "Defense S&T" [国防科技] is typically but not always omitted.
- Defense S&T Key Laboratory of Missile Control Systems Simulation [导弹控制系统仿真国防科技重点实验室]
    - Name that appears on the original online list of Defense S&T Key Labs, apparently out of use since 2011.
- Defense S&T Key Laboratory of Beijing Simulation Center [北京仿真中心国防科技重点实验室]
- State Key Laboratory of Control System Simulation
- Science and Technology on Space System Simulation Laboratory
- Science and Technology on Special System Simulation Laboratory

## 5. Defense S&T Key Laboratory of Aircraft Control and Integration Technology

**Official English Name:** Science and Technology on Aircraft Control Laboratory[123]

**Chinese Name:** 飞行器控制一体化技术国防科技重点实验室

**Post-2024 Name:** National Key Laboratory of Aircraft Control and Integration Technology[xxv] [飞行器控制一体化技术全国重点实验室][124]

**Research Focus:**

Domain:

- Air
- *Secondary: Space*

Equipment:

- Aircraft
- *Secondary: Helicopters, Non-ballistic Missiles, Space Vehicles, Unmanned Systems*

Functional field:

- GNC
- *Secondary: Hypersonic Technologies, Intelligent Technologies, Sensing*

**Affiliations:**

- Beihang University [北京航空航天大学]
  - School of Automation Science and Electrical Engineering [自动化科学与电气工程学院]
- Aviation Industry Corporation of China (AVIC) [中国航空工业集团]
  - Xi'an Flight Automatic Control Research Institute (FACRI) [西安飞行自动控制研究所]
    - *a.k.a. AVIC 618th Research Institute [618 研究所]*

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown[125]
- Official start of operations: 2010
- Floor Space: Unknown

[xxv] Literal translation, no official name given

**Lab Overview:**

This lab conducts research on advanced aircraft control systems, with a focus on flight attitude control, aircraft decisionmaking, and intelligent sensing. Its research focuses on automatic and intelligent control, inertial technology, guidance, precision mechanics, microcomputers, sensors, hydraulics, and electronics, for use in combat and transport aircraft, helicopters, and UAVs. It may also be known as the AVIC Navigation, Guidance and Control (GNC) Technology R&D Center [中国航空工业导航、制导与控制(GNC)技术研发中心].[126]

Under the ongoing reorganization of the PRC's national key lab system, this lab is now known as the National Key Lab of Aircraft Control and Integration Technology [飞行器控制一体化技术全国重点实验室]. Interestingly, despite the official name change, at least two 2024 conferences still include the symbol for the Defense S&T Key Lab system to represent this lab, suggesting it is still a DSTKL.[127]

This lab is jointly controlled by Beihang University and the AVIC Xi'an Flight Automatic Control Research Institute (FACRI) (a.k.a. the AVIC 618th Research Institute). This collaboration is not immediately apparent at first glance (possibly by design) and is not stated on the website for either this lab or FACRI. FACRI was placed on the U.S. Commerce Department Entity List in December 2020 as a "military end user."[128]

**Further Information:**

- This lab manages the Beihang Space Intelligent and Autonomous Systems Research Center [空间智能自主系统研究中心]. This Center utilizes military-civil fusion [军民融合] and has 230m RMB of funding. Its research has been applied to multiple missiles, satellites, and UAVs.[129]
- This lab manages several Research Teams, including:
    - Bionic Autonomous Flight System Research Team [仿生自主飞行系统研究组] focused on autonomous unmanned system swarm control [无人系统集群自主控制], bionic vision and intelligent sensing [仿生视觉及智能感知], advanced flight control [先进飞行控制], and biological swarm intelligence [生物群体智能].
    - Aircraft Anti-Jamming Control Innovation Team [飞行器抗干扰控制创新团队], associated with the Ministry of Education Changjiang Scholars program [教育部长江学者]
    - Aircraft Advanced Navigation and Control Systems Innovation Team [飞行器先进导航与控制系统技术创新团队], associated with the Ministry of Science and Technology.[130]

**Research Direction:**

1. Aircraft control system research [飞行器控制体制研究]
2. Flight attitude control [飞行姿态控制]
3. Aircraft decision making management and control [飞行器决策管理与控制]
4. Integration of intelligence sensing and control [智能感知与控制一体化][131]

The Bionic Autonomous Flight System Research Team has its own research direction:

1. Autonomous unmanned system swarm control [无人系统集群自主控制]
2. Bionic vision and intelligent sensing [仿生视觉及智能感知]
3. Advanced flight control [先进飞行控制]
4. Biological swarm intelligence [生物群体智能][132]

*Other Notable Research Areas:*

- Use of low-cost "loyal wingman" UAVs to be launched from high-cost combat aircraft in denied environments, protecting expensive aircraft from missiles[133]
- Deep learning for hypersonic vehicle guidance[134]
- UAV swarming[135]
- Anti-jamming filtering methods in bionic intelligent navigation systems[136]

**Notable Applications:**

- In addition to its development of aircraft control systems, this lab has been involved in research of unidentified missile, satellite, and UAV technology.[137]
- The lab's parent institution, FACRI, has been involved in the development of the J-10 combat aircraft, as well as the flight control systems for the J-11, J-15, and J-16 combat aircraft. While no information was found directly connecting this lab to those projects, it is likely that it did, given its mission.[138]

**Leadership and Key Personnel:**

- Director: Jiao Zongxia [焦宗夏][139]
- Deputy Directors: Lu Zhengren [卢正人]; Ren Zhang [任章]; Guo Lei [郭雷][140]
    - Guo Lei has conducted research in the U.K., France, and Japan, with a focus on jamming and anti-jamming, control theory of uncertain and stochastic systems, and high-precision navigation.
    - Ren Zhang researches hypersonic vehicle flight control.

*Key Personnel:*

- Duan Haibin [段海滨][141]

- Part of the first batch of young talents with the Ten Thousand Talents Plan [万人计划].
- Research focus on autonomous control of UAVs based on bionic intelligence.

**Notable Collaborations:**

*Domestic*

- This lab has worked with the National Innovation Center for Micro-Nano Manufacturing [国家微纳制造创新中心]. This Center was established in 2024 via cooperation by multiple academic and industry entities, including Brightstone Innovation Technology Group [明石创新技术集团], Xi'an Jiaotong Uniersity, Huazhong University of Science and Technology, Tianjin University, Dalian University of Technology, Norinco 214th RI, AVIC 618th RI, and Shandong Guochuang Micro-Nano Manufacturing Research Institue [山东国创微纳制造研究院有限公司].[142]
- This lab has a presence at the Xi'an Artificial Intelligence Industrial Park [西安人工智能产业园].[143]
- In 2019, this lab partnered with other Beihang labs and the COMAC Shanghai Aeroplane Design & Research Institute [上海飞机设计研究院] to establish the Large Aircraft Innovation Valley Joint Laboratory [大飞机创新谷联合实验室], focused on large aircraft flight control, hydraulics, landing gear, and brake technology.[144]
- In 2019, this lab established an Intelligent Flight Technology Joint Innovation Center [智能飞行技术联合创新中心] with the Beihang University School of Astronautics, signing a strategic cooperation agreement.[145]
- This lab collaborated with the CASC Infrared Detection Technology R&D Center [红外探测技术研发中心] and Shanghai Institute of Spaceflight Control Technology [上海航天控制技术研究所] to research quadrotor aircraft attitude control.[146]
- This lab collaborated with the CETC 10th RI [中国电子科技集团公司第十研究所] on airborne refueling.[147]
- In 2017, this lab co-hosted the 2nd Summit on New Navigation Technology and Applications [第二届新型导航技术及应用研讨会]. Notable participants included personnel from CASC's 1st, 5th, 8th, and 9th Academies, CASIC's 2nd, 3rd, and 4th Academies, the National University of Defense Technology, Air Force Engineering University, and Rocket Force Engineering University. Another co-host was the Key Laboratory of Advanced Cruise Missile Guidance and Control Technology [巡航导弹先进制导控制技术重点实验室]. The conference discussed spacecraft flight control, guidance and control technology for hypersonic vehicles, and intelligent/autonomous aerospace systems.[148]
- In 2020, this lab collaborated on the 4th Chinese Conference on Swarm Intelligence and Cooperative Control with multiple organizations, including the Chinese Institute of

Command and Control, the 2nd Department-Beihang Swarm Intelligent Control Joint Lab [二部-北航集群智能控制联合实验室], and other labs. Representatives from the PLAN and PLAAF Research Academies, CASC 5th Academy, and National University of Defense Technology participated.[149]

*International*

- This lab has co-organized the 2022 and 2024 iterations of the International Conference on Guidance, Navigation and Control [国际制导、导航与控制学术会议]. The 2022 conference was co-organized with the Chinese Society of Aeronautics and Astronautics [中国航空学会], Chinese Association for Automation [中国自动化学会], and Harbin Engineering University. Other PRC participants included the AVIC 601st and 618th RI, Norinco, CSSC, CASC Beijing Institute of Control Engineering [北京控制工程研究所], Beihang University, Nanjing University of Aeronautics and Astronautics, Northwestern Polytechnical University, Harbin Institute of Technology, and CAS Institute of Automation. Named foreign presenters came from the U.K. (Loughborough University) and Russia (Bauman Moscow State Technical University). The 2024 conference was also co-organized with National University of Defense Technology, and featured participation from many of the same institutions as the 20222 conference. Foreign participants came from France (Institut National de Recherche en Informatique et en Automatique).[150]
- This lab co-hosts an annual International Aerial Robotics Competition along with AVIC Shenyang Aircraft Design Institute, AVIC 631st RI, and others. U.S. university MIT has been among the participants.[151]
- The lab's parent institution, FACRI, signed a joint agreement with U.S. aerospace company Honeywell in 2018 to jointly develop a commercial flight control system. This includes building a 10,000 sqm research and production base in Xi'an. The venture will be called HonFei Flight Technology Co and will research and manufacture advanced flight control technologies, including fly-by-wire controls. HonFei also provides flight systems for the C919 passenger jet.[152]

**Lab Equipment:**

A list of major lab equipment includes several pieces of equipment sourced from U.S. or western companies, possibly in violation of export controls:

- Copterworks AF25B Remote Control Helicopter, from U.S. company Copterworks
- MS07104A Mixed Signal Oscillator, from U.S. company Agilent
- Mercury Winrunner 9.0, from U.S. company HP
- VxWorks 6.7, from U.S. company Wind River Systems
- Mx3+ Indoor Positioning System and 7500 connection cable from U.S. company Vicon
- Custom ARINC629 communication simulation software, from Germany company Kunbus
- Novatel OEMV-3 GPS device, from Canadian company Novatel
- RTLAB 8.0 Software, from Canadian company Opal-RT

Other lab equipment includes:

- Residual Computer System
- VME computer
- PDM software
- Pioneer 3 Mobile Research Platform
- TT-XLC Remote Control Helicopter
- SSC-01 UAV
- 6U VPX Single Board Computer
- Cybertouch Data Glove
- XL50 Data Helmet
- Flock of Bird (sic) Tracker
- Reliability Airborne Software Verification Methodology Research Unit 1.0
- Hardware Environment Simulation System
- Software Modeling Tool 7.0

The lab utilizes the following data models：

- UAV General Planning Methodology
- Terrain Data Model
- 3D solid model of moving bodies
- Domestic and international military and civilian dynamics, kinematic models[153]

**Address**:

Possibly co-located with Beihang and FACRI at No. 37 Xueyuan Road, Haidian District, Beijing [北京市海淀区学院路 37 号] and No. 92 Dianzi 1st Road, AVIC No. 618 Institute, Xi'an, Shaanxi Province [西安市电子一路 92 号], respectively

**Website**:

http://dept3.buaa.edu.cn/zdsys/gjzdsys.htm

**Known Aliases:**

- Key Laboratory on Aircraft Control [飞行器控制一体化技术重点实验室]
    - More commonly used name on FACRI side
- AVIC Navigation, Guidance and Control (GNC) Technology R&D Center [中国航空工业导航、制导与控制(GNC)技术研发中心]

## 6. Defense S&T Key Laboratory of Airfoil and Blading Aerodynamics

**Official English Name:** National Key Laboratory of Aerodynamic Design and Research[154]

**Chinese Name:** 翼型、叶栅空气动力学国防科技重点实验室

**Post-2024 Name:** National Key Laboratory of Aircraft Configuration Design [飞行器基础布局全国重点实验室][155]

**Research Focus:**

Domain:

- Air
- *Secondary: Maritime*

Equipment:

- Aircraft
- *Secondary: Helicopters, Underwater Vehicles, Unmanned Systems*

Functional Field:

- Aerodynamics
- *Secondary: Stealth*

**Affiliations:**

- Northwestern Polytechnical University (NWPU) [西北工业大学]
    - School of Aeronautics [航空学院] (Airfoil Section)
    - School of Power and Energy [动力与能源学院] (Blading Section)
- Aviation Industry Corporation of China (AVIC) [中国航空工业集团]
    - 1st Aircraft Institute [中航工业一飞院]

**Key Data:**

- Established: 1992
- Total Funding: Unknown
- Personnel: 50 (45 with PhD)[156]
- Official start of operations: 1995
- Floor Space: 8,350 sqm

**Lab Overview:**

This lab claims to be the only lab in the PRC focused on basic and applied basic research in the field of airfoil aerodynamics, particularly aerodynamic design, analysis, and verification of aircraft and aero-engine airfoils and blading. It aims to create a new generation of advanced

military and civilian aircraft, helicopters, and UAVs, with the goal of enabling China to independently develop high performance aerospace vehicles through research of advanced aerodynamic designs, analysis, and experimental technology. It does work on aircraft engines, airfoils (including aircraft wings, helicopter rotors, and propellers), optimization and design of aircraft aerodynamic configurations, design methods, evaluation, and verification, and new concepts for airfoil and aircraft wing designs based on flow control technology.[157]

The lab was originally conceived due to the urgent need for indigenous aircraft wing design, as this technology was under foreign embargo. As NWPU was already a leading researcher of airfoil design, COSTIND decided to put this new lab at NWPU and invest in the NF-3 wind tunnel, which was approved in 1988 and completed in 1994. The NF-3 was awarded a 1994 1st Class Aviation Science and Technology Progress Award. Today, the lab revolves around the capabilities of its suite of advanced wind tunnels (see below for more).[158]

In January 2024, this lab was reorganized as the National Key Laboratory of Aircraft Configuration [飞行器基础布局全国重点实验室], now under both NWPU and the 1st Aircraft Institute of AVIC. Its new mandate is to carry out basic and applied basic research, frontier technology exploration, and key technoloy research on aircraft layout, particularly in areas like wings and airfoils. It also appears to be more interested in stealth design of future aircraft, emphasizing the design relationship between aerodynamics, structure, control, and stealth.[159]

**Further Information:**

The lab has five major research teams:

- Design Aerodynamics Research Team [设计空气动力学研究团队] under Professor Gao Zhenghong [高正红]
- Flow Control Research Team [流动控制研究团队] under Professor Cai Jinsheng [蔡晋生]
- Fluid-Solid Coupling Interdisciplinary Research Team [流固耦合交叉学科研究团队] under Professor Ye Zhengyin [叶正寅]
- New Flight Vehicle Exploration Research Team [新型飞行器探索研究团队] under Professor Song Bifeng [宋笔锋]
- Blading Aerodynamics Research Team [叶栅空气动力学研究团队] under Professor Liu Bo [刘波][160]

**Research Direction:**

1. advanced wing spectrum of future aircraft [未来飞行器先进翼型谱系]
2. basic layout principle and design technology [基础布局原理与设计技术]
3. discipline coupling analysis theory and method [学科耦合分析理论与方法]

4. basic layout performance verification technology [基础布局性能验证技术][161]

*Pre-2024 Research Direction*:

1. Basic airfoil theory, design methods, and applications [翼型的基础理论、设计方法及其应用] toward future aircraft needs
2. Experimental aerodynamics, wind tunnel experimental methods, and experimental techniques for airfoils and their application to aircraft design [翼型及其应用于飞行器设计的风洞实验方法和实验技术研究]
3. Theoretical, computational, and aerodynamic studies of blading [叶栅的理论、计算与空气动力研究][162]

*Other Notable Research Areas:*

- Airfoil/wing design theory and methods
- Airfoil/wing experimental techniques
- Flow control research
- New concepts of aerodynamic layout design
- Advanced aeronautical impeller research
- Aircraft aerodynamic design optimization
- Numerical computation of Reynolds-averaged Navier-Stokes (RANS) equations for complete aircraft at high angles of attack
- RANS calculation of hover and forward flight for helicopter rotors
- Aero elasticity analysis
- Static/dynamic measurements of pressure over wings, airplanes, and in inlets[163]

In 2024, the lab's open fund was interested in funding research (at 400,000 RMB per project for one year) into the following priorities:[164]

1. Mapping Mechanisms of 2D Airfoil and 3D Airfoil Performance Characteristics [二维翼型与三维机翼性能特性的映射机理研究]:
   Assessment indexes and results:

   (1) Reveal the mechanisms influencing 3D flow on the performance of airfoils of different aircraft wings

   (2) Establish an airfoil design model that takes into account the influence of the wing's swept back angle, cusp ratio, and torsion angle, etc.

   (3) Complete design optimization of the airfoil taking into account the effect of three-dimensional flow, and validate the design in wind tunnel experiments

2. Airfoil aerodynamic/stealth synergistic mechanisms and design methods [翼型气动/隐身协同机制与设计方法]

Assessment indexes and results:

(1) Reveal the mechanisms influencing local geometric features of the airfoil and wave-absorbing material coating on aerodynamic and stealth characteristics;

(2) Establish the airfoil design models considering the requirements of aerodynamics, stealth, wave-absorbing material coating, maneuvering stability, etc.

(3) Formulate an airfoil aerodynamic/stealth synergistic optimization and design methodology and independent software

3. Research on aerodynamic/stealth key mechanisms of flying wing layout aircraft [飞翼布局飞行器气动/隐身关键机理研究]

   Assessment indexes and results:

   (1) Reveal aerodynamic/stealth coupling mechanisms and the influence of key parameters such as airfoil shape, chord ratio, leading/trailing edge swept angle, etc. on stealth characteristics, stabilization characteristics, and damping characteristics

   (2) Establish the aerodynamic/stealth co-design method of flying wing layout aircraft

4. Research on the principles of wide-speed domain layout of supersonic vehicles [超声速飞行器宽速域布局原理研究]

   Assessment indexes and achievements:

   (1) Establish an aerodynamic/acoustic explosion parameter sensitivity analysis model of wide-speed domain layout for supersonic vehicles, and esrablish a parameter sensitivity analysis database

   (2) Develop an aerodynamic/acoustic explosion comprehensive optimization design method for wide-speed domain layouts of supersonic vehicle, and design relevant software

5. Research on Bionic Tail Layout Principles [仿生尾翼布局原理研究]

   Assessment indexes and achievements:

   (1) Establish a comprehensive evaluation model of maneuvering stability characteristics and bionicity of a bionic tail layout

   (2) Establish an evaluation method and validation strategy of a bionic tail layout

   (3) Develop one set of tail layout validation samples

6. Research on Multidisciplinary Parameter Characterization and Uncertainty of Stealth Bearing Structures [隐身承载结构多学科参数表征与不确定性研究]

   Assessment indexes and results:

   (1) Establish a multidisciplinary parameter characterization model of stealth bearing structures;

   (2) Reveal the influence of uncertain parameters of stealth bearing structures on stealth performance

7. Rigid-elastic coupling similarity criteria and experimental model design methods for flying wing layout aircraft [飞翼布局飞机刚弹耦合相似性准则与实验模型设计方法]

   Assessment indexes and results:

   (1) Reveal the coordination mechanism of flight mechanics and aeroelastic similarity criterion for flying wing layout aircraft

   (2) Establish design methods and evaluation criteria for rigid-elastic coupling similarity experimental models for flying wing layout aircraft; the rigid-elastic coupling speed error of a similar model and original quasi-model should not be more than 10%

8. Construction of cross-level evaluation index system for aircraft layout performance/efficacy [飞行器布局性能/效能的跨层级评估指标体系构建]

   Assessment indexes and results:

   (1) Form an index system of multidisciplinary parameter-layout performance-efficacy of a typical layout scheme for no less than 2 types of aircraft

   (2) Establish a mapping relationship of indexes of typical layout schemes based on the multidisciplinary coupling effects

**Notable Applications:**

This lab is involved in the development of advanced airfoils and blading for many of the PRC's aircraft, helicopters, and UAVs. Publicly-named examples include:

- Design of the air intakes and supercritical wing design for the Y-20 military heavy transport aircraft, an unnamed bomber aircraft (presumably a variant of the H-6), the KJ-200 early warning aircraft, and the air intakes and parafoils of the C919 passenger aircraft, via the NF-3 and NF-6 wind tunnels.[165] It was also involved in design of the J-20 combat aircraft.[166]

- In addition to aircraft, the lab has used its wind tunnels to do experiments involving airborne paratroopers.[167]
- This lab also developed the PRC's first aerodynamic export software: the Multi-microcomputer network parallel computing system [微机网络并行计算系统], the CADR3D advanced complex shape full machine aerodynamic computing software system [CADR3D 先进复杂外形全机气动计算软件系统], and a non-structural mesh aerodynamic analysis system [非结构网格气动分析系统]. It has also developed other software systems for aerodynamic research, including an on-structural grid aerodynamics software analysis system, vehicle dynamic derivative calculation software system, and a civil aircraft aerodynamic calculation software system.[168]
- In 2024, the lab (under its new post-reorganization name) released the PRC's first aircraft wing profile spectrum database, allowing the PRC to shed its dependence on foreign airfoil databases, improve its demostic aviation R&D capabilities, and establish its own IP in this area. The database includes over 1,000 airfoils from six series.[169]

**Leadership and Key Personnel:**

- Director: Tang Changhong [唐长红 [170]
- Standing Committee Director: Liu Bin [李斌][171]
- Deputy Directors: Han Zhonghua [韩忠华]; Ning Yu [宁宇][172]
    - Han Zhonghua previously served as Director[173]

**Notable Collaborations:**

*Domestic*

- This lab has collaborated with AVIC Avicopter (creators of the Z-10, Z-19, and other military helicopters) on a new, optimized helicopter rotor blade.[174]
- The NF-6 wind tunnel was constructed with the help of AVIC (then known as CAVIC).[175]
- This lab has collaborated on various research topics with PLA military units 95939, 95949, 96215, and 63837.[176]
- This lab co-organized the 2012 China Aerostat Conference [中国浮空器大会] at Northwestern Polytechnical University, attended by the PLAAF Equipment Research Academy [空军装备研究院], CASIC Base 068, China Special Aircraft Research Institute [中国特种飞行器研究所], and the CETC 38th RI [38 研究所]. The conference discussed military uses for aerostats, including airborne early warning, emergency command and communications, counterterrorism, and anti-submarine warfare.[177]
- This lab co-organized the 5th Western China Young Scholars of Mechanics Academic Salon [西部力学青年学者学术沙龙]. Military participants included the PLA Air Force

Engineering University [空军工程大学] and the PLA GAD's 19th Test and Training Base [总装二十九试验训练基地].[178]

*International*

- Between 2017 and 2020, this Lab formed an Aircraft Complex Flow and Control Innovation and Intelligence Base ["飞行器复杂流动与控制"创新引智基地] with several foreign academic institutions, including UC Irivine in the U.S., Oxford University in the U.K., and other institutions from Germany (Max Planck Society), Netherlands (University of Twente), and Singapore (National University of Singapore). It is unclear if this base is still in operation.[179]
- Between 2007 and 2016, this Lab formed a "Behavioral Science and Technology of Structural Mechanics" Innovation and Intelligence Base ["结构力学行为科学与技术"创新引智基地] with multiple foreign academic institutions, including Akron University in the US, and universities in Australia (University of Sydney, Swinburne University of Technology), France (Université Paris VI), and the Netherlands (Delft University of Technology).[180]

**Lab Equipment:**

- The total value of the lab's equipment is 137.1 million RMB.[181]
- NF-3 wind tunnel
    - Asia's largest low-speed wing wind tunnel [低速翼型风洞], equipped with three experimental sections, including a binary experimental section [二元实验段], ternary experimental section [三元实验段], and propeller experimental section [螺旋桨实验].
    - Maximum wind speed of 145 m/s, highest test Reynolds number greater than 7 million for airfoil tests, wind tunnel turbulence less than 0.05%.
    - Binary experimental section: experimental section size 8m×3m×1.6m, maximum wind speed 130m/s, average turbulence 0.045%, maximum experimental Reynolds number 7×106, suitable for new concept airfoil flow mechanism research and engineering design verification.
    - Ternary experimental section: experimental section size 12m×3.5m×2.5m, maximum wind speed 90m/s, average turbulence 0.08%.
    - Propeller experimental section: cross-section is positive octagonal, distance between opposite sides is 2.2m, length is 4.5m, the maximum wind speed is 145m/s, the incoming flow speed and the Mach number of the propeller tip can be simulated at the same time, and it has an Eiffel-type anechoic chamber, which can carry out propeller noise tests.[182]
- NF-6 wind tunnel
    - The only pressurized continuous high-speed wing wind tunnel [增压连续式高速翼型风洞], commissioned in 2000 and finished in 2003.

    - Mach number range of 0.25-1.2, wing experimental Reynolds number up to 2.3 × 107, with a fixed Mach number and variable Reynolds number test capabilities. Wind tunnel Mach number stability accuracy can reach 0.001, suitable for flow mechanism research and engineering design verification.[183]
- Continuous high-subsonic leaf grid wind tunnel
    - Basic experimental facility for aero-engines, which has been in use since 1993 and conducts blowing tests with very high reliability.
    - The maximum air outlet size of the test section is 100×300mm, the range of inlet Mach numbers is 0.3 to 0.9, and the range of airflow angle adjustment is 0 to 90 degrees.[184]
- China's only set of axial flow double-row counter-rotating compressor experimental devices [轴流式双排对转压气机实验装置]
    - Completed in 2006 these devices provide an important platform for advanced research into aviation power systems, including in the development of China's first counter-rotating aero-engine. The counter-rotating impeller machinery is a key technology to substantially improve engine performance. The axial double-row counter-rotating compressor test stand is a key piece of experimental equipment to provide verification for the development of high thrust-to-weight ratio counter-rotating aero-engines.[185]
- Low-speed and high-speed small research wind tunnels, including:
    - 1.5 m diameter low-speed ternary wind tunnel
    - 300 mm × 300 mm Mach 0.3 to 4.5 high-speed wind tunnel
    - Adaptive wall wind tunnel
    - Low turbulence wind tunnel[186]
- Low (or varying) turbulence intensity wind tunnel
    - An advanced low-speed, low-noise, low-turbulence research wind tunnel with tandem ternary and binary experimental sections and a cross-sectional ratio of about 3:1. The shrinkage ratio of the first shrinkage section is 7.11, the shrinkage ratio of the second shrinkage section is 3.18, and the total shrinkage ratio is 22.6. Between the two shrinkage sections, a variable turbulence grille can be installed to change the turbulence of the test section.[187]
- Other wind tunnels:
    - No.2 wind tunnel
    - Ice wind tunnel
    - Supersonic multifunctional wind tunnel (under construction as of 2020)
    - Tri-sonic (sub-, trans-, and super-sonic) wind tunnel
    - Open-jet low-speed wind tunnel[188]
- Parallel-type microcomputer computing system with a computer networking facility of 400 billion times/sec.[189]
- DANTEC (a Danish company) 3-d laser velocimeter system
    - DAS1800 dynamic data acquisition and TVS thermal infrared imaging systems[190]

**Address**:

This lab may be located within NWPU's Youyi campus, at No. 127 Youyi West Road, Xi'an, Shaanxi Province [陕西省西安市友谊西路 127 号]

**Website**:

http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=260

**Known Aliases:**

- National Key Laboratory of Science and Technology on Aerodynamic Design and Research
- 翼型叶栅空气动力学国防科技重点实验室 (Alternative spelling with no comma)

## 7. Defense S&T Key Laboratory of Antennas and Microwave Technology

**Official English Name:** National Key Laboratory of Science and Technology on Antennas and Microwaves[191]

**Chinese Name:** 天线与微波技术国防科技重点实验室

**Post-2024 Name:** National Key Laboratory of Radar Detection and Perception[xxvi] [雷达探测感知全国重点实验室][192]

**Research Focus:**

Domain:

- Multi-domain (Air, Ground, Maritime)

Equipment:

- Radar

Functional Field:

- Microwave Technology
- *Secondary: Electromagnetics, Fire Control, Stealth Technologies*

**Affiliations:**

- Xidian University [西安电子科技大学]
- China Electronics Technology Group Corporation (CETC) [中国电子科技集团]
    - Nanjing Research Institute of Electronic Technology [南京电子技术研究所]
        - *a.k.a. CETC 14th Research Institute [14 研究所]*
    - Huadong Electronic Engineering Institute [华东电子工程研究所]
        - *a.k.a. CETC 38th Research Institute [38 研究所]*

**Key Data:**

- Established: 1992
- Total Funding: >30m RMB/year[193][xxvii]
- Personnel: 74[194]
- Official start of operations: 1998
- Floor Space: 5,136 sqm[xxviii]

[xxvi] Literal translation, no official name given
[xxvii] However, another source says "several hundred million RMB"
[xxviii] 4,971 sqm of research space and 165 sqm of office space; also has an 897 sqm anechoic chamber

**Lab Overview:**

The Defense S&T Key Laboratory of Antennas and Microwave Technology conducts research into various aspects of antenna and microwave technology, primarily for radars.

The Nanjing Research Institute of Electronic Technology (a.k.a. the CETC 14th Research Institute) is referred to as the birthplace of Chinese radar, and is a current pioneer in the field of cutting edge radars.[195] It is on the U.S. Commerce Department Entity List for export control.[196]

Under the ongoing reorganization of the PRC's national key lab system, this lab was reorganized in 2024 and is now known as the National Key Laboratory of Radar Detection and Perception [雷达探测感知全国重点实验室]. The CETC 38th Research Institute has also apparently joined as a third managing partner, and it now has branches in Nanjing, Xi'an, and Hefei.[197]

**Further Information:**

- The lab receives over 30 million RMB per year in research funding. During the period of the 12th Five Year Plan, it completed 251 projects funded at 105.596 million RMB. 230 of these were related to national defense and were worth 88.218 million RMB, 84 percent of funding. Research areas included antenna and microwave measurement theory, technology, analysis, and design.[198] From 2017 to 2018, the lab's research funding rose by 70 percent.[199]
- The lab has a "Military Photonic/Phononic Crystal Basic Research Group " [军用光子/声子晶体基础研究课题组][200]
- The lab has a subordinate Unmanned Intelligence Team [无人智能团队].[201]

**Research Direction:**

1. Complex electromagnetic properties characterization and regulation [复杂电磁特性表征与调控]
2. Open RF aperture and processing [放式射频孔径与处理][202]

Other interests for the

*Former Research Direction of Pre-2024 Lab:*

1. Modern antenna and microwave measurement theory and technology [现代天线微波测量理论与技术]

2. Antenna and microwave analysis and design technology [天线微波分析与设计技术]

3. New theories and technologies for antennas and microwaves

*Other Notable Research Areas:*

- Phased array, low, and ultra-low subflap antennas
- Electromagnetic scattering
- Radar cross section[203]

**Notable Applications:**

- According to an unverified passage that may have appeared in a previous iteration of the lab's description on its website, this lab has been involved with developing a wide array of radars, including the PRC's first airborne early warning solid-state active phased array radar, first phased array ballistic measurement radar, first shipboard multifunctional solid-state active phased array radar, first satellite-based solid-state active synthetic aperture radar, first skywave over-the-horizon radar, first solid-state active phased array target characteristic measurement radar, first solid-state active phased array precision tracking measurement radar, first airborne fire-controlled phased array radar, and first large airborne early-warning radar radome. It is involved with satellite phased array technology, integrated aperture technology, component technology, active sub-array technology, and stealth technology, and has made major strides in long-range and airborne early warning, airborne fire control and guidance, shipboard functions, manned spaceflight measurement and control, and missile and ballistic measurement.[204]
- The 14th RI which oversees this lab has been involved in multiple notable recent projects, including the alleged development of a stealth-defeating quantum radar, and the anti-stealth JY-27 long-range surveillance radar. It is responsible for the majority of the PRC's ground based anti-missile radars, large ship-based main battle phased array radars, aircraft fire control radars, and space measurement and control radars. It was responsible for the development of the KJ-2000 early warning aircraft's radar, overcoming a foreign technology blockade, the "Sea Star" [海之星] Type 346 radar installed on PLAN destroyers, and measurement and control radars related to the Shenzhou, Tianzhou, and Chang'e space missions. It is likely that this lab has played a role in many of these projects, especially since 14th RI Director Hu Mingchun also serves as Director of this lab's Nanjing branch.[205]
- The AEMC Group within this lab specializes in microwave fillers and multiplexers, and has developed multiple types of ultra-shortwave multiplexer equipment [超短波多路耦合器设备] for the PLAN, including those deployed on the Liaoning aircraft carrier and dozens of destroyers.[206]
- In 2023, this lab developed a "5G miniaturized high-performance terminal and base station antenna" [5G 小型化高性能终端与基站天线].[207]
- In 2024, the lab's Unmanned Intelligence Team [无人智能团队] developed the PRC's lightest and smallest radar and optoelectronic integrated air-to-ground sensing system, which was mounted on a small UAV.[208]

**Leadership and Key Personnel:**

- Director: Sun Lei [孙磊][209]
- Xi'an Director: Liu Ying [刘英][210]
- Nanjing Director: Hu Mingchun [胡明春] (Nanjing)[211]
    - Hu is also the Director of the CETC 14th RI
- Academic Committee Director: Duan Baoyan [段宝岩][212]
- Xi'an Deputy Directors: Su Tao [苏涛], Jiang Wen [姜文], Zhang Yanfeng [张严锋][213]

*Key Personnel:*

- Lu Hongmin [路宏敏][214]
    - Lu's CV contains several partially redacted studies that may give insight to the lab's research goals, including:
        - "Simulation analysis of the effect of radar pulse[xxix] electromagnetic signal on the general layout of the whole vehicle" [雷达脉冲 电磁信号对整车总体布局影响的仿真分析]
        - "Electromagnetic jamming/sensitivity modeling and testing techniques for (REDACTED) Equipment" [XXX 设备电磁干扰/敏感度建模与试验技术]
        - "Multifunctional (REDACTED) Sensor EMC Simulation Analysis" [多功能 XXX 传感器 EMC 仿真分析]
        - (REDACTED) Numerical analysis of electromagnetic environmental information monitoring" [XXX 电磁环境信息监测的数值分析],
        - "Electromagnetic compatibility of (REDACTED) bus and fast charging system" [XXX 总线与快速充电系统的电磁兼容性研究与改进]

**Notable Collaborations:**

*Domestic*

- The lab has established a Joint Laboratory of Antenna Measurement Technology [天线测量技术联合实验室] with Shanghai Holevo Electronic Systems Technology Co. [上海霍莱沃电子系统技术股份有限公司].[215]
- In 2018, Xidian University and Huawei formed the Xidian-Huawei Terminal Antenna Joint Laboratory [西安电子科技大学-华为终端天线联合实验室]. Xidian's contributions will be run through this lab. This joint lab was formed in line with Li Keqiang's directive to improve enterprise innovation and integrate industry-university research. It will focus on R&D of mobile communication terminal antennas.[216]

[xxix] "Pulse" is redacted in his public CV

- This lab's Xi'an Branch has a strategic cooperation agreement with the Shanghai Supercomputing Center [上海超级计算中心], forming the Ultra-Large Scale Parallel Electromagnetic Computing Joint Laboratory [超大规模并行电磁计算联合实验室] in 2010. This joint lab will develop and build large-scale electromagnetic computing platforms based on the Shanghai supercomputing platform. By 2010, the joint lab had successfully conducted trial calculations of the American HOBBIES software with more than 1,024 CPU cores, which is the first high-precision 3D general electromagnetic simulation software with more than 1,000 cores successfully deployed and run by the Shanghai Supercomputing Center so far.[217]
- This lab has cooperative relationships with several private communications companies, including Huawei [华为技术有限公司], Tongyu Communications [广东通宇通讯股份有限公司], Shenglu [广东盛路通信科技股份有限公司], Kenli Technology [江苏肯立科技股份有限公司], and Hollywave [上海霍莱沃电子系统技术股份有限公司].[218]
- This lab has cooperative relationships with the CETC 20th RI (Xi'an Institute of Navigation Technology [西安导航技术研究所] and 5th RI. It also lists CSSC, Norinco, CASC, and CASIC as long-term partners.[219]
- The lab's 2017 Annual Academic Conference of the Key Laboratory of Antenna and Microwave Technology [2017 学术年会] was attended by personnel of PLA Army Engineering University, Air Force Engineering University, the CETC 14th, 20th, 29th, 39th, and 55th RIs, and the Xi'an Branch of the CASC 5th Academy.[220]
- In 2018, this lab hosted the Annual Academic Conference of the Key Laboratory of Antenna and Microwave Technology and Lectures on Electromagnetic Spatial Perception Technology [天线与微波技术重点实验室学术年会暨电磁空间感知技术名家讲坛] along with several others in the antenna and microwave field. Participants included personnel of the Air Force Engineering University, CETC 14th and 39th RIs, and Norinco 39th and 206th RIs.[221]
- This lab has collaborated on research with PLA Units 61255, 93567, 95989, the Air Force Engineering University, and research related to cruise missiles with the Air Force Engineering University's School of Missiles [导弹学院].

*International*

- Professor Tong Meisong [童美松] of Tongji University has lectured at this lab. Tong studied in the U.S., and has led or participated in 11 research projects (eight of which he led) funded by the U.S. Air Force Office of Scientific Research, Air Force Research Laboratory (AFRL), Army Research Laboratory, Intel, and IBM. He then returned to the PRC and has led projects for NSFC, MOST, state key labs, and others. He specializes in electromagnetic fields, antennas, and microwaves.[222]
- The Lab claims to have cooperative relationships with a number of insitutions around the world, including several U.S. universities: University of California, University of Texas, Ohio State University, U Penn, MIT, and University of Houston, as well as exchanges with others. One photo shows an employee of IBM being given an honorary professorship. It

also claims to have foreign relationships with Canada (University of Ottawa, University of Toronto), U.K. (University of Kent, Queen Mary University London), Singapore (National University of Singapore, Nanyang Technological University), Australia (University of Sydney, University of Technology Sydney), New Zealand (Massey University), Japan (Tohoku University, University of Tokyo), and Korea (Hanyang University, Sungkyunkwan University).[223]

- Since 2016, numerous exchanges and visits from U.S. and foreign academics are described on the Lab's website, including from Duke University and Penn State. One Lab academic was sent to study at University of Wisconsin from 2017 to 2019. Another studied at Ohio State University for several months in 2015. It is also unknown which, if any, of these collaborations are ongoing. Foreign visitors coming to the lab for exchange and lecture have come from Germany (Ulm University), Singapore (National University of Singapore), Sweden (Chalmers University of Technology), and the U.K. (Queen Mary University of London, University of Kent). They have spoken on topics such as satellite communications and 5G.[224]
- The lab's foreign collaboration page claims a large number of exchanges, including with British, German, Swiss, Japanese, and Singaporean researchers on topics that include 5G (from Kent University) and satellite communications.[225] [xxx]
- The Director of this lab was a presenter at the 2024 International Symposium on Measurement and Modeling of 6G Wireless Channels [2024年 "6G无线信道测量与建模"国际研讨会]. While much of the conference's website is now inaccessible, other PRC presenters came from CETC and Huawei, while foreign presenters came from the U.S. (New York University, University of Southern California, National Instruments, National Academy of Engineering, National Academy of Inventors), U.K. (Royal Society of Edinburgh), Canada (Canadian Academy of Engineering), Germany (Technical University of Braunschweig), and Austria (Austrian Academy of Sciences).[226]
- Personnel of this lab participated in the 9th Conference on Microwave Photonics Technology and Applications [第九届微波光子学技术及应用会议]. Other presenters came from the PLA National University of Defense Technology, speaking directly after a presenter from Netherlands company LioniX, who spoke on multifunctional hybrid integrated microave photonic chips. Several other presenters came from NUDT. Other PRC presenters came from PLA Air Force Early Warning College, AVIC, CASIC 23rd and 25th RI, CASC China Academy of Space Technology, CETC 23rd, 29th, 34th, 38th, and 44th RI, Beijing Institute of Technology, Nanjing University of Aeronautics and Astronautics. Another conference chair came from Canada's University of Ottawa.[227]
- In 2024, this lab co-organized the 14th International Conference on Antenna, Propagation and Electromagnetic Theory (ISAPE 2024) [第十四届天线、传播及电磁理论国际会议], along with multiple other national and provincial-level labs and research centers, as well as at least one other national-level defense lab. Foreign presenters gave talks on smart hypersurfaces, 6G wireless communications, wireless energy transfer, integrated waveguides, and electromagnetic information theory, coming from the U.K. (Durham

[xxx] A full list of institutions is available upon request.

University, University of Liverpool), Canada (University of Montreal), Japan (Chiba University), Italy (University of Siena) and Finland (Aalto University).[228]

- In 2017, this lab took part in the 7th IEEE MAPE international conference, which was co-hosted by Xidian University that year, and included multiple foreign researchers.[229]
- A scholar from the U.K.'s Kent University has guest lectured on 5G terminals.[230]

**Lab Equipment:**

- The lab has invested over 20 million RMB in its major lab equipment (primarily its anechoic chamber and field measurement systems), including an 8 million RMB near-field measurements darkroom.
- The total value of the lab's fixed property is 37.8039 million RMB, including 739 pieces of equipment worth 36.3197 million RMB. Equipment includes 27 pieces of major equipment worth over 300,000 RMB.[231]

This lab has several pieces of equipment from foreign sources, including:

- N5244A 10MHz-43.5GHz Two-port vector network analyzer from U.S. company Agilent
- N5230A 300KHz-20GHz Four-port vector network analyzer from U.S. company Agilent
- 2 Hz-50 GHz signal spectrum analyzer from German company Rohde & Schwarz

Other lab equipment includes:

- Large microwave darkroom (anechoic chamber)
- Antenna near and far field measurement systems

**Address**:

S&T Lab Building #10, No. 2 Taibai South Road, Xi'an, Shaanxi Province [陕西省西安市太白南路 2 号科技实验楼 10 楼]

The given English address is 10-11 F, Sci-tech Building, North Campus[232]

The lab also has branches in Nanjing, Jiangsu Province, and Hefei, Anhui Province.[233]

**Website**:

https://amt.xidian.edu.cn/index.html

**Known Aliases:**

- (Xidian) Antenna Institute [天线所]

- Key Laboratory of Antenna and Microwave Technology [天线与微波技术重点实验室]
- National Key Laboratory of Antenna and Microwave Technology [天线与微波技术国家重点实验室]
- Antennas and Microwave Technology Key Laboratory of National Defense
- Defense S&T Key Laboratory of Antennas and Microwave Technology
- Science and Technology on Antenna and Microwave Laboratory
- State Key Laboratory of Antennas and Microwave Technology
- National Laboratory of Antennas and Microwave Technology
- National Key Laboratory of Science and Technology on Antenna and Microwave

## 8. Defense S&T Key Laboratory of Aviation Engine High-Altitude Simulation Technology

**Official English Name:** Unknown

**Chinese Name:** 航空发动机高空模拟技术国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Air

Equipment:

- Aircraft
- *Secondary: Unmanned Systems*

Functional Field:

- Propulsion
- *Secondary: Hypersonic Technologies, Intelligent Technologies, Simulation & Modeling, Stealth Technologies*

**Affiliations:**

- Aero Engine Corporation of China (AECC) [中国航空发动机集团]
    - China Gas Turbine Establishment [中国燃气涡轮研究院]
        - *a.k.a. AECC 624th Research Institute*

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown[234]
- Official start of operations: Unknown
- Floor Space: 50,000 sqm

**Lab Overview:**

This lab is dedicated to R&D of high-altitude testing and simulation technology for the design of military and civilian aircraft engines.[235] It is the PRC's leading institution for high-altitude simulation of turbofan, turbojet, and turboshaft engines, and has been involved in the development of over 30 types of engines. It has also aided in the development of high-altitude, long-endurance UAVs, as well as hypersonic glide vehicles. It features the PRC's leading high-

altitude simulation test system, which it claims is the largest in the world by scale and capacity, and in 2010 it established a second high-altitude test base in Mianyang.[236]

The AECC 624th Research Institute was established in 1965. It is primarily responsible for development of aviation turbofan and turbojet engines and aeronautical engine high-altitude simulation tests and technology, as well as gas turbine technology.[237]

**Further Information:**

- The lab's founding date is not entirely clear. The initial incarnation of the lab, as the Key Laboratory of High-Altitude Aircraft Engine Simulation [航空发动机高空模拟重点实验室], was established in or around 1997 under the AVIC 11th RI, which later became the AECC 624th RI.[238] CAE Academician Liu Daxiang has been the leading light for this lab since its establishment, serving as Director of its Academic Committee since its founding to at least 2017.[239] However, a more recent source states that the lab only had its first academic committee meeting in or around August 2018.[240] It is possible that this latter date refers to the current incarnation of the lab, as a national-level DSTKL. Liu apparently wrote a letter to SASTIND about the establishment of this lab (using its current name and calling it a DSTKL) which appears in a collection of his works available for purchase online; since SASTIND was established in 2008, and the book was published in early 2016, the lab may have been in the process of being upgraded in that time period.[241] More recent photographs confirm that the lab is today a DSTKL.[242]
- The lab's facilities were badly damaged in the 2008 Wenchuan earthquake, and its capabilities were only fully restored in 2010.[243]

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- Engine testing and simulation technology[244]
- Aerodynamic noise testing and fault diagnosis of compressor fan blades
- Multi-modal simulation of rotor blade end timing and dynamic stress measurement
- Blade health monitoring tests for crack-containing blades
- Ultra-high circumferential fatigue tests and crack extension tests for blades[245]

In a 2019 list of research priorities, this lab was tasked with researching the following six topics:[246] [xxxi]

1. Intake system modeling and control method based on data mining and machine learning

[xxxi] A much more detailed list of priorities, objectives, and researcher info is available.

Aimed at the problem of poor simulation accuracy of intake pressure in engine transition state tests.

Includes research on filtering of test data, data mining of test data of air intake systems, black box modeling for high-altitude air intakes, intelligent control methods based on machine learning, and simulation, verification, and optimization of intelligent control methods

2. Nonlinear Characteristics Compensation and Control Technology of Butterfly Valve for High Altitude Stage Regulation

   Aimed at the problems of significant nonlinear characteristics and poor regulation accuracy of regulating butterfly valves in aerial platforms.

   Includes research on modeling of butterfly valve structure and flow field, nonlinear compensation methods based on flow characteristics, transition pressure control methods based on nonlinear compensation of butterfly valve, and simulation and verification of control methods based on digital and semi-physical simulation.

3. Intelligent Algorithm-based Vector Thrust Stand Data Modeling and Decoupling Technology

   Aimed at the nonlinear coupling problems between the force measurement components in static and super-static vector thrust stands.

   Includes research on coupling of super-static vector thrust frames, intelligent algorithms applicable to vector thrust table data analysis, modeling of vector thrust table calibration data and measurement data, decoupling technology of vector thrust frames based on mathematical models, and calibration data expansion based on mathematical modeling.

4. Research on spectral characteristic parameters of engine nozzle particulate matter and its diffraction behavior

   Includes research on spectral characteristics of typical particulate matter in the nozzle gas stream, diffraction behavior of high temperature, high speed and high brightness particles, high-frequency on-line analysis and detection of engine nozzle particulate emission and absorption spectra, and calibration technology of spectral identification of particulate matter components.

5. Infrared Background Processing Technology and Mathematical Models for Differentiated Test Platforms

   Includes research on background characteristic parameters of the engine in the use environment, the influence of the background infrared radiation of the atmosphere, ground and limited test chambers on infrared stealth test effects, effects of typical atmospheres such as summer, winter, and compressed air on the effectiveness of infrared stealth testing, effects of two typical exhaust states, namely subsonic cruise and supersonic cruise, on the

infrared stealth test effect, and models of background infrared radiation processing technology.

6. Aerodynamic stability and vibration diagnosis technology of aero-engines

   Includes research on vibration mechanisms of whole-engine aerodynamic instability, engine test big data mining and pre-processing technology research, engine instability vibration feature extraction and information fusion technology, diagnostic technology for improved genetic neural network algorithms, and aero-engine aerodynamic stability vibration diagnosis systems.

**Notable Applications:**

None found

**Leadership and Key Personnel:**

No leadership found

*Key Personnel:*

- Ma Hongwei [马宏伟]
  - Former member of the lab's 1st academic committee
  - Currently a Beihang professor
  - From 2000 to 2003, visiting scholar at the University of Aachen, Germany
  - In summer 2009, worked as a visiting professor at the Department of Aeronautics at Iowa State University in the U.S.
  - From February to March 2011, was a guest professor at the Laboratory of Fluid Mechanics and Acoustics, École Centrale Polytechnique, Lyon, France
  - Conducted a major project with the French Science Agency and National Natural Science Foundation of China called "Advanced Experimental and Numerical Simulation Research on Complex Flows in Impeller Mechanisms" [叶轮机械内复杂流动的先进实验与数值模拟研究]
  - Conducts research of internal flow testing technology, flow field diagnosis, compressor and turbine flow mechanisms
  - Developed a variety of steady state, dynamic flow field measurement technology[247]
- Liu Daxiang [刘大响]
  - First director of lab academic committee from 1997 to at least 2017
  - CAE academician[248]

**Notable Collaborations:**

*Domestic*

- In 2023, this lab agreed to cooperate on research and graduate training with Chongqing Jiaotong University [重庆交通大学], particularly in the area of engine exhaust system design and testing.[249]
- In 2020, this lab co-organized the Fifth Aero-engine Key Manufacturing Technology Innovation Development Forum [第五届航空发动机关键制造技术创新发展论坛] along with the AVIC Manufacturing Technology Center [中国航空工业集团有限公司制造技术中心], AECC Sichuan Institute of Gas Turbine Research, and the Manufacturing Engineering Branch of the Aviation Society of China. Research topics included intelligent manufacturing of aero-engine and gas turbine key components such as blades, turbine disks, etc., additive manufacturing technology, high temperature alloys, intermetallic compounds, and ceramic-based/resin-based/metal-based composites, anti-fatigue manufacturing, coating technology, and digital production. Speakers came from AECC, AVIC, NUAA, NWPU, CAS Institute of Metals, and others.[250]

*International*

- This lab (using its more innocuous name, which removes the "Defense S&T" part) co-sponsored the 2022 Forum of the Global Power & Propulsion Society (GPPS), along with AECC, the Journal of Propulsion Technology (a journal managed by defense SOE CASIC), Iranian company Mapna Group, U.S. company GE Avio Aero, and several other PRC SOEs. Presenters came mostly from the western world, including the U.S., U.K., France, Italy, Germany, the Netherlands, Greece, Sweden, Switzerland, and others. Institutions included the U.S. Southwest Research Institute, Texas A&M's Turbo Lab, Pratt & Whitney, French company Safran, Italian company Piaggio Aerospace, Airbus, Imperial College London, University of Naples, etc. Topics included more efficient and cleaner engines, hybrid electric aircraft, gas turbines, clean energy storage.[251]

**Lab Equipment:**

The lab has an SB101 high-altitude testing platform.[252]

**Address**:

Possibly co-located with its parent company at No. 105 Beixin Road, Xindu District, Chengdu, Sichuan Province 621703 [四川省成都市新都区北新路 105 号][253]

Per some sources, the lab may actually be located in Jiangyou [江油], a city near Mianyang[254]

**Known Aliases:**

- Key Laboratory of High-Altitude Simulation Technology [高空模拟技术重点实验室]
- 航空发动机高空模拟重点实验室
- 航空发动机高空模拟技术重点实验室
- 国家高空模拟技术重点实验室

## 9. Defense S&T Key Laboratory of Aviation Plasma Dynamics

**Official English Name:** Science and Technology on Plasma Dynamics Laboratory[255]

**Chinese Name:** 航空等离子体动力学国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Air

Equipment:

- Aircraft

Functional Field:

- Multiple (Aerodynamics, Propulsion, Plasma Technologies, Stealth Technologies)

**Affiliations:**

- PLA Air Force Engineering University [空军工程大学]
    - Aeronautics and Astronautics Engineering College [航空航天工程学院]

**Key Data:**

- Established: 2010
- Official start of operations: 2011
- Total Funding: Unknown[256]
- Personnel: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research into the use of plasma technology for military aviation, including for improved aircraft propulsion, aerodynamics, and stealth.[257] The lab is led by a PLAAF corps deputy leader-grade Major General who is a leading expert in aircraft propulsion.[258]

Plasma can be used to increase combustion power and efficiency in aircraft engines and decrease fuel use, as well as to significantly improve aircraft aerodynamics, drag, lift, angle of attack, and maneuverability. It can also theoretically be used to increase the stealthiness of future aircraft. Based on this lab's research output, it appears to be actively engaged in researching the use of plasma technology for all these applications.[259]

**Research Direction:**

No official research direction was found. A 2019 document details 25 key projects for the upcoming year. Interesting topics of study include research into aero-engines, aerodynamics, and stealth technology. A sampling of topics includes:[xxxii]

- Engine nozzle design
- Liquid fuel injection
- Intelligent materials for aero-engines
- Aerodynamic designs using plasma control technology
- Control mechanisms of plasma flow on supersonic surfaces
- Aircraft rudder design
- Single crystal turbine blades
- Deep learning for manufacturing processes
- Plasma-based composite materials
- Aero-engine fatigue
- Stealth aircraft technology
- Aircraft honeycomb damage detection and repair[260]

*Other Notable Research Areas:*

- Research into plasma flow technology for aerospace, still in early stages of development[261]

**Notable Applications:**

- This lab's research will be applied to improved propulsion, aerodynamics, and stealth for future military aircraft.
- This lab is developing plasma active flow control technology for use in flying-wing aircraft, improving control and obviating the need for elevators and rudders (thus improving stealth). According to one article, the B-2 Spirit already utilizes this technology. This technology is likely to end up in the future H-20 stealth bomber.[262]
- Re-ignition after engine flameouts at high altitudes, high speeds, and/or cold environments (including the Tibetan Plateau, where PLA combat aircraft operate) is currently a major problem (unclear if this means generally, or for Chinese engines specifically). Researcher Wu Yun has successfully developed plasma jet igniters [多路等离子体点火器], greatly widening ignition boundary and shortening ignition delay, allowing aircraft to re-ignite without losing altitude and improving combat effectiveness. This tech can be applied to higher speed sub-combustion ramjet engines, super-combustion ramjet engines, and turbo ramjet combination engines, allowing ignition even at Mach 3-5. It may be applied to the future H-20 stealth bomber. This research was conducted in collaboration with Xi'an

[xxxii] The full list, including project descriptions and final goals, is available upon request.

Aerospace Engine & Smart Manufacturing Institute Co. [西安空天能源动力智能制造研究院有限公司.[263]

- Researchers under Wu Yun have also developed a "thermal knife" [热刀] device which can be used for rapid de-icing of aircraft in flight over harsh environments.[264]
- He Weifeng conducts research into aircraft engine fatigue fractures and solutions using laser impact strengthening technology [激光冲击强化技术]. He also conducts research into improving engine resilience against sand inhalation and preventing sand erosion of engines, using nano multi-element coatings [纳米多元涂层] to mask engine blades.[265]

**Leadership and Key Personnel:**

- Director: Li Yinghong [李应红][266]
    - Corps Deputy Leader-grade Major General, CAE Academician, and Director since the lab's opening in 2011
    - Considered the leading authority in the PLAAF on the topic of plasma dynamics.
    - 19th Communist Party Congress representative
    - Director of the PLAAF Engineering University's "Aircraft Propulsion Technology High-Tech Center" [飞机推进技术高新技术中心].

*Key Personnel:*

- Wu Yun [吴云][267]
    - A leader in plasma applications in aero-engines, whose research will likely be used in the future H-20 stealth bomber
    - Member of the International Committee on Plasma Dynamics and Lasers of the American Institute of Aeronautics and Astronautics (AIAA) and a review expert for both the U.S. National Science Foundation and the U.S. Department of Energy

**Notable Collaborations:**

*Domestic*

- This lab collaborated with Xi'an Aerospace Engine & Smart Manufacturing Institute Co. [西安空天能源动力智能制造研究院有限公司] to develop a new plasma igniter [多路等离子体点火器] for aircraft in colder or high-altitude environments, which may be applied to the future H-20 bomber. AESM is a joint venture of Xi'an Jiaotong University and the Xi'an Aerospace Base [西安航天基地].[268]
- This lab collaborates with Xi'an Aerospace Purple Discharge Plasma Tech Co., a private enterprise focused on (it seems) civilian uses for plasma technology, including disinfectant and treatments for air pollution and wastewater. This company is a subsidiary of Xi'an Aerospace, which per its website conducts military and aerospace research in support of the Made in China 2025 program.[269]

- This lab has collaborated on research with PLA units/institutions, including Unit 94314, 95156, and the PLA Military Representative Office to Xi'an Aircraft.[270]

*International*

- This lab collaborated with Ecole Polytechnique in France (specifically the Laboratoire de Physique des Plasmas) to help code PASSKEy, a parallel streamer solver to calculate electric field, species densities, and fluid dynamics in a non-thermal plasma with detailed complex chemistry.[271]
- This lab co-organized the 2023 International Conference on Surface Science Technology and Application (ICSSTA 2023) [2023 国际表面科学技术与应用大会]. Other notable organizers included the PLA Air Force Engineering University, Norinco, CSSC, AVIC, CASC, and Harbin Institute of Technology. Foreign presenters came from the U.K. (University of Bristol, University of Windsor, University of Leicester, University of Surrey), Canada (University of Alberta, University of Calgary), Korea (Korea Advanced Institute of Science and Technology, Chungnam National University, Korea Institute of Materials and Science), Singapore (SIMTech), Ireland (Trinity College Dublin), and Russia (Moscow State Technological University). Other invitees reportedly included researchers from the European Academy of Sciences.[272]
- In 2019, this Lab co-sponsored the 1st international Symposium on Thermal-Fluid Dynamics [第一届热与流体动力学国际研讨会举行], along with several other institutions, including Sheffield Hollam University in the UK. Participants came from the U.S. (Georgia Institute of Technology, Iowa State, UC Santa Barbara), U.K. (University of London Brunel, University of Southampton Sheffield Hallam University), Canada (Western University), Japan (Kobe University), Singapore (National University of Singapore). Notable PRC participants came from the PLA Air Force Engineering University, AECC, Nanjing University of Aeronautics and Astronautics, Beijing Institute of Technology, and Northwestern Polytechnical University. Professor Wu Yun of this lab, confirmed to work on military aircraft projects, was a key organizer.[273]
- Wu Yun is a member of the International Committee on Plasma Dynamics and Lasers of the American Institute of Aeronautics and Astronautics (AIAA) and a review expert for both the U.S. National Science Foundation and the U.S. Department of Energy.[274]
- This lab helped organize the 9th International Workshop on Detonation for Propulsion (IWDP 2018) in 2018 at Tsinghua University. Researchers came from the University of Michigan in the U.S., Russia, France, Japan, Singapore, Korea, Poland, and Germany. Researchers from the PLA's National University of Defense Technology were present, along with personnel of this lab.[275]

**Lab Equipment:**

None found

**Address**:

No. 1 Baling Road, Baqiao District, Xi'an, Shaanxi Province [陕西省西安市灞桥区霸陵路 1 号等离子体实验室][276]

**Known Aliases:**

- National Key Laboratory of Plasma Dynamics [等离子体动力学国家级重点实验室]
    - In addition to oftentimes removing the "Defense" from its name, as is common for these labs, this lab often removes the "Aviation" from its name, especially in international fora, perhaps further obscuring its purpose.
- Plasma Dynamic Laboratory [等离子体动力学重点实验室]
- Key Laboratory of Science and Technology on Plasma Dynamics

## 10. Defense S&T Key Laboratory of Ballistic Missile Penetration Technology

**Official English Name:** National Key Laboratory of Science and Technology on Ballistic Missile Penetration[277]

**Chinese Name:** 弹道导弹突防技术国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Air

Equipment:

- Ballistic Missiles

Functional Field:

- Countermeasures

**Affiliations:**

- PLA Rocket Force Research Academy [中国人民解放军火箭军研究院]

**Key Data:**

- Established: pre-2011
- Total Funding: Unknown
- Personnel: Unknown[278]
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

The PLARF Research Academy allegedly oversees two Defense S&T Key Labs,[279] neither of which is usually public facing. However, one of these Labs has been publicly identified as the Defense S&T Key Laboratory of Ballistic Missile Penetration Technology, which was profiled by CCTV in 2017[280] and matches the description given of this Lab's research and role. The other PLARF lab remains unidentified as of publication.

There is evidence this Lab may be involved in the development of countermeasures to improve missile survivability and defeat enemy air and missile defense systems. Liu Xuemei [刘雪梅] is a researcher at the PLARF Research Academy who may have joined a research center under this Lab in 2011. Most of the information here is based on this presumed (but unconfirmed) association. Liu specializes in missile attack and defense, including developing theoretical

frameworks of missile offense and defense, missile testing and evaluations (carried out via test launches in the Gobi Desert), and development of missile attack and defense simulations.[281]

**Research Direction:**

No formal research direction was found.

*Other Notable Research Areas:*

The Space Vehicle Survival Technology and Effectiveness Assessment Lab which may be affiliated with this Lab researches the following areas:

- Ballistic missile survivability via countermeasures such as stealth, decoys, jamming, and ECM[282]
- Study of US missile defense technologies and how to defeat them[283]

**Notable Applications:**

- While no specifics have been given, it can be assumed that the lab's research is utilized by many or all of the PLARF's ballistic missile systems.

**Leadership and Key Personnel:**

No leadership found

**Notable Collaborations:**

*Domestic*

- This Lab may be closely associated with the Space Vehicle Survival Technology and Effectiveness Assessment Lab (officially known as the Institute of Effectiveness Evaluation of Flying Vehicle) [航天飞行器生存技术与效能评估实验室], which is the organization Liu Xuemei has historically affiliated with. This Lab is located in the same postal code as PLARF Headquarters (100085)[284] and is likely affiliated with the PLARF Research Academy.

*International*

- Assuming a connection between this lab and the Space Vehicle Survival Technology and Effectiveness Assessment Lab, the latter has cooperated with the University of Tennessee - Knoxville to conduct research on hyperspectral image anomaly detection based on twin neural networks.[285]

**Lab Equipment:**

None found

**Address**:

Possibly in Beijing's 100085 postal code,[286] along with the Space Vehicle Survival Technology and Effectiveness Assessment Lab and PLARF Headquarters

**Known Aliases:**

None found

## 11. Defense S&T Key Laboratory of Ballistics

**Official English Name:** National Key Laboratory of Transient Physics

**Chinese Name:** 弹道国防科技重点实验室

**Post-2024 Name:** National Key Laboratory of Transient Physics[xxxiii] [瞬态物理全国重点实验室][287]

**Research Focus:**

Domain:

- Multi-domain (Air, Ground, Maritime)

Equipment:

- Munitions
- *Secondary: Unmanned Systems*

Functional Field:

- Aerodynamics
- *Secondary: Blast, Impact & Damage, GNC, Plasma Technologies, Simulation & Modeling*

**Affiliations:**

- Nanjing University of Science and Technology (NJUST) [南京理工大学]

**Key Data:**

- Established: 1991
- Total Funding: Unknown
- Personnel: 189
- Official start of operations: 1995
- Floor Space: 22,000 sqm research space[288]

**Lab Overview:**

The Defense S&T Key Laboratory of Ballistics is focused on the national key discipline of "armament launch theory and technology" [兵器发射理论与技术]. It conducts research related to munition guidance and control, launch, flight, and chemical dynamics, as well as fluid, explosive, and damage mechanics, plasma and thermal physics, and associated test and simulation technologies.[289] It is described as the PRC's only national-level ballistics research center.

[xxxiii] Literal translation, no official name given

The lab is also frequently referred to, particularly in English Language sources, as the Key Laboratory of Transient Physics [瞬态物理国家重点实验室]. The two names have been used interchangeably, although "Ballistics" may be more frequently used in more military contexts. The Ballistics lab also has a slightly different founding date, holding its opening ceremony in December 1992, so it is possible these two labs started out as different entities, although today they are one and the same.[290] As part of the ongoing reorganization of the PRC's national key lab system, this lab appears to have officially changed its name to the National Key Laboratory of Transient Physics [瞬态物理全国重点实验室] by 2024.

The lab also appears to have grown significantly in recent years. Older sources give figures of 59 personnel and between 4,036 to 5,470 square meters of space.[291] However, sources describing the new, post-reform lab give figures of 189 personnel (including 163 research personnel and over 30 visiting researchers) and 22,000 square meters of research space. It also now has branches in Beijing, the Tangshan area of Nanjing, Xuyi in Jiangsu Province, and Baotou in Inner Mongolia.[292]

**Further Information:**

- This lab has a subordinate Underwater Ballistics Team [水中弹道团队]. The team was formed by Li Hongzhi in 2016 and won a major Defense S&T award in 2020. It leads a major Underwater Ballistics Cooperation and Innovation Center [水中弹道协同创新中心] with 11 other work units. This team has formed a joint research team with an unidentified PLA Navy Center [海军某中心].[293]
- The lab has six research offices [研究室], one admin office, and one fund management office.[294]
- According to different sources, this lab is "cared for, guided and supported" [关心、指导与支持] by COSTIND (now SASTIND) and the GAD, and "managed" [主管] by MIIT.[295]
- The lab supports the Nanjing Zhuangda Intelligent S&T Institute [南京壮大智能科技研究院], a research institute focused on vertical takeoff and landing and AI-based multi-purpose and intelligent UAVs. It is particularly focused on intelligent, large-payload, long-endurance UAVs for emergency response, firefighting, rescue, inspection, security, logistics, agriculture, forestry and plant protection, and military-civilian fusion.[296]

**Research Direction:**

1. New domain ballistics [新域弹道]
2. New substance ballistics [新质弹道]
3. New ballistic capabilities [弹道新能力][297]

*Former, pre-reorganization research direction:*

1. Armament launch theory and technology [兵器发射理论与技术]
2. Ultra-high-speed launch dynamics [超高速发射动力学]
3. Flight dynamics [飞行动力学]
4. Chemical dynamics and fluid mechanics [化学动力学以及流体力学]
5. Explosion mechanics [爆炸力学]
6. Modern damage mechanics [现代损伤力学]
7. Guidance and control [制导与控制]
8. Plasma physics [等离子物理]
9. Engineering thermal physics [工程热物理]
10. High simulation technology [高仿真技术]
11. Transient test technology [瞬态测试技术][298]

**Notable Applications:**

- This lab's basic research likely filters into a wide range of munitions, including small arms, artillery, missiles, and torpedoes, as well as satellite and flight vehicle GNC.
- This lab has allegedly been researching Electrothermal Chemical Launch (ETC) Technology for weapons firing systems since 1993, and has presided over multiple projects related to this technology, making significant progress in areas like super capacitor pulse power source + solid powder electro-thermal chemical emissions systems [超级电容脉冲功率源+固体火药电热化学发射系统]. This technology holds promise for superior firing range and velocity.[299]

**Leadership and Key Personnel:**

- Director: Li Baoming [栗保明][300]
- Academic Committee Director: Bao Weimin [包为民][301]
    - CAS Academician
- Deputy Director: Wang Jinxiang [王金相][302]
- Party Committee Secretary: Huang Lei [黄磊][303]
- Standing Committee Deputy Director: Yang Guolai [杨国来][304]
- Party Deputy Secretary, Discipline Inspection Sec: Qin Fei [秦非][305]

*Key Personnel:*

- Li Hongzhi [李鸿志][306]
    - CAE Academician, former Director and founder of this lab
    - Founder of the field of ultra high-speed electrothermal emission technology [超高速电热发射技术]

- Has given talks on torpedo ballistics [鱼雷弹道的现状和发展趋势], sonar in an oceanic environment [声纳与海洋环境], and high-speed underwater ballistics [高速水中弹道学的研究现状]

**Notable Collaborations:**

*Domestic*

- This lab is associated with the Underwater Ballistics Collaborative Innovation Center [水中弹道协同创新中心] at Nanjing University of Science & Technology, along with personnel of the CMC Equipment Development Department Research and Acquisitions Bureau and Comprehensive Planning Bureau, PLAN Equipment Research Academy, Harbin Engineering University, CSSC 716th, 713th, and 705th RIs, Norinco 202nd RI, Xi'an Kunlun Industry Group [西安昆仑工业集团有限公司], and Shaanxi Huatong Mechanical and Electrical Manufacturing Co. [陕西华通机电制造有限公司].[307]
- This lab collaborated with the PLAN Equipment Research Academy to co-host the Military Engineering Society Ballistics Experts Committee's 2016 Ballistics Academic Conference [中国兵工学会弹道专业委员会 2016 年弹道学术会议] in Beijing. Li Hongzhi of this lab gave talks on torpedo ballistics, sonar in an oceanic environment, and high-speed underwater ballistics. In 2017, this lab again co-hosted the same conference, this time with the CSIC 713th RI. Topics included naval artillery defense systems [舰炮防御系统] and flight-controlled artillery technology [飞行控制炮弹技术]. The 2021 iteration of this event was co-hosted with Inner Mongolia North Heavy Industries Group Corp [内蒙古北方重工业集团有限公司]. Topics included new firing technology for firearms, internal ballistics and new dynamic technology for rocket engines, external ballistics of hypersonic vehicles, warhead terminal ballistics, and others.[308]
- The lab's Underwater Ballistics Team formed a joint research team with an unidentified PLA Navy Center and won a major Defense S&T award in 2020.[309]
- Weng Chunsheng of this lab was part of a NJUST delegation which met with CASC, the PLA General Armaments Department, and senior PLARF personnel in 2017.[310]
- The lab is affiliated with the China Society of Military Industry [中国兵工学会], particularly the Ballistic Professional and Technical Committee [挂靠有弹道专业技术委员会] and Underwater Weapon and Equipment System Professional Committee [水下武器装备系统专业委员会].[311]

*International*

- This lab invited a senior researcher, who is an expert on artillery ballistics, propellants, combustion, and advanced charge loading from the U.K.'s Imperial College and the International Ballistics Society to speak in 2016. The researcher gave a talk with explicitly military applications, on the topics of electrothermal chemical and electrothermal ignition guns. Further, the researcher's talk may have been in some way sponsored by or affiliated with British defense company QinetiQ.[312]

**Lab Equipment:**

- The lab possesses a Microscopic imaging differential scanning calorimeter system from U.S. company Mettler Toledo[313]
- 500-acre underwater science experiment center in Xuyi[314]
- Seven technical research platforms for internal ballistics, external ballistics, propulsion range extension and drag reduction, high-speed underwater ballistics, terminal ballistics, ballistic simulation, and ballistic planning and control[315]
- 3-in-1 ballistic research facility which includes a wind tunnel/target track/target range and water tunnel/water target/target range[316]
- Other lab equipment and facilities include:[xxxiv]
    - Rail signal controller system
    - Heating and ventilation integrated testing device
    - High-speed camera system
    - X-ray machine
    - Transient recorder
    - Digital coherent full-field strain test system
    - Digital turning center
    - High overload simulation test platform
    - Echo-free anechoic test system
    - Millimeter-wave test system
    - Multi-chip assembly equipment
    - Submillimeter-wave circuit design software
    - Infrared imaging system
    - Comprehensive ballistic target path, with the following parameters:
        - Launch weapon caliber: not more than 37mm
        - Launch initial velocity: not more than 6000m/s
        - Target path test distance: 240m
        - Static explosion equivalent: not more than 3TNT[317]
- An unofficial source[xxxv] lists further equipment:
    - 240m full ballistic target path
    - Explosion and impact laboratory
    - Target path measurement and control system
    - Orthogonal spark flash shadow photography system
    - Ultra-high speed launch test system
    - Pulse forming network and pulse power measurement and control system
    - VXI virtual instrument bus integrated measurement and control system
    - Stationary blast propulsion experiment system

[xxxiv] Photos for much of this equipment are available upon request
[xxxv] The source's unofficial nature means this information should be taken with caution, but likely originates from a now-deleted official source

    - Combustion-explosion reaction experimental platform - integrated measurement and control system
    - Fluid control and drag reduction experimental system
    - YA16 high-speed shadow photography system
    - Flash X-ray imaging system
    - Hopkinson rod experiment system
    - Computation and Data Processing Center - Microcomputer Parallel Computing Cluster System
    - Electromagnetic Orbital Emission Outdoor Integrated Test Site[318]
- Per one source, the current facility is the only laboratory that can conduct ultra-high speed (projectile velocity 6000m/s) ballistic tests.[319]

**Address**:

No. 200 Xiaolingwei Subdistrict, Nanjing, Jiangsu Province [江苏省南京市孝陵卫街道 200 号][320]

**Website**:

http://zdsys.njust.edu.cn/main.htm

**Known Aliases:**

- National Key Laboratory of Transient Physics [瞬态物理国家重点实验室]
- National Defence Research Laboratory of Ballistic

## 12. Defense S&T Key Laboratory of Communications Anti-Jamming Technology

**Official English Name:** National Key Laboratory of Science and Technology on Communications[321]

**Chinese Name:** 通信抗干扰技术国防科技重点实验室

**Post-2024 Name**: National Key Laboratory of Wireless Communications[xxxvi] [通信抗干扰全国重点实验室][322]

**Research Focus:**

Domain:

- Multi-Domain (Air, Space, Ground, Maritime)

Equipment:

- Communications Equipment

Functional Field:

- Multiple (Acoustics, GNC, Intelligent Technologies, Robotics, Sensing, Target Detection/Recognition)

**Affiliations:**

- University of Electronic Science and Technology of China (UESTC) [电子科技大学]

**Key Data:**

- Established: 1994
- Total Funding: 199m RMB
- Personnel: 77 (researchers)[323]
- Official start of operations: 1997
- Floor Space: Unknown

**Lab Overview:**

The Defense S&T Key Laboratory of Communications Anti-Jamming Technology conducts research into wireless, mobile, and satellite communications networks, broadband, signal processing, communications security, and integrated circuits for communications. It has also been

[xxxvi] While this appears to be the official English translation, the literal translation from Chinese is still "Communications Anti-Jamming," indicating a desire to conceal its military work.

involved in terahertz spectrum research, likely primarily for communications applications, and has been at the forefront of the PRC's 5G and 6G communications research.

As part of the systemic reorganization of the PRC research system, in January 2023 this lab reorganized as the National Key Laboratory of Wireless Communications [通信抗干扰全国重点实验室]. While this is its official English name, in Chinese it is still known as the "National Key Lab of Communications Anti-Jamming," indicating an effort to obscure its military work.[324]

**Further Information:**

- The lab may have at one time been called the Key Laboratory of "Tactical Communications and Anti-Jamming Technology," a far more military sounding name than the anodyne Key Laboratory of "Communications," as it is known in English. The use of the word "Tactical" in this lab's name is rarely seen, with the exception of the lab's research fund [战术通信抗干扰技术国防科技重点实验室基金], which still includes the term.[325]
- This lab (like many of these labs) confers graduate degrees. The lab currently has over 700 grad students, including roughly 130 PhD students and 570 master's students.[326] It sends the largest group of graduates to Huawei and ZTE. Smaller numbers found defense positions at CETC, CAEP, and the Research Institute of Nuclear Power Operation. Students have also gone on to CETC 10th, 29th, 30th, and 54th RIs, as well as private companies like Ali, China Mobile, China Unicom, and China Telecom.[327]
- Research teams under this lab include:
    - *Broadband Wireless Communication Systems and Intelligent Jamming Team* [宽带无线通信系统与智能抗干扰研究团队]
    - *Communication Coding and Transmission Team* [通信编码与传输研究团队]
    - *Wireless Communication Signal Processing Team* [无线通信信号处理研究团队]
    - *Communication Signal Processing and Special Integrated Circuit Team* [通信信号处理与专用集成电路研究团队]
    - *Intelligent Network and Robotic Studies Team* [智能网络与机器学习团队]
    - *Intelligent Wireless Self-Organizing Networks Team* [智能无线自组织网络团队].[328][xxxvii]
- This lab oversees at least two research centers: the Sichuan Terahertz Communications Engineering Research Center [四川省太赫兹通信工程研究中心] and the Intelligent Communications and Future Networks Research Center [智能通信与未来网络研究中心].[329]
- 90 percent of the lab's research is basic and applied basic research.[330]

[xxxvii] Detailed information about each of these teams is available upon request.

**Research Direction:**

1. Communication anti-jamming technology [通信抗干扰技术]
2. Broadband wireless communication technology [宽带无线通信技术]
3. Coding and communication security [编码与通信安全]
4. Satellite communication [卫星通信]
5. Communication special-purpose integrated circuits [通信专用集成电路]
6. Intelligent network and machine learning [智能网络与机器学习]

*Former (pre-2023 reform) lab research direction:*

1. Military-civil fusion wireless communications jamming technology [军民融合的无线通信干扰技术]
2. 5G/6G mobile communication technology and systems [5G/6G 移动通信技术与系统]
3. Wireless big data and intelligent communications technology [无线大数据与智能通信技术]
4. Millimeter wave, terahertz, new spectrum resources communications technology [毫米波，太赫慈新频谱资源通信技术]
5. Special broadband multimedia trunking communications technology [专用宽带多媒体集群通信技术]
6. Satellite communication technology [卫星通信技术]
7. Space-ground integrated network technology [天地一体化网络技术]
8. Antenna sensing and positioning technology [天线感知与定位技术]
9. Special chip design and technology for wireless communications [无线通信专用芯片设计技术][331]

*Other Notable Research Areas:*

- Fourth generation mobile communications technology
- Broadband wireless access technology
- Ultra-broadband radio technology
- Cognitive radio technology and networks
- Self-organized wireless communication networks
- Adaptive spread spectrum hopping technology
- Shortwave communications technology
- Cooperative wireless communications technology
- Air-time frequency multi-dimensional signal processing technology
- High-speed signal processing and implementation technology
- Satellite communications and networking technology
- Efficient compilation code technology
- Cryptography and information security technology
- Wireless communications positioning technology

- Sensor network technology
- Wireless communications system-on-chip design technology
- Spread spectrum hopping communications anti-jamming real technology
- Adaptive signal processing anti-jamming technology
- Wireless communications network anti-jamming technology
- Wireless and mobile communications systems and technology
- Satellite communications key technologies
- Communications special integrated circuit design technology
- New anti-jamming communication theories[332]

**Notable Applications:**

- This lab's research into the terahertz spectrum has widespread military implications, including for secure communications, anti-stealth radar, and ISR. The lab may have also been involved in using THz for space situational awareness and inter-satellite comms. A UESTC satellite, Tianyan-05 天雁 05 卫星] was launched in 2020 with THz Communications Equipment. Lab Director Li Shaoqian is involved in projects using terahertz technology for both anti-stealth radar and communications.[333]
- This lab and its Director Li Shaoqian led a major National 863 Project during the 11th Five Year Plan called "Spectrum Resource Sharing Wireless Communication Systems." The project achieved a breakthrough around 2012 and will be used in a new generation of mobile communications, including for security and military communications.[334]
- This lab is heavily involved in the development of 5G and 6G in China.[335]

**Leadership and Key Personnel:**

- Director: Tang Wanbin [唐万斌][336]
- Deputy Directors: Zhou Liang [周亮][337]; Chen Zhi [陈智][338]
- Former Director: Li Shaoqian [李少谦][339]
    - See "Notable Applications" section for more information.

*Key Personnel:*

- Gao Xiang [高翔][340]
    - Studied at Lund University in Sweden, worked for Sony Ericsson and in Silicon Valley in the U.S. on 5G-related projects
    - Projects currently funded by Huawei
- Liang Yingchang [梁应敞][341]
    - Academician with Acadamia Europaea, also worked in Silicon Valley for unknown U.S. company
    - Since returning to the PRC in 2015, has specialized in intelligent networks

- Liu Hao [刘皓][342]
    - Previously worked for Motorola

**Notable Collaborations:**

*Domestic*

- This lab has a joint 5G lab with Huawei. It is already working with Huawei on 6G technologies.[343]
- According to its website, this lab cooperates with major military aerospace, electronic, and armaments industry institutions, including CETC 7th RI, 54th RI, 30th RI, and 10th RI, CAS Software Institute, PLA GSD 61st RI, 63rd RI, and 57th RI, the PLA GAD Measurement and Control Institute, CSSC 722nd RI, CASC 1st Academy, 5th Academy, and 8th Academy, Huawei, ZTE Datang, Changhong, and the 783 Factory.[344]
- The lab has conducted research collaborations with PLA Units 63981 and 78006, and provided funding for research of the PLA GSD's 63rd RI and PLA Army Engineering University Communications Engineering College through its fund.[345]
- This lab co-hosted the 2020 Space Electronic Information Academic Exchange Conference [2020空间电子信息学术交流大会]. Topics included space communications technology and space internet technology, space exploration technology, space remote sensing technology, basic theories of space information, and space microwave, millimeter wave and terahertz technology. Discussions topics included the Beidou space navigation system, satellite communications, and space terahertz communications.[346]

*International*

- This Lab claims to have grad student joint training agreements with Columbia and Princeton Universities in the U.S., as well as Canadian (University of Toronto, University of Waterloo), U.K. (University of Glasgow), Australian (University of Sydney), and Swedish (KTH Royal Institute of Technology) universities.[347] One PhD student at the lab, Zhang Qianqian [张倩倩] who focuses on mobile 6G communications, studied at Princeton University in 2019-2020.Following her return to the PRC, she allegedly continued to work with the Princeton team.[348]
- This lab claims to have cooperated with U.S. and international companies Intel, Siemens, Nokia, DoCoMo, National Semiconductor, Philips, France Telecom, LG, STMicroelectronics, and the Swiss government. Its grad students have allegedly gone on to work at Texas Instruments, Lucent, and Ericsson.[349]
- The lab established the Cisco-UESTC Joint Research Center for Green Technology [思科公司-电子科技大学绿色技术联合研究中心] with U.S. company Cisco.[350]
- This lab established a Joint Research Center for Wireless Communications [联合无线通信研究中心] with the KTH Royal Institute of Technology in Sweden.[351]

- In 2024, this lab co-organized the 3rd International Conference on Electronic Information Technology (EIT 2024) [第三届电子信息技术国际学术会议], along with the University of Electronic Science and Technology of China and others. Foreign presenters came from Canada (National Research Council of Canada) and Finland (University of Eastern Finland).[352]
- This lab is slated to co-organize the 2025 10th International Conference on Computer and Communications Systems (ICCCS 2025) [2025 年第十届计算机与通信系统国际会议], which will focus on 5G/6G communications, internet-of-things, and AI technologies. PRC presenters and organizers came from Northwestern Polytechnical University. Foreign presenters came from the U.K. (University of Glasgow), Singapore (Singapore University of Technology and Design). Conference committee members came from Japan (Okayama University) and the Philippines (John Paul College, Technological Institute of the Philippines).[353]
- In 2024, the Director of this lab served on the committee for the 24th International Conference on Communication Technology (IEEE ICCT 2024) [2024 年 IEEE 第 24 届国际通信技术会议]. Other committee members came from Huawei, ZTE, China Mobile, and others. Foreign committee members came from the U.K. (University of Glasgow), Norway (University of Oslo), Greece (Aristotle University of Thessaloniki), Singapore (Nanyang University of Technology, Singapore University of Technology and Design). Foreign presenters came from the U.K. (Imperial College London), Canada (University of Waterloo), Japan (Tohoku University), and Singapore's Agency for Science, Technology and Research.[354]

**Lab Equipment:**

None found

**Address**:

Main Building, Area B3, UESTC Qingshuihe Campus, Xiyuan Boulevard, Chengdu, Sichuan Province [四川省成都市西源大道电子科技大学清水河区主楼 B3 区][355]

**Website**:

https://www.ncl.uestc.edu.cn/index.htm

**Known Aliases:**

- Defense S&T Key Laboratory of Tactical Communications Anti-Jamming Technology [战术通信抗干扰技术国防科技重点实验室]

- State Key Laboratory of Science and Technology on Communications [通信抗干扰技术国家级重点实验室]
- 抗干扰技术国防科技重点实验室
- 通信抗干扰技术国家级重点实验室
- National Key Laboratory of Communication
- National Anti-Interference Communication Technology Lab
- National Key Laboratory of Communication Anti-interference Technology
- National Key Laboratory of Anti-Interference Communication Technology
- National Key Laboratory of Anti-jamming Communications Technology

## 13. Defense S&T Key Laboratory of Communications Countermeasures Technology

**Official English Name:** Science and Technology on Communication Information Security Control Laboratory[356]

**Chinese Name:** 通信对抗技术国防科技重点实验室

**Post-2024 Name:** National Key Laboratory of Electromagnetic Space Security [电磁空间安全全国重点实验室][357]

**Research Focus:**

Domain:

- Likely multi-domain

Equipment:

- Multiple (Communications Equipment, Electronic Warfare)

Functional Field:

- Communications Technologies
- *Secondary: Countermeasures, Intelligent Technologies*

**Affiliations:**

- China Electronics Technology Group Corporation (CETC) [中国电子科技集团]
  - CETC 36th Research Institute [36 研究所]
  - (Possibly) CETC 29th Research Institute [29 研究所]

**Key Data:**

- Established: 2005
- Total Funding: Unknown
- Personnel: Unknown[358]
- Official start of operations: 2007
- Floor Space: Unknown

**Lab Overview:**

The Defense S&T Key Laboratory of Communications Countermeasures Technology conducts research into communications technologies, including information control and security, signal processing, communications in complex electromagnetic environments, communications jamming and countermeasures, electronic warfare, and information warfare.[359]

This lab is also frequently referred to as the Key Laboratory of Communications Information Control and Security Technology [通信信息控制和安全技术重点实验室].[360] Under the ongoing reorganization of the PRC's national key lab system, this lab is now known as the National Key Lab of Electromagnetic Space Security [电磁空间安全全国重点实验室].

The lab's parent institution, the CETC 36th Research Institute, was established in 1978 and is located in Jiaxing. It is responsible for research into communications and information control systems and equipment. Today, it is concerned with research into mobile communications security, 5G and the internet of things.[361] There is also evidence that this lab may now also be subordinate to the CETC 29th Research Institute.[362]

**Further Information:**

- This lab, along with the 36th Research Institute, oversees an academic journal called "Communications Countermeasures" [通信对抗]. It is focused on communications electronic warfare and information warfare.[363]
- This lab released a translation of Richard Poisel's "Modern Communications Jamming Principles and Techniques."[364] Richard Poisel is a senior engineer at Raytheon and formerly the chief scientist at U.S. Army Research, Development and Engineering Command who has written a large number of books on electronic and information warfare.[365]
- The lab's Innovation Team [创新团队] was named as part of the 1st batch of National Defense Industry, Science, and Technology Innovation Teams [国防工业科技创新团队] in June 2007. A photo of the Innovation Team shows 14 members, all men.[366]

**Research Direction:**

No formal research direction was found. Informally, the research direction may be:

1. Communications and information control and security technology [通信信息控制和安全技术]
2. Communications signal processing [通信信号处理][367]

**Notable Applications:**

- This lab's research has been applied to cognitive electronic warfare [认知电子战] (i.e., the use of AI, networks, and deep learning in electronic warfare).[368]
- A team made up primarily of members of this lab designed an anti-UAV defense system utilizing tracking and jamming of UAVs for the protection of nuclear power plants and other sensitive targets.[369]

- Yang Xiaoniu's team has developed AI for information control systems, allowing deep learning to drive end-to-end target identification technology for electromagnetic signals. It also developed the first portable equipment for signal target identification, improving electromagnetic signal target identification capabilities.[370]
- There was speculation in PRC media that Yang Xiaoniu's team was involved in the development of the CETC millimeter-wave anti-stealth radar, but this is not backed up by hard evidence.[371]

**Leadership and Key Personnel:**

- Director: Zhao Ming [赵明][372]
    - Also serves as 36th RI Director
- Academic Committee Director: Yang Xiaoniu [杨小牛][373]
    - CAE Academician
    - Expert on signal processing and software radio [软件无线电] technology
    - Invented an advanced broadband digital receiver [宽带数字接收机] in the early 1990s which filled a major domestic need
    - Developed the PRC's first comprehensive electronic information control system [综合电子信息控制系统] in the early 2000s, with significant military benefits
    - Created command system for an unidentified satellite payload
    - Created a new generation of systems architecture for a military electronic information system
    - Based on number of mentions, Yang seems to be the most celebrated figure working at this lab rather than Director Zhao.

**Notable Collaborations:**

*Domestic*

- Yang Xiaoniu was a co-chairman of the 2017 China Electronic Warfare Exchange Conference [2017 全国电子战学术交流大会], and the lab's journal, "Electronic Countermeasures," was a supporting media for the event.[374]
- This lab co-hosted a conference on big data, with topics including big data for national defense, network defense, AI and deep learning, and Beidou satellite navigation. Yang Xiaoniu spoke on the subject of signal data.[375]
- This lab participated in a conference on radio wave propagation [电波传播] in 2019 which featured participants from PLA Naval Aviation University and the National University of Defense Technology.[376]

*International*

- In 2024, this lab co-organized the 14th International Conference on Antenna, Propagation and Electromagnetic Theory (ISAPE 2024) [第十四届天线、传播及电磁理论国际会议], along with multiple other national and provincial-level labs and research centers, as well as at least one other national-level defense lab. Foreign presenters gave talks on smart hypersurfaces, 6G wireless communications, wireless energy transfer, integrated waveguides, and electromagnetic information theory, coming from the U.K. (Durham University, University of Liverpool), Canada (University of Montreal), Japan (Chiba University), Italy (University of Siena) and Finland (Aalto University).[377]
- This lab is co-organizing the 2025 International Conference on UAV Application and 6th China International UAV and Anti-UAV [2023 国际无人机应用及防控大会]. PRC organizers included the CETC 11th and 36th RIs, CASC 3rd Academy, Beihang University, Nanjing University of Aeronautics and Astronautics, and People's Police University. Foreign organizers included Italy's AIAD (an aerospace and defense industry federation), the Spain Defense, Security, and Aerospace Association [西班牙防务安全与航空航天协会 - author's translation, real name unknown], the Europe UAV Training and Operation Association [欧洲无人机培训运营协会 - author's translation], and France's Association for Medium and Small Enterprise Sustainable Development [法国中小企业可持续发展合作创新协会 - author's translation]. Among other topics, the conference is interested in exploring UAVs and anti-UAV technologies for defense, security, and law enforcement use, as well as various civilian uses. While little is available about presenters or participants, the previous conference in 2023 featured presenters from the PLA National University of Defense Technology, PLA Academy of Military Sciences, AVIC, CASC, CASIC, CETC, Harbin Engineering University, Beijing Institute of Technology, and Beihang University. One presenter came from Spain (Spanish Association for UAVs [西班牙无人机协会 - author's translation]).[378]
- In 2024, this lab co-organized the 2024 and 2025 International Conference on Communication Software and Networks (ICCSN) [通信软件与网络国际会议]. Other co-organizers or committee members included CETC 41st and 54th RI, and Harbin Institute of Technology. Foreign organizers, speakers, and committee members came from the U.S. (University of Houston, University of Alabama, Tuscaloosa, Bethel University, Oakland University, University of Texas Dallas), U.K. (Liverpool John Moores University), Australia (La Trobe University), Canada (University of Alberta), France (Sorbonne Paris Nord University, University of Haute-Alsace), Italy (Universita di Roma La Sapienza), Poland (Polish Academy of Sciences), Portugal (University of Evora), Singapore (A*STAR), Israel (Israel Institute of Technology), and India (Hooghly Engineering & Technology College, IIT-Kanpur, Sri Krishna Polytechnic College, Jaypee University of Information Technology, Govt. Polytechnic), as well as universities from Malaysia, Morocco, Bangladesh, Brazil, Brunei and Pakistan.[379]
- This Lab co-organized the 12th International Symposium on Antennas, Propagation and EM Theory in December 2018. At least two other DSTKLs, the DSTKL of Electronic

Information Control and the DSTKL of Radio Wave Environmental Characteristics and Modeling Technology, were also co-organizers. It featured multiple international speakers and participants, including speakers from the U.S. (University of West Virginia, URSI USA, Duke University, University of Utah, Arizona State, University of Illinois, University of Arizona, Penn State, 2COMU Inc, University of New Mexico), Canada (Concordia University, Polytechnique Montréal, Royal Military College of Canada), U.K. (University of Kent, University of Nottingham), Singapore (Nanyang Technological University, National University of Singapore), Japan (Chiba University, Hosei University, Nagasaki University, Tohoku University), Germany (Karlsruhe Institute of Technology), Italy (University of Florence), Netherlands (URSI Commission J), and Spain (Charles III University of Madrid). PRC presenters and committee members came from the PLA National University of Defense Technology, CETC, Beihang University, Beijing Institute of Technology, Harbin Institute of Technology, and Nanjing University of Science and Technology.[380]

- This Lab participated in the 2020 4th Micro-Nano Optics Technology and Application Exchange Conference [第四届微纳光学技术与应用交流会], which featured foreign participants, including from UC Irvine, UCLA, and Canada's Institut National de la Recherche Scientifique. PRC Participants came from CETC, Beijing Institute of Technology, and Nanjing University of Science and Technology.[381]

**Lab Equipment:**

- The lab has over 120 pieces of equipment related to RF testing [射频测试], simulation testing [仿真测试], and electromagnetic compatibility testing [电磁兼容测试].[382]

**Address**:

No. 387 Hongxing Road, Jiaxing, Zhejiang Province [浙江省嘉兴市洪兴路 387 号][383]

**Known Aliases:**

- Key Laboratory of Communications Information Control and Security Technology [通信信息控制和安全技术重点实验室]
    - This is the far more common name used in Chinese sources.
- 通信信息控制与安全技术重点实验室
    - Same name as above, but swaps a single character (与 instead of 和)
- Key National Laboratory of Communications Systems Information Control and Security Technology [通信系统信息控制技术国家级重点实验室]
- Defense Key Lab of Communications Information Control Technology [通信信息控制技术国防重点实验室]

- Key Laboratory of Communications Information Control Technology [通信信息控制技术重点实验室]
- Defense S&T Key Laboratory of Low Interception Probability Signal detection [低截获概率信号侦测国防科技重点实验室]
    - There is a single public mention of this lab, and it is unclear if it is the same or a different lab.
- National Laboratory of Information Control Technology for Communication System
- Science and Technology on Communication Information Security Control Laboratory
- Key Laboratory of Communication Information Control and Security Technology
- Communication Information Controlling Safety Technology Laboratory

## 14. Defense S&T Key Laboratory of Complex Aviation Systems Simulation

**Official English Name:** Science and Technology on Complex Aviation Systems Simulation Laboratory[384]

**Chinese Name:** 复杂航空系统仿真国防科技重点实验室

**Post-2024 Name**: (likely) National Key Laboratory of Complex Aviation Systems Simulation [复杂航空系统仿真全国重点实验室][385]

**Research Focus:**

Domain:

- Multi-Domain (Air, Space)

Equipment:

- Multiple (Aircraft, Air/Missile Defense, Non-Ballistic Missiles, Radars, Space Vehicles, Unmanned Systems)

Functional Field:

- Multiple (Countermeasures, Hypersonic Technologies, Intelligent Technologies, Simulation & Modeling)

**Affiliations:**

- PLA Air Force Research Academy [空军研究院]
    - Institute of Systems Engineering [系统工程所]

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab was the PLAAF's first national-level lab.[386] It conducts research into a wide range of weapons systems and technologies relevant to the PLAAF, including aircraft, UAV, missile, radar, and air defense systems.

The lab appears to have gone by multiple names over the years. It is likely the same as the Defense S&T Key Laboratory of Air Force Weapons and Equipment Systems Research due to an overlap in missions, location, and personnel. Around 2010, it may have also been known as the

Complex Systems 4th Laboratory.[387] It is most frequently referred to simply as a "Key Lab" rather than a DSTKL, but has occasionally been referred to as a DSTKL in official sources.[388] Further, it is referred to as a "national-level" lab, suggesting it may in fact be a DSTKL.[389] It was likely formerly subordinate to the former PLAAF Equipment Research Academy's Overall Equipment Demonstration Institute [空军装备研究院装备总体论证研究所][390] before finding itself under the PLAAF Research Academy's Institute of Systems Engineering following reforms to the PLA's Research Academy system.

Under the ongoing reorganization of the PRC's national key lab system, this lab may now be known as the National Key Lab of Complex Aviation Systems Simulation [复杂航空系统仿真全国重点实验室].

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

Topics of research are as varied as the missions of the PLAAF, and include:

- Air defense command simulations and modeling[391]
- Air-to-ground missile target damage simulation[392]
- Modeling of air force weapons and equipment effectiveness[393]
- UAV development[394]
- Radar tracking for missile defense[395]
- Tracking of hypersonic targets[396]
- Satellite telemetry[397]
- UAV systems[398]
- Air-to-air missile development[399]
- Radar tracking of ground targets[400]
- Next-generation fighter aircraft[401]

**Notable Applications:**

None found

**Leadership and Key Personnel:**

No leadership found

*Key Personnel:*

- Zhang Jing [张菁]

    - Senior Engineer
    - Co-hosted "Youth Salon" on Air Intelligent Gaming Countermeasures[402]
    - Researches trends in next-gen fighter aircraft[403]
- Liu Yongjian [刘永坚]
    - Senior Engineer
    - Co-hosted the Second Target Recognition and Artificial Intelligence Summit [目标识别与人工智能高峰论坛] (see "Domestic Collaborations" for more)[404]
- Cui Yonghua [崔永花]
    - On the executive committee of China Computer Federation's Special Committee for Fault Tolerant Computing [容错计算专业委员会][405]

**Notable Collaborations:**

*Domestic*

- In 2020, this lab co-hosted a "Youth Salon" on Air Intelligent Gaming Countermeasures [空中智能博弈对抗技术发展青托沙龙] with the China Association for Science and Technology [中国科学技术协会], led by lab senior engineering Zhang Jing [张菁] and focused on airborne intelligent technologies. Participants included young scholars from the PLA Naval Aviation University, Beihang University, Northwestern Polytechnical University, Air Force Engineering University, University of Science and Technology of China, Nanjing University of Aeronautics and Astronautics, National University of Defense Technology, Xi'an Jiaotong University, Shenyang University of Aeronautics and Astronautics, Peking University, CAS Xi'an Institute of Optical Mechanics, and AVIC.[406]
- This lab co-hosted the 2020 National High-end Forum on Avionics Information Technology [2020年全国航空电子信息技术高端论坛] with CETC, the Chinese Institute of Electronics [中国电子学会], Chinese Society of Aeronautics and Astronautics [中国航空学会], and Chinese Society for Optical Engineering [中国光学工程学会]. The forum was focused on overall avionics system technology, informatization network application technology, airborne sensors, and information processing technology.[407]
- Senior Engineer Liu Yongjian [刘永坚] of this lab co-hosted the Second Target Recognition and Artificial Intelligence Summit [目标识别与人工智能高峰论坛] for both military and civilian applications. The summit featured participation from CAS institutes such as the Xi'an Institute of Optics and Precision Machinery and Shenyang Institute of Automation. Topics included target detection and tracking, robotic visual perception and learning, ballistic automatic target recognition, and AI for space-based remote sensing.[408]

**Lab Equipment:**

None found

**Address**:

Beijing 100076 [北京市][409]

**Known Aliases:**

- Complex Systems 4th Laboratory [复杂系统第四实验室]
    - Likely former name
- Defense S&T Key Laboratory of Air Force Weapons and Equipment Systems Research [空军武器装备体系研究国防科技重点实验室]
- 复杂航空系统仿真重点实验室
    - Much more common Chinese name
- 北京复杂航空系统仿真重点实验室

## 15. Defense S&T Key Laboratory of Complex Land Systems Simulation

**Official English Name:** Unknown

**Chinese Name:** 地面复杂系统仿真国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Ground
- *Secondary: Air*

Equipment:

- Equipment/Acquisitions Strategy
- *Secondary: Ballistic Missiles, Armor, Ground Vehicles, Air/Missile Defense, Artillery*

Functional Field:

- Simulation & Modeling

**Affiliations:**

- (likely) Central Military Commission Equipment Development Department [中央军委装备发展部]
    - *Formerly PLA General Armaments Department [总装备部]*

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

Much of the information about this lab can be gleaned from what is known about its Director, Tang Xuemei, an officer in the General Armaments Department (now the CMC Equipment Development Department). The lab itself may be a part of the GAD/EDD, although this is never explicitly stated. As with its air force and naval counterparts, it conducts research into new weapons and equipment development via modeling and simulation,[410] as well as performing equipment analysis and assessment. Its research has been used to improve equipment development

for surface-to-surface missiles and armored systems, and for more realistic modeling of operations and OPFOR training for PLA air defense and artillery.

One of the lab's key distinctions is its emphasis on Small Sample Theory [小子样理论], analyzing subsystem test data to draw conclusions about the whole system based on a small/limited number of field tests. This method reduces the necessary number of tests, shortening the equipment development cycle and saving time and money. This lab is reportedly the leading organization applying Small Sample Theory to PLA weapons and equipment.[411]

This Lab is known to have existed since at least 2008 by a different name, the Defense S&T Key Lab of Army Weapons and Equipment Systems Research [陆军武器装备体系研究国防科技重点实验室]. It appears to have changed to its current name around 2016, just as the PLA's major reforms were being implemented and the lab likely became part of the EDD.[412]

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- Equipment Testing Analysis and Assessment Technology [装备试验分析与评估技术][413]
- Experimental analysis and evaluation based on small/limited number of field tests [小子样试验评估][414]
- Large complex systems modeling and simulation [复杂系统建模与仿真][415]

**Notable Applications:**

- Small Sample Theory is used in missile development, and one source describes the importance of this theory to the PLA's ballistic missiles: using this method, only 3 test firings were required rather than 15 for a certain tactical missile.[416]
- The lab has conducted modeling of operations and training in complex electromagnetic environments, including more realistic simulations of air defense operations in complex electromagnetic environments.[417]
- The lab has conducted assessments and simulations of surface-to-surface missiles for superior penetration, and assessments of enemy missile defense and early warning systems.[418]
- The lab has developed an "Applied Equipment Systems Research and Wargame System" [应用装备体系研究推演系统] for OPFOR simulations, including armor and artillery.[419]
- The lab has contributed to new armor systems, including the 3rd generation main battle tank, a new generation of tracked infantry fighting vehicle, an airborne fighting vehicle, an amphibious armored assault vehicle, and a wheeled armored vehicle.[420]

**Leadership and Key Personnel:**

- Director: Tang Xuemei [唐雪梅]
  - Serves on CMC Military Product Determination Committee [中央军委军工产品定型委员会][421]
  - PLAA officer and graduate of NUDT[422]
  - Served as Director of the 5th Office of the GAD Artillery and Air Defense Equipment and Technology Research Institute [总装炮兵防空装备技术研究所五室][423]

**Notable Collaborations:**

None found

**Lab Equipment:**

None found

**Address**:

Possibly north of Beijing[424]

**Known Aliases:**

- Defense S&T Key Lab of Army Weapons and Equipment Systems Research [陆军武器装备体系研究国防科技重点实验室]

## 16. Defense S&T Key Laboratory of Complex Vessel Systems Simulation

**Official English Name:** Unknown

**Chinese Name:** 复杂舰船系统仿真国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Maritime
- *Secondary: Air*

Equipment:

- Equipment/Acquisitions Strategy
- *Secondary: Aircraft, Computers, Surface Vessels, Underwater Vehicles*

Functional Field:

- Simulation & Modeling
- *Secondary: Cyber Technologies*

**Affiliations:**

- PLA Navy Research Academy [海军研究院]

**Key Data:**

- Established: possibly around 2002[425]
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: 2010[426]
- Floor Space: Unknown

**Lab Overview:**

This lab may have been first established around 2002, and passed inspection in November 2010. As with its army and air force counterparts, it is tasked with conducting assessments and simulations to gauge future procurement requirements for naval weapons and equipment, utilizing computer simulations and comprehensive integrated technologies [综合集成技术] to aid decision making. It researches both strategic and operational requirements, covering the whole process of equipment systems research.[427] Areas of research are wide (presumably as wide as the requirements of the PLAN), and include study of equipment for future joint warfare, cyber warfare, naval aircraft, and underwater warfare, among many other topics.

Previously known as the Defense S&T Key Laboratory of Naval Weapons and Equipment Systems Research [海军武器装备体系研究国防科技重点实验室], this lab changed its name following the 2016 PLA reforms. While no public sources indicate that it is currently a Defense S&T Key Lab, this is presumed based on the fact that its army and air force equivalents are both confirmed to be DSTKLs.

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- Joint warfare simulations[428]
- Network operations and cyber defense[429]
- VSTOL aircraft design[430]
- Underwater combat capabilities based on underwater preset systems (designed to resist unnamed "strong enemies" seeking to contain PLAN forces)[431]

**Notable Applications:**

None found

**Leadership and Key Personnel:**

- Management Office Director: Jing Tao [荆涛]
    - 2010, possibly dated[432]

**Notable Collaborations:**

None found

**Lab Equipment:**

None found

**Address**:

Beijing 100161 [北京市][433]

**Known Aliases:**

- Key Laboratory of Complex Vessel Systems Simulation [复杂舰船系统仿真国防科技重点实验室]
    - More common
- Defense S&T Key Laboratory of Naval Weapons and Equipment Systems Research [海军武器装备体系研究国防科技重点实验室]
    - Former name

## 17. Defense S&T Key Laboratory of Composite Material Technology in Special Environments

**Official English Name:** National Key Laboratory of Science and Technology on Advanced Composites in Special Environments[434]

**Chinese Name:** 特种环境复合材料技术国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Space
- *Secondary: Air*

Equipment:

- Space Vehicles
- *Secondary: Aviation*

Functional Field:

- Materials
- *Secondary: Intelligent Technologies, Manufacturing, Simulation & Modeling*

**Affiliations:**

- Harbin Institute of Technology (HIT) [哈尔滨工业大学]
    - School of Astronautics [航天学院]

**Key Data:**

- Established: 2000
- Total Funding: over 90m RMB
- Personnel: 78[435]
- Official start of operations: 2008
- Floor Space: 9,205 sqm

**Lab Overview:**

This lab researches key technologies related to advanced composite materials and structures under extreme environmental conditions. These "special environments" include ultra-high and ultra-low temperatures, ultra-high pressure, and irradiated environments. The research is primarily geared toward the PRC's space program, but is also utilized by aviation and other fields requiring advanced materials.[436]

**Further Information:**

- The lab has a branch in Shenzhen as part of an HIT research cluster in the city.[437]
- The lab has an "Infrared Thin Films and Crystals" Team [红外薄膜与晶体团队] which is led by Sam Zhang [张善勇], an HIT professor who is also a Fellow of the U.K. Institute of Materials, Minerals and Mining and Royal Society of Chemistry.[438]
- This lab may have seen a major increase in size and funding since 2018, when it allegedly had only 60 full-time personnel, 6,180 sqm of space, and 112 million RMB of equipment (as opposed to 78 personnel, 9,205 sqm, and 174m RMB of equipment by 2020).[439]
- This lab is also associated with the HIT Composite Materials and Structures Research Institute [复合材料与结构研究所]. According to one source, the Institute "relies upon" this lab, and there is overlap in personnel and leadership. The Institute's research focuses on ultra-high temperature anti-insulation materials [超高温防隔热材料], lightweight structural composites [轻质结构复合材料], and intelligent composites and structures [智能复合材料与结构]. Special composite materials created by the Institute are mainly utilized for aerospace applications, most notably in the C919 aircraft.[440]
- The lab's Innovation Team [创新团队] has made advances in space heat defense materials [航天热防护材料], lightweight structures [轻量化结构], special opto-electronic functional materials [特种光电功能材料], and intelligent materials [智能材料]. It has been designated as a Ministry of Science and Technology National-Level International Joint Research Center [科技部国家级国际联合研究中心].[441]
- In 2020, HIT began construction of a Key Lab Cluster [重点实验室集群] in Shenzhen featuring research space for several of its key labs, including this one. The cluster will focus on automated products [自动化产品], high-end equipment design and distribution [高端装备设计开发], technical transformation and improvements [技术改造提升], and guided production applications and industrialization [指导生产应用和产业化]. It is set to open in December 2023.[442]

**Research Direction:**

1. Simulation and design optimization of special environment composites [特种环境复合材料模拟表征与优化设计]
2. Composite and organizational property control technology [复合与组织性能控制技术]
3. Property testing and analysis techniques [性能测试与分析技术][443]

*Other Notable Research Areas:*

- Material-environment coupling mechanisms [材料与环境耦合作用机理]
- Material design and low-cost manufacturing [材料设计与低成本制造]

- Material performance characterization and evaluation [材料使用性能表征与评价][444]
- Ultra-high temperature anti-insulation materials
- Intelligent composites and structures

In 2024, the lab's open fund [特种环境复合材料技术国家级重点实验室开放基金] expressed interest in funding the following research:[445]

Each project has a 2-3 year period and 200,000 to 800,000 RMB in funding

1. Simulation, characterization and optimization of special environmental composites design technology
   (1) Combined active/passive ultra-high temperature thermal protection mechanism and method
   To carry out research on the design of new active/passive combined ultra-high temperature thermal protection materials and thermal protection mechanisms.
   (2) Basic Research on applications of high performance materials for thermal protection
   Using low-density, high-temperature resistant carbon foam or ceramic-type porous heat-insulating materials, research on porous materials and their microstructural features in the anti-insulation, energy diversion in the role of mechanisms and design, evaluation and other applications.
   (3) Mechanisms and simulation means of interaction between thermal insulation materials and the environment under high temperature extreme environments
   Analyze the key physical effects of high enthalpy non-equilibrium flow and the characteristics of aerodynamic thermal environment, and study the coupling mechanisms of new ablative/non-ablative thermal protection materials and aerodynamic thermal environments, service behavior evolution simulation, and performance characterization.
   (4) Research on comprehensive simulation methods of multifactor coupling effects in proximity space
   Carry out simulation of multi-factor coupling effect of composite materials, research composite material performance evolution and composite material evolution mechanisms.
2. Special materials composite and organization performance control technology
   (1) Anti-/heat insulation of new materials, new technology exploration and research
   Explore new materials, new processes, and new methods for heat prevention/insulation, develop long-term non-ablative materials, lightweight performance materials, and improve the efficiency of heat prevention systems and thermal structures. Carry out research on new processes for the preparation of new heat-proof coating materials and heat-insulating materials.
   (2) Structural Functional Composite Materials Technology Research
   Carry out technical research on transparent ceramics, infrared window materials, sound-transparent composites and thin film materials, and improve the performance of optical windows, infrared windows and infrared hoods.
   (3) Preparation Methods of Shape Memory Polymer Composite Materials

Research methods to improve the specific stiffness and deformation recovery rate of shape memory polymers, and master the preparation methods of new epoxy resin-based shape memory composites suitable for space use.

(4) Research on Preparation Technology of Microelectronic/Optoelectronic Materials
Develop wide-band semiconductor diamond single crystal, gallium nitride single crystal, aluminum nitride single crystal, silicon carbide single crystal preparation technology, improve the power density of core components, high temperature resistance, and anti-irradiation performance. Carry out laser dielectric materials, infrared detection materials and ultraviolet detection materials preparation of new processes to improve material uniformity and photoelectric properties.

3. Special materials performance testing and analysis technology
   (1) Basic performance of special materials testing and characterization methods
   Development of reusable materials in extreme environments under the performance of the test and characterization methods and technologies.
   (2) Flight test service environments and material response special sensing test methods
   Carry out research on special sensing test methods for high-performance miniaturized service environment factors and material response, and provide technical means for ground simulation test and flight test research.
   (3) Non-destructive testing technology for defects in carbon fiber reinforced resin matrix composites
   Explore new non-destructive testing techniques for defects in carbon fiber reinforced resin matrix composites, improving the accuracy and efficiency of defect detection, and realize online non-destructive testing.
   (4) New sensor technology
   Design and prepare novel pressure sensors, icing sensors, and temperature sensors, and explore their applications in whole-life health monitoring of space/aircraft.

**Notable Applications:**

- This lab developed composite materials and instruments for multiple space vehicles. Public examples include materials for the Long March-5 rocket, a measurement sensor for spacecraft re-entry vehicles, an inflated deployable discrete reinforced membrane boom for satellite attitude control, and the world's first shape-memory polymer composite–based flexible solar array used in space.[446]
- The HIT Composite Materials and Structures Research Institute, which relies heavily on this lab for research, was involved in creating composite materials for the C919 passenger aircraft.[447]

**Leadership and Key Personnel:**

- Director: He Xiaodong [赫晓东][448]

- Deputy Directors: Zhang Xinhong [张幸红]; Lu Haibao [吕海宝]; He Fei [何飞]; Xiong Jian [熊健][449]

**Notable Collaborations:**

*Domestic*

- A study on ultra-high temp ceramics was conducted in collaboration with PLAAF Unit 93413 1st Flight Group [93413 部队飞行一大队].[450]
- In 2010, this lab ran a joint experts group with the Defense S&T Key Laboratory of Precision Hot Forming of Metals [金属精密热加工两个国家级重点实验室] for SASTIND and the PLA General Armaments Department.[451]
- In 2019, this lab hosted a conference, the National Academic Conference on Ultra-High Speed Collisions [全国超高速碰撞学术会议], with two other labs: the Key National Lab of Space Environment Materials Behavior and Evaluation Technology [空间环境材料行为与评价技术国家级重点实验室] and the National Defense S&T Key Lab for Micro-Spacecraft Technology [微小型航天器技术国防重点实验室].[452]

*International*

- This lab has a branch in Shenzhen, where it is part of HIT's Shenzhen key lab research cluster. At least one other DSTKL, the DSTKL of Tunable Gas Lasers, is also present. HIT's Shenzhen research cluster also features the Sauvage Intelligent New Materials Laboratory, which is run by French chemist and 2016 Nobel Prize winner Jean-Pierre Sauvage. As of 2022, it has 5-year funding of 100m RMB. It researches new intelligent materials, including micro and nano-machines and smart sensing based on smart new materials, bio-applications of new two-dimensional atomic crystalline materials, smart quantum materials and flexible sensors, flexible and smart electrochemical energy storage devices, and energy-containing materials based on smart molecular design. It is unclear to what extent the two labs interact.[453]
- This lab oversees the HIT International Center of Applied Mechanics [哈尔滨工业大学国际应用力学中心] along with the HIT School of Astronautics Institute of Composite Materials and Structures [航天学院复合材料与结构研究所], Department of Aerospace Science and Mechanics [航天科学与力学系], Institute of Flight Vehicle Dynamics and Control [飞行器动力学与控制研究所], the National Engineering Mechanics Teaching Base [国家工科力学教学基地], and the National Mechanics Experimental Teaching Demonstration Center [国家级力学实验教学示范中心]. The Center facilitates international exchange and cooperation on cutting-edge issues in the field of mechanics. Areas of focus include extreme environment materials and structural mechanical behvior, lightweight and composite mechanics, new aerospace vehicle dyanmics and vibration control, and intelligent composite materials. As of 2023, it is recruiting doctoral students from overseas research institutions.[454] Researchers from the University of Maryland

Department of Aerospace Engineering and the University of Bristol in the U.K. have visited and given lectures at the Center.[455] A Russian researcher affiliated with the Center, Pavel Utkin, gave a lecture on numerical simulation of high-speed compressible flows in aerospace research and explosion safety. In the lecture, he apparently showed a video provided by a researcher at U.S. Argonne National Laboratory, although the nature of the relationship is unclear.[456]

- As of 2015, the HIT Composite Materials and Structures Research Institute [复合材料与结构研究所], which is closely associated with this lab, claimed to have an overseas joint lab with Harvard University, as well as long-term exchange and cooperation with Stanford and Northwestern University in the U.S., Australia's Sydney University, and the University of Bristol in the U.K. It claims to have various agreements with institutions in France, Russia, Ukraine, and Singapore.[457]
- This lab collaborates with several other HIT labs on the HIT Functional Composite Materials Lab [功能复合材料实验室], an interdisciplinary lab which allegedly cooperates with unnamed universities in the U.S., Germany, Belgium, Russia, and Singapore.[458]

**Lab Equipment:**

- This lab has 1,726 pieces of equipment worth 174 million RMB.[459]

**Address**:

Co-located with HIT School of Astronautics at No. 92 Dazhi West Road, Nangang District, Harbin, Heilongjiang Province [哈尔滨市南岗区西大直街 92 号][460]

**Website**:

http://sa.http://sa.hit.edu.cn/2020/1225/c6640a250512/page.htmhit.edu.cn/2020/1225/c6640a250512/page.htm

**Known Aliases:**

- National Key S&T Laboratory on Advanced Composites in Special Environments [特种环境复合材料技术国家级科技重点实验室]
- National Key Laboratory on Advanced Composites in Special Environment

## 18. Defense S&T Key Laboratory of Computational Fluid Dynamics

**Official English Name:** National Laboratory for Computational Fluid Dynamics

**Chinese Name:** 计算流体力学国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Space
- *Secondary: Air*

Equipment:

- Space Vehicles
- *Secondary: Aircraft*

Functional Field:

- Aerodynamics
- *Secondary: Hypersonic Technologies, Simulation & Modeling*

**Affiliations:**

- Beihang University [北京航空航天大学]
  - School of Aeronautic Science and Engineering [航空科学与工程学院]
- PLA China Aerodynamics Research and Development Center (CARDC) [中国空气动力研究与发展中心]
  - *a.k.a. Base 29 [29 基地]*
  - *a.k.a. Unit 63820 [63820 部队]*

**Key Data:**

- Established: 1995
- Total Funding: 53.82m RMB
- Personnel: 15-23[461]
- Official start of operations: 1997
- Floor Space: 2,818 sqm

**Lab Overview:**

The Defense S&T Key Laboratory of Computational Fluid Dynamics conducts research into aerodynamics for military and civilian aerospace. It was first established in the 1990s under the First National Expert Committee of the National 863 Plan in the field of space [国家 863 计划

第一届航天领域专家委员] to advance China's space science and engineering efforts, particularly around China's manned space program.[462]

While it appears on the "official" online list of DSTKLs, this lab is far more commonly referred to as the National Laboratory for Computational Fluid Dynamics [国家计算流体力学实验室].

The lab is jointly managed by Beihang University's School of Aeronautic Science and Engineering and the China Aerodynamics Research and Development Center (CARDC), a PLA research institute under the Academy of Military Sciences which conducts research into aerodynamics. Notably, CARDC does not mention its military status on its website (even dressing its military leadership in civilian clothing for their headshots), and its military association is in no way apparent at first glance. The lab's subordination to CARDC thus means that it is directly administered by a PLA unit while actively attempting to hide this association.[463]

**Further Information:**

- The lab's original funding came from the 863 Plan for aerospace [863 计划航天领域].[464]

**Research Direction:**

1. Computational methods, including DNS, LES, DES, DSMC
2. Physical model research, including:
    - Compressible turbulence [可压缩湍流]
    - Combustion [燃烧]
    - Chemical reactions [化学反应]
    - Real gas effects [真实气体效应]
    - Thermal radiation [热辐射]
3. Applied basic research, including:
    - Aerodynamic layout design methods [气动布局设计方法]
    - Precision aerodynamic/thermal calculations [气动力/热精确计算]
    - Complex flow mechanisms [复杂流动机理]
    - Multiphase flow simulation methods [多相流模拟方法]
    - Multidisciplinary coupled dynamics [多学科耦合动力][465]

*Other Notable Research Areas:*

- Computational theory and method research
- Flow mechanism research
- Flight vehicle aerodynamics research
- Laboratory computer system environment and technology development

- Numerical simulation calculations of aerodynamic/thermal/chemical reactions and thermal radiation
- Research into hypersonics, including flight vehicles[466]

**Notable Applications:**

- This lab utilized the Wuxi Supercomputing Center's [超算无锡中心] Sunway TaihuLight [神威·太湖之光] supercomputer to calculate the return path of the Tiangong-1 [天宫一号] space station. The study utilized 16,384 processors (1/8 of TaihuLight's total) and achieved in 20 days what would have otherwise taken 12 months.[467]
- This lab played a role in research for the C919 large passenger aircraft, by utilizing the Tianhe-1 [天河一号] supercomputer to conduct complex aerodynamic numerical simulations.[468]
- The lab has developed better security for facial recognition technology.[469]

**Leadership and Key Personnel:**

- Director: Li Chunxuan [李椿萱] [470]
    - CAE Academician
    - Received PhD in the U.S. in 1972.
- Academic Committee Director: Zhang Hanxin [张涵信][471]
    - Academician at CARDC
- Deputy Director: Ye Youda [叶友达][472]
    - Member of Chinese People's Political Consultive Congress[473]

**Notable Collaborations:**

*Domestic*

- According to the lab's former (and now defunct) homepage, this lab has cooperated on projects with CASC 1st, 2nd, 3rd, 4th, 5th, and 7th Academies, and with AVIC 601st and 611th Research Institutes.[474]
- This lab has a cooperation agreement with the Wuxi Supercomputing Center [超算无锡中心], utilizing the Sunway TaihuLight [神威·太湖之光] supercomputer to do aerospace research.[475]

*International*

- A center partially managed by this lab had a role in organizing the 2023 Beihang International Forum for Young Scientists [北航宁波梅山国际青年学者学术论坛], specifically a sub-forum on advanced flight vehicles and space power [先进飞行器与空

天动力分论坛]. Other PRC participants included Beihang University, Harbin Institute of Technology, Shanghai Jiao Tong University, University of Science and Technology of China, Huazhong University of Science and Technology, and the Zhijian Laboratory [之江实验室]. Foreign participants came from the U.K., including Universiy of Manchester, University of Sheffield, and Southampton University. U.S. MIT's Ningbo (China) Supply Chain Innovation Institute [麻省理工宁波（中国）供应链创新学院] also participated. The forum was intended to advance the PRC's major strategic needs to implement Xi Jinping's call for greater S&T talent. Topics included aviation, aerospace, materials, high-end intelligent manufacturing, and ocean engineering.[476]

**Lab Equipment:**

- Dawning Sky Tide computer cluster [“曙光”天潮计算机集群拥]
  - TC 4600E (85 nodes) and nearly 3,000 CPU cores, with a computing peak of more than 30 trillion times/second.[477]
- ACANS numerical simulation platform
  - Utilizes the lab’s own proprietary CFD software, capable of numerical simulation calculations of aerodynamic/thermal/chemical reactions and thermal radiation in the full Mach number range.
  - Sophisticated numerical simulation software for N-S equations.[478]
- Dedicated National CFD Lab [国家 CFD 实验室].[479]

**Address**:

Co-located with Beihang University at No. 37 Xueyuan Road, Haidian District, Beijing [北京海淀区学院路 37 号][480]

**Website**:

http://www.ase.buaa.edu.cn/info/1123/9958.htm

**Alias**:

- National Laboratory for Computational Fluid Dynamics [国家计算流体力学实验室]
  - This is the far more common name for this lab.

## 19. Defense S&T Key Laboratory of Computational Physics

**Official English Name:** Unknown

**Chinese Name:** 计算物理国防科技重点实验室

**Post-2024 Name:** National Key Laboratory of Computational Physics[xxxviii] [计算物理全国重点实验室][481]

**Research Focus:**

Domain:

- Nuclear

Equipment:

- Nuclear Weaponry & Energy
- *Secondary: Computers*

Functional Field:

- Simulation & Modeling
- *Secondary: Intelligent Technologies, Materials*

**Affiliations:**

- Chinese Academy of Engineering Physics [中国工程物理研究院]
    - Institute of Applied Physics and Computational Mathematics (IAPCM) [北京应用物理与计算数学研究所]

**Key Data:**

- Established: 1992
- Total Funding: Unknown
- Personnel: Unknown[482]
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab was first ratified by COSTIND in 1991,[483] and formally established on 9 December 1992.[484] It conducts scientific computation and numeric simulation toward basic theoretical research, including basic research of computational physics, mechanics, and

[xxxviii] Literal translation, no official name given

mathematics.[485] As part of the Chinese Academy of Engineering Physics, this research is primarily intended to benefit the PRC's nuclear energy and weapons programs.

The Institute of Applied Physics and Computational Mathematics (IAPCM) was established in 1958 and conducts research on nuclear warhead design computations on behalf of CAEP. Research areas include theoretical physics, particle physics and atomic nuclear physics, plasma physics, laser physics, fluid mechanics, applied mathematics, computational mathematics, computer applications, and arms control science and technology.[486] It has been implicated in espionage against the United States and is on the US BIS Entity List.[487]

Under the ongoing reorganization of the PRC's national key lab system, this lab is now known as the the National Key Lab of Computational Physics [计算物理全国重点实验室].[488]

**Further Information:**

- Not to be confused with the Key Lab of Computational Physics [计算物理重点实验室] at Yibin University.

**Research Direction:**

1. Basic research on scientific problems and key technologies of numerical simulation of nuclear weapon physics [核武器物理数值模拟的科学问题与关键技术的婴童基础性研究]
2. Cutting-edge exploratory research under extreme force conditions such as high temperature and high pressure [高温高压等极端武力条件下的前沿探索性研究]
3. Cultivation of high-level talents for national defense and national scientific and engineering computation in China [我国国防和国家科学与工程计算高层次人才培养][489]

*Other Notable Research Areas:*

- Microfabrication and Non-equilibrium Behavior of Complex Flow Processes[490]
- Algorithms for Tianhe-2 supercomputer[491]
- Supercomputer design[492]

*Lab's 2023 research priorities:*[493] [xxxix]

1. Second-Order Conservation ALE Algorithms for Ball-Preserving Symmetry in Column Coordinate Systems [柱坐标系下保球对称的二阶守恒 ALE 算法研究]
2. Implicit Monte Carlo Algorithm for Physics-Preserving Properties of Radiative Transport Equation Containing Coupled Electrons and Ions [含电子、离子耦合的辐射输运方程保物理特性隐式蒙特卡罗算法研究]

[xxxix] Detailed information on research areas, targets, and funding for each of these priorities is available upon request.

3. Research on High-precision and Efficient Discrete Format of Arbitrary Polyhedral Mesh Three-Temperature Radiation Diffusion Equation System [任意多面体网格三温辐射扩散方程组高精度高效离散格式研究]
4. 3D MMALE Method Based on Adaptive Mesh Refinement and Clear Interface Capture [基于自适应网格细化与清晰界面捕捉的三维 MMALE 方法]
5. Research on Centroidal WENO Format of Compressible Multicomponent Fluid [可压缩多组分流体的中心型 WENO 格式研究]
6. First Principle Methods for X Thomson Scattering Spectroscopy of Warm Dense Matter [温稠密物质 X 汤姆逊散射谱的第一性原理方法研究]
7. Research on High-precision Machine Learning Algorithms for Partial Differential Equations [偏微分方程高精度机器学习算法研究]
8. Design of first-principles pseudopotentials for high-temperature and high-pressure and its application to simulation modeling of broad-area equations of state [面向高温高压的第一原理赝势设计及其在宽区物态方程]
9. Research on Modeling and Computational Methods of ICF Numerical Simulation Based on Machine Learning [基于机器学习的 ICF 数值模拟建模与计算方法研究]
10. Multiscale Fracture Damage and Mechanical Modeling of Microstructured Materials under Impact Load [冲击载荷下微结构材料的多尺度断裂损伤和力学模型研究]
11. Study on damage mechanisms of Cu-Zr alloy composites under strong impact loading [强冲击载荷下 Cu-Zr 合金复合材料的损伤机理研究]
12. Theoretical Study of Atomic Energy Levels and Electron Collision Processes in Strongly Coupled Plasmas [强耦合等离子体中的原子能级和电子碰撞过程理论研究]
13. Heterogeneous Parallel Conservative Clear Interface Computing and Cross-Scale Interface Simulation Methods [异构并行的守恒清晰界面计算和跨尺度界面模拟方法研究]

**Notable Applications:**

None found

**Leadership and Key Personnel:**

- Director: (possibly dated) Shen Longjun [沈隆钧]
  - Also serves as IAPCM Deputy Director
  - Expert in computational mathematics
  - Has been awarded two First-Class Military S&T Progress Awards [军队科技进步一等奖][xl]
  - Born in 1939, so possibly retired now[494]

[xl] First-class awards are relatively rare and indicate the highest achievements in military S&T. In this case, it is likely related to participation in the PRC's nuclear program.

- Academic Committee Director: (possibly dated) Yuan Guangwei [袁光伟]
    - Expert in computational mathematics
    - Vice President of Chinese Society for Computational Mathematics
    - Awarded a First-Class Military S&T Progress Awards [军队科技进步一等奖]
    - Recipient of "Hundred Million Talents" Award in 2000[495]
- Deputy Directors: Wei Xijun [蔚喜军][496]; Chen Yibing [陈艺冰][497]
    - Wei has conducted research on numerical methods in fluid dynamics, numerical mesh generation and adaptive methods, multi-media fluid dynamics interface processing and numerical simulation

*Key Personnel*

- Xu Weihou [许为厚]
    - Worked at the US Naval Postgraduate School and NASA's Ames Research Center in the 1990s before becoming an advisor at this lab in 2000
    - Elderly and likely retired, living in Canada now[498]

**Notable Collaborations:**

None found

**Lab Equipment:**

- Per one source, this lab is equipped with the PRC's most advanced computers and numerical simulation technology[499]

**Address**:

No. 6 Huayuan Rd., Haidian District, Beijing [北京市海淀区花园路六号][500]

The lab also has a presence in Beijing's 100094 and 100088 postal codes[501]

**Known Aliases:**

- 计算物理与数值模拟国防科技重点实验室
- 计算物理国防重点实验室
- 计算物理重点实验室
- 计算物理国家级重点实验室
- 计算物理国家重点实验室
- 计算物理全国重点实验室

## 20. Defense S&T Key Laboratory of Diesel Engine Booster Technology

**Official English Name:** Unknown

**Chinese Name:** 柴油机高增压技术国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Ground
- *Secondary: Maritime*

Equipment:

- Ground Vehicles
- *Secondary: Surface Vessels*

Functional Field:

- Vehicle Parts & Technology

**Affiliations:**

- China Ordnance Industries Group Corporation (Norinco) [中国兵器工业集团]
    - China North Engine Research Institute [中国北方发动机研究所]
        - *a.k.a. Norinco 70th Research Institute*

**Key Data:**

- Established: 2002
- Total Funding: Unknown
- Personnel: 39 researchers[502]
- Official start of operations: 2004
- Floor Space: Unknown

**Lab Overview:**

This lab was established in 2002[503] and formally approved in 2004.[504] It is the only national-level[505] key lab specializing in engine boosting technology, including supercharger and turbocharger systems (the characters in the lab's name, 增压机, can refer to either type of system).[506] Further areas of emphasis include booster reliability[507] and performance in high-altitude environments.[508] The lab also established the Datong North Tianli Supercharger Technology Co., Ltd. [大同北方天力增压技术有限公司] with the Shanxi Provincial Research Center of Internal Combustion Engine Supercharging Technology [山西省内燃机增压技术研究

中心]. This company manufactures turbocharger production, assembly, and monitoring equipment for vehicles, ships, and power generation.[509]

Prior to the lab's establishment, ground vehicle power systems were a major source of need for the PLA, whose capabilities lagged in this area. The PRC's first domestic high-power diesel engine was built in 1999 by Wang Zengquan, who would go on to found this lab three years later to further improve vehicle propulsion technology. According to Wang, booster technology is a key technology to improving engine power, allowing for higher mobility, lighter weight, and less energy consumption.[510] The lab's boosting technology research is also promoted as an important technical means toward realizing energy savings and emissions reductions as a part of the PRC's "Energy Saving and New Energy Development Strategy" and "Made in China 2025" strategies.[511]

The lab's parent institution, the China North Engine Research Institute (a.k.a. the Norinco 70th Research Institute) was founded in 1958 and is the PRC's leading institute for research of tank and armored vehicle engines.[512]

**Further Information:**

- This lab has a subordinate specialist team for regulatory systems [调节系统专业组].[513]
- The lab's academic committee consists of 15 experts from vehicle, ship and aviation related organizations.[514]

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- Booster performance and reliability of fully automated test rig
- Dual booster cycle endurance test rig
- Booster test rigs
- Booster performance and reliability test rigs
- Rotor vibration measurement and analysis systems
- Low circumference fatigue testing machines
- Laser multispectral three-dimensional flow measurement and analysis systems
- Dynamic stress measurement systems for turbine blades
- Three-coordinate measurement systems
- Laser scanning measurement systems
- Five-axis CNC machining[515]

The lab released its 2023 research priorities. Each project is funded at 50-500k and lasts 1-2 years. These are:[516]

1. Research on gas flow theory and flow process of pressurizer and turbine:

Research related to the theory and calculation of gas flows in pressurizers and turbines, three-dimensional gas physical simulation and testing technology in pressurizers and turbines, and CAD/CAM design of pressurizers and turbines. This year's program focuses on supporting:

a) Turbine long intermittent pulse boundary loss and efficiency enhancements

b) Expansion flow of turbojet engines

c) Aerodynamic test technology of turbojet engines

2. Research on transient response and regulation of pressurization system:

   Research related to flow field analysis of intake and exhaust systems, transient response characteristics of supercharging systems, and regulation theory and technology of supercharging systems. This year's program focuses on supporting:

   a) Intelligent control of transient switching processes of supercharging systems

   b) Variable cross-section nozzle and flow field improvements of radial turbines

   c) Transient matching of electrically-assisted supercharging systems

3. Research on pressurization system reliability technology:

   Research related to main impeller and shaft system reliability technology, boosting system regulation, control reliability technology, and related research. This year's program focuses on supporting:

   a) Dynamic characteristics and modal analysis of supercharger regulation systems

   b) Supercharger bearing systems and rotor shaft thermo-mechanical coupling lubrication characteristics

   c) Influence of processing technology on the reliability of superchargers

   d) Supercharger pressurizer surge testing and identification

4. Research on optimization and matching technology of supercharging system performance

   Research related to supercharging and gas exchange process coupling, supercharging thermal process energy transfer, supercharging systems and whole machine performance optimization matching technology, and related research. This year's program focuses on supporting:

   a) High inlet temperature gas exchange and combustion of supercharged diesel engines

   b) Turbojet engine scroll-liquid mixing combustion

   c) Supercharged rotor engine exhaust energy utilization

**Notable Applications:**

- According to one profile, Wang Zengquan, who was director of the lab from its founding to at least 2017, led a team which designed the engines of multiple PLAA vehicles, including an unnamed main battle tank model and other armored vehicles.[517]

**Leadership and Key Personnel:**

- Director: Wu Aijun [武爱军]
  - Also serves as Party Committee Secretary of the Norinco 70th RI[518]
- Standing Deputy Director [常务副主任]: Zhang Yan [张岩][519]
- Academic Committee Director: Xu Jianzhong [徐建中]
  - Also Chairman of Chinese Engineering Thermophysics Association and member of the Executive Committee of the Chinese Academy of Sciences (CAS)[520]

*Key Personnel:*

- Wu Xintao [吴新涛]
  - Director of the lab's specialist team for regulatory systems [调节系统专业组][521]
- Wang Zengquan [王增全]
  - Former lab director from 2002 to at least 2017[522]; still working for Norinco as a "leading expert" [首席专家] in 2020[523]
  - Led a team which has designed multiple main battle tank and armored vehicle engines, including the PRC's first high-powered diesel engine in 1999
  - Won a First-Class S&T Progress Award in 2017[524]

**Notable Collaborations:**

*Domestic*

- This lab established the Datong North Tianli Booster Technology Co., Ltd. [大同北方天力增压技术有限公司] with the Shanxi Provincial Research Center of Internal Combustion Engine Booster Technology [山西省内燃机增压技术研究中心]. This company manufactures precision casting and internal combustion engine electric control products for vehicles, ships, and power generation.[525]
- This lab has a long-term cooperative relationship with Shanghai Jiao Tong University to research military diesel boosting technology. The two institutions have jointly undertaken a large number of national defense projects, including the Defense 973 Project [国防 973], Defense DEDP [国防 DEDP], Defense Basic Research [国防基础科研], GAD Pre-research [总装预先研究], and Key Lab Fund [重点实验室基金] projects. Boosting projects completed by SJTU and the lab were awarded a Second Prize for Scientific and Technological Advancement by Norinco. In 2014 the two parties signed an agreement on

the joint cultivation of master's degree students in which each graduate student is guided by two supervisors from the university and the lab, with the experimental part of the project carried out by the lab.[526]

- This lab has a strategic cooperation agreement with Shandong Xinde Make Supercharger Co. [山东信德玛珂增压器股份有限公司], a company specializing in engine supercharger products [涡轮增压器产品] for diesel engines, electric engines, and ship engines.[527]
- This lab has a cooperation agreement with the Hunan Province Key Lab of Critical Components for High-End Intelligent Equipment [高端智能装备关键部件湖南省重点实验室 ].[528]
- In 2020, the Norinco 70th RI signed an agreement with Tianjin University [天津大学] to cooperate in research, training, and resource sharing. The agreement was signed by 70th RI Party Committee Secretary Wu Aijun, who is also director of this lab. The two sides have been cooperating since 2012 and have jointly developed new technologies for diesel intake and exhaust flow stabilization, vibration and noise evaluation, high-efficiency supercharged fuel injection, and high-power fast combustion.[529]
- Personnel of this lab took part in the 2016 Internal Combustion Engine Booster Industry Development Forum [2016 内燃机增压器行业发展论坛] hosted by the Beijing Institute of Technology Machinery Industry Internal Combustion Engine Supercharger Engineering Research Center [机械工业内燃机增压技术工程研究中心]. Participants came from Shanghai Jiao Tong University and several companies and booster technology industry groups. This appears to be a loose consortium tasked with carrying out the elements of Made in China 2025 and the Energy Saving and New Energy Development Strategy concerned with improving booster technology for energy saving and emission reductions.[530]

*International*

- In 2022, this lab co-organized the 8th International Symposium of Clean and High-Efficiency Combustion in Engines [内燃机 “高效、低碳、清洁燃烧”国际学术研讨会]. Participants came from the US, Europe, Japan, Saudi Arabia, and South Korea. Research topics included test technologies and control, highland and alpine special engines, and low/zero-carbon fuels and gas engines.[531]
- This lab co-organized the 2019 Joint Annual Academic Conference of the China Internal Combustion Engine Society [2019 年联合学术年会暨八届九次常务理事会], along with the Tianjin University State Key Laboratory of Combustion Science [天津大学内燃机燃烧学国家重点实验], the China National Petroleum Lubricants Corporation [中国石油润滑油公司], and multiple branches of the China Internal Combustion Engine Society. It featured speakers from the Norinco 70th RI, PetroChina Lanzhou Lubricant Research and Development Center [中国石油兰州润滑油研究开发中心], Tsinghua University, Beijing Institute of Technology, Shanghai University, CSSC, Tianjun University, South

China University of Technology, and Weichai Power Co. [潍柴动力股份有限公司]. It also featured at least one speaker from the Royal Canadian Academy of Sciences.[532]

- In 2014, this lab co-organized the 2nd International Forum on Supercharging Technology [二届增压技术国际论坛] with the Supercharger Branch of the China Internal Combustion Engine Industry Association [中国内燃机工业协会增压器分会]. International participants included an engineer for US company Ford, researchers from U.K. City University of London and University of Cambridge, and a researcher from IHI in Japan. Topics included "Future Demand," "New Technologies and Systems," "Materials, Processes and Reliability," "Secondary Booster Systems and Combined Cycles," and "Design and Optimization."[533]

**Lab Equipment:**

- The lab has 108 sets of equipment and software, including 16 sets of large equipment and instruments.[534]

**Address**:

No. 96 Yongjin Ave., Beichen District, Tianjin [天津市北辰区永进道 96 号][535]

Another possible location is in Datong, Shaanxi 037036 [山西省大同市][536]

**Known Aliases:**

- Key Laboratory of High-Pressure Technology for Diesel Engines
- 柴油机增压技术国防科技重点实验室
    - Single character difference
- 柴油机增压技术国防重点实验室
- 柴油机增压技术重点实验室
- 柴油机高增压技术国防重点实验室
- 柴油机高增压技术重点实验室

## 21. Defense S&T Key Laboratory of Detonator Safety and Reliability

**Official English Name:** Unknown

**Chinese Name:** 火工品安全性可靠性技术国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- likely Multi-domain

Equipment:

- Munitions

Functional Field:

- Munitions Technologies
- *Secondary: Blast, Impact & Damage*

**Affiliations:**

- China Ordnance Industries Group Corporation (Norinco) [中国兵器工业集团]
    - Shaanxi Institute of Applied Physical Chemistry [陕西应用物理化学研究所]
        - *a.k.a. Norinco 213th Research Institute [213 研究所]*

**Key Data:**

- Established: prior to 2006
- Total Funding: Unknown
- Personnel: Unknown[537]
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

The Defense S&T Key Laboratory of Detonator[xli] Safety and Reliability conducts research into new detonators/initiating devices for explosives, including the most advanced third and fourth generation detonators. It also researches explosions, blast mechanics, and energetic materials.[538]

[xli] 火工品 could also be translated as "initiator," "initiating device," or "pyrotechnic." "Detonator" seems like the clearest translation based on its research.

The Shaanxi Institute of Applied Physical Chemistry (a.k.a. the Norinco 213th RI), claims to be the only national institute for research into the physical and chemical analysis and performance of detonators, pyrotechnics, and blasting equipment. Its products appear in both civilian and military equipment, and are exported to the U.S., U.K., Germany, and France.[539]

**Research Direction:**

1. New technologies for detonator action mechanisms and malfunction suppression [新技术火工品作用机理与故障抑制技术]
2. Detonator system integration technologies [火工系统集成技术]
3. Advanced explosive detonator technologies [先进火工药剂技术]
4. Detonator safety and reliability testing and assessment technologies [火工品安全性可靠性试验与评估技术][540]

**Notable Applications:**

- Development of third and fourth generation of detonators for PLA munitions.[541]
- New sensitivity testing methods and standards[542]
- The 213th RI played a role in the launching of the Jilin-1 and Gaofen-3 satellite groups into space, although it is unclear if this lab played a role.[543]

**Leadership and Key Personnel:**

- Director: Chu Enyi [褚恩义][544]
- Deputy Director: Zhang Rui [张蕊][545]

**Notable Collaborations:**

*Domestic*

- In 2020, this lab established a joint Optoelectric Testing and Applied Innovation Lab [光电测试与应用创新实验室] with Xi'an Technological University as a military-civil integration project.[546]
- In 2019 this lab signed a strategic cooperation agreement with the State Key Laboratory of Explosive Science and Technology [爆炸科学与技术国家重点实验室] and the Defense S&T Key Laboratory of Explosive Combustion [火炸药燃烧国防科技重点实验室] to form the Energetic Materials Innovation Alliance Laboratory [含能材料创新联盟实验室].[547]

- This lab is associated with Norinco Special Energy Group Ltd. [特种能源集团], which is a joint effort of multiple Norinco entities responsible for research, production, and sales of various Norinco firearms, explosives, and civilian products.[548]
- In 2013, this lab signed a cooperation agreement to work on new innovations with the Defense S&T Key Laboratory for Micro/Nanofabrication Technology [微米 / 纳米加工技术国防科技重点实验室] at Shanghai Jiao Tong University and the Defense S&T Key Laboratory for Fuze Dynamic Characteristics [引信动态特性国防科技重点实验室] of Norinco Xi'an Institute of Electromechanical Information Technology.[549]
- In 2016 this lab took part in the 11th National Academic Conference on Explosive Mechanics [全国爆炸力学学术会议]. The conference featured researchers from the fields of military engineering, aerospace, and marine technology, among others. Participants came from PLA Engineering University National Key Lab of Blast Shock Disaster Prevention and Mitigation [爆炸冲击防灾减灾国家重点实验室], CAEP, the Norinco 208th RI, among other universities and labs.[550]

*International*

- In 2018, this Lab co-hosted the 4th International Symposium on Nanostructured energetic Materials and Applied Technology [国际纳米结构含能材料及其应用技术研讨会] in 2018. International participants included the UK's Royal Society of Chemistry (who also co-hosted the event), as well as institutions from France, South Africa, Russia (Semenov Institute of Chemistry, Institute of Chemical Dynamics and Combustion), and Belarus. PRC participants included CAEP, Nanjing University of Science and Technology, Beijing Institute of Technology, and Northwestern Polytechnical University.[551]

**Lab Equipment:**

None found

**Address**:

No address found, possibly co-located with the 213th RI at No. 213 Zhuque Street, Xi'an, Shaanxi Province 710061 [西安市朱雀大街 213 号][552]

**Known Aliases:**

- 火工品安全性可靠性国防科技重点实验室
    - Same name without the characters 技术 ("technology"). This is the name that appears on the "official" online list of DSTKLs.

## 22. Defense S&T Key Laboratory of Electromagnetic Compatibility (EMC)

**Official English Name:** Unknown

**Chinese Name:** 电磁兼容性国防科技重点实验室

**Post-2024 Name:** (likely) National Key Laboratory of Maritime Equipment Electromagnetic Effects and Security [海洋装备电磁效应及安全全国重点实验室][553]

**Research Focus:**

Domain:

- Maritime
- *Secondary: Air, Ground*

Equipment:

- Surface Vessels
- *Secondary: Aircraft, Communications Equipment, Computer Technologies, Radar*

Functional Field:

- Electromagnetics
- *Secondary: Communications Technologies, EMP, Measurement Technologies, Microwave Technologies*

**Affiliations:**

- China State Shipbuilding Corporation (CSSC) [中国船舶集团]
    - CSSC Research and Design Center [中国舰船研究设计中心]
        - *a.k.a. CSSC 701st Research Institute [701 研究所]*

**Key Data:**

- Established: 1993
- Total Funding: Unknown
- Personnel: 35[554]
- Official start of operations: 1996
- Floor Space: Unknown

**Lab Overview:**

The Defense S&T Key Laboratory of Electromagnetic Compatibility (EMC) claims to be the PRC's largest and most advanced EMC research base, and the only national-level key lab devoted to research of EMC. Electromagnetic compatibility represents the ability of electronic systems to function in a given electromagnetic environment with minimal interference.

The lab is primarily tasked with R&D of EMC equipment for naval warfare, but also works in other areas. The lab's advanced EMC test facility cluster [试验设施群] is focused on naval vessels, but also does research into aircraft, combat vehicles, missiles, and other combat platforms for air and ground forces. The lab's EMC research extends to radar, communications, automatic control, computer applications, measurement instruments, and other equipment.[555]

In late 2023, a new lab, which translates roughly as the "National Key Lab of Maritime Equipment Electromagnetic Effects and Security" [海洋装备电磁效应及安全全国重点实验室] was inaugurated. This is likely the same lab, although this is never explicitly confirmed. The certificate and plaque for the new lab was issued by SASTIND, indicating a continued subordination to SASTIND and military mission, despite ostensibly being a civilian lab.[556]

The lab's parent institution, the CSSC Research and Design Center (a.k.a. the CSSC 701st RI, formerly known as the Wuhan Ship Development and Design Institute [武汉船舶设计研究院] and formerly subordinate to CSIC prior to the 2019 CSIC-CSSC merger) is a major institution for research and overall design of the PRC's warships, and is known variously as the "cradle of warships" or the "cradle of Chinese aircraft carriers." It is headquartered in Wuhan, with a branch in Shanghai.[557] It is on the U.S. Commerce Department Entity List for export control.[558]

**Further Information:**

- This lab, along with the 701st RI, oversees the CSSC EMC Testing Center [中国船舶工业电磁兼容性检测中心], which provides EMC testing of weapons and equipment for aerospace, aviation, armaments, electronics, and naval weapon platforms.[559]

**Research Direction:**

1. Limited space electromagnetic interference control [有限空间电磁干扰控制]
2. Electromagnetic environment characteristics and electromagnetic radiation hazard protection [电磁环境特性与电磁辐射危害防护]
3. Electromagnetic compatibility prediction and analysis [电磁兼容性预测和分析]
4. Electromagnetic compatibility experiments and testing [电磁兼容性试验与测试][560]

*Other Notable Research Areas:*

- System platform-level overall EMC prediction simulation and analysis evaluation
- Experimental verification of multi-antenna centralized and optimized arrangement models
- Ship RCS prediction and model test validation
- Equipment, system and platform EMC experiments and research
- Diagnosis, control and evaluation of electromagnetic interference in equipment, systems, and platforms
- System-level electromagnetic environment prediction effects testing and evaluation

- Strong EMP damage and protection simulation research
- EMC test method research and standard specifications development
- EMC test instrumentation development and research
- Electromagnetic interference control product development and research
- EMC test facility design and test system integration[561]

**Notable Applications:**

- This lab, working under the "cradle of warships" 701st Research Institute, is primarily responsible for ensuring the EMC of the PRC's warship designs, including safeguarding surface vessels from an electromagnetic pulse (EMP). For instance, personnel associated with this lab were involved in the design of the PRC's first domestic aircraft carrier. In addition to these tasks, it seems to also do some EMC work in other areas, such as aerospace, munitions, and other military electronics.[562]
- This lab ensures the EMC of military equipment in the South China Sea.[563]

**Leadership and Key Personnel:**

- Director: Lu Xioahui [卢晓晖][564]
    - Also Director of CSSC 701st RI
- (likely former) Academic Committee Director: Lu Jianxun [陆建勋][565]
    - CAE Academician
- Deputy Director: Zhou Kaiji [周开基][566]

*Key Personnel:*

- Xiao Long [肖龙][567]
    - Promising young researcher who developed the world's first on-chip free electron radiation source [片上自由电子辐射源]. Also developed the first microwave diffraction-free technology [微波无衍射技术], along with a high-power device to solve a bottleneck problem with miniaturization
- Liu Qifeng [刘其凤][568]
    - Chief designer for a national defense project related to orderly use of electromagnetic space (avoiding signal interference) in the South China Sea
    - Currently deputy lead designer for an unidentified warship design
- Zhu Yingfu [朱英富][569]
    - CAE Academician
    - Lead designer of several types of PLAN warships, including the Liaoning aircraft carrier

**Notable Collaborations:**

*Domestic*

- Other key labs in this field include the Key Laboratory of Electromagnetic Environmental Effects and Optoelectronic Engineering [电磁环境效应与光电工程重点实验室], the Electromagnetic Environmental Effects (likely the Defense S&T Key Lab of the same name) [电磁环境效应国防科技重点实验室], and the Key Laboratory of Aerospace Science and Technology for Electromagnetic Environmental Effects [电磁环境效应航空科技重点实验室]. These labs appear to be frequent partners for collaboration due to their overlapping research. In 2016 this lab co-hosted an academic conference on electromagnetic compatibility with these labs.[570]
- In 2021 this lab co-hosted the 4th National Conference on Complex Electromagnetic Environment Technology and Applications [第四届全国复杂电磁环境技术及应用学术会议] in Hangzhou. Participants came from CAEP, the Military Aircraft Radar Defense Laboratory [军用飞机雷电防护实验室], CETC, and a large number of labs and private companies.[xlii] Defense-related topics included complex electromagnetic environments faced by weapons and equipment [武器装备面临的复杂电磁环境特性], electromagnetic environment predictions for combat operations platforms [作战平台电磁环境预测], mechanisms of complex electromagnetic environment effects on weapons and equipment [武器装备复杂电磁环境效应机理], complex electromagnetic environment effect suppression and utilization technology [复杂电磁环境效应抑制与利用技术], and intelligent electromagnetic spectrum operations technology [智能电磁频谱作战技术].[571]

*International*

- In 2020, this Lab co-hosted the 2020 IEEE International Microwave Symposium Series - Advanced Materials and Processes for RF and Terahertz Applications [2020 IEEE MTT-S 国际微波研讨会系列-应用于射频及太赫兹的先进材料和工艺] (IEEE MTT-S IMWS-AMP 2020) in Singapore, along with Northwestern Polytechnical University and others. It co-hosted the event with National Singapore University and several other PRC institutions. Participants came from the US, UK, Germany, Canada (University of Montreal), Singapore (National University of Singapore), and Australia.[572]
- In 2020, this Lab co-hosted the 6th IEEE Global Electromagnetic Compatibility Conference (GEMCCon 2020) [第六届 IEEE 全球电磁兼容国际会议在西安举行] in Xi'an. Participants included CETC 33rd RI and CAEP. Notable international participants included researchers from the US, Japan, Austalia, Germany, Russia, the U.K. (De Montfort University), Switzerland (Swiss Federal Technology Institute of Lausanne), Italy (Polytechnic University of Milan), and Brazil.[573]
- In 2019, this lab co-hosted the Asia Electromagnetics Conference [亚洲电磁学国际会议] (ASIAEM 2019), featuring personnel of AVIC and CAEP. International participants

[xlii] A full list is available upon request.

included the President of the U.S. Metatech Corporation, as well as personnel from Germany, France, Japan, Italy, Switzerland, Korea, Russia, Sweden (SAAB), UAE, and Sri Lanka.[574]

- In 2011, this lab participated in the IEEE International Symposium on Microwave, Antenna, Propagation, and EMC Technologies for Wireless Communications (MAPE 2011), alongside the European School of Antennas and the IEEE Antennal and Electric Wave Dissemination Association.[575]

**Lab Equipment:**

- The CSSC EMC Testing Center [中国船舶工业电磁兼容性检测中心], which is overseen by this lab and the CSSC 701st RI, provides EMC testing of weapons and equipment for aerospace, aviation, armaments, electronics, and naval weapon platforms. It has over 400 major pieces of equipment, including:
    - Asia's only antenna layout test field and shielded semi-electric dark room
    - Strong EMP laboratory
    - Reverberation room
    - Shielding room
    - EMC digital and physical simulation laboratory
    - Electromagnetic interference control laboratory within/between systems
    - EMC testing experimental technology research laboratory[576]

**Address**:

CSSC EMC Testing Center, #5 No. 268 Zhangzhidong Road, Wuchang District, Wuhan, Hubei Province 460064 [武汉市武昌区张之洞路 268 号 5 号 460064][577]

**Known Aliases:**

- National Key Lab of Defence Technology for EMC [电磁兼容性国家级重点实验室/电磁兼容性国家重点实验室]
- Science and Technology on Electromagnetic Compatibility Laboratory
- Defense S&T Electromagnetic Compatibility Key Laboratory [国防科技电磁兼容性重点实验室]
- Key Laboratory of Electromagnetic Compatibility [电磁兼容性重点实验室]

## 23. Defense S&T Key Laboratory of Electromagnetic Environment Effects

**Official English Name:** Unknown

**Chinese Name:** 电磁环境效应国防科技重点实验室

**Post-2024 Name**: No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Multi-Domain (Air, Space, Ground)

Equipment:

- Electronic Warfare
- *Secondary: Aircraft, Ground Vehicles, Munitions, Radar, Space Vehicles, Unmanned Systems*

Functional Field:

- Electromagnetics
- *Secondary: EMP, Munitions Technologies, Simulation & Modeling*

**Affiliations:**

- PLA Army Engineering University [陆军工程大学][xliii]

**Key Data:**

- Established: 2003
- Total Funding: Unknown
- Personnel: Unknown[578]
- Official start of operations: 2006
- Floor Space: Unknown

**Lab Overview:**

First established in 2003,[579] this Lab's academic committee was ratified by COSTIND and the GAD in June 2006,[580] with the goal of improving weapons and equipment survivability and operations capabilities in a strong electromagnetic environment.[581] It is particularly focused on the future battlefield, which will increasingly necessitate defense against enemy jamming and electronic warfare, as well as improved electromagnetic compatibility amongst friendly units to

[xliii] Formerly known as the PLA Ordnance Engineering College [军械工程学院]

avoid self-jamming. Further, it is focused on electrostatic simulation and testing to improve electrostatic safety.[582] Officially, the lab focuses on four main research areas: electrostatic safety, environmental simulation and testing of strong electromagnetic fields, environmental effects assessment of strong electromagnetic fields, and strong electromagnetic field protection.[583]

This lab is also sometimes called the Defense S&T Key Laboratory of Simulation and Protection Technology for Strong Electromagnetic Field Environments [强电磁场环境模拟与防护技术国防科技重点实验室]. Significant overlap in personnel (e.g., Chen Yazhou is Director of both,[584] and Pan Xiaodong[585] and Liu Shanghe are associated with both) and other data indicates the two are the same lab.

**Further Information:**

- There is some confusion about the relationship between this lab and the Defense S&T Key Laboratory on Electromagnetic Environmental Effects and Electro-Optical Engineering [电磁环境效应与光电工程国家级重点实验室]. The two have in some cases been mistaken as the same lab, but the latter is probably a different lab with a similar name based at the PLA University of Science and Technology's former campus in Nanjing. There are numerous instances of the two labs being listed separately for conferences, and the latter also has a different director. PLAUST merged with this university in 2017, but so far it appears that both labs continue to exist separately under this university, one in Shijiazhuang and one in Nanjing.

**Research Direction:**

1. Electrostatic safety [静电安全性]
2. Environmental simulation and testing of strong electromagnetic fields [强电磁场的环境模拟与测试]
3. Environmental effects assessment of strong electromagnetic fields [强电磁场环境效应评估]
4. Strong electromagnetic field protection [强电磁场防护][586]

**Notable Applications:**

- This lab designed an electrostatic discharge device for testing effects of electromagnetic pulse radiation. This can be used to test the safe operation of both military and civilian spacecraft.[587]
- Former Director Liu Shanghe was involved in the design of the Shenzhou 5 and Shenzhou 7 manned spacecraft. Liu helped design the return capsule of the Shenzhou 5 and the static safety work for the Shenzhou 5 and 7.[588]

- This lab has conducted extensive experimentation on radiation effects on radar.[589]
- This lab has conducted research into the effects of electrostatic discharge interference on aircraft satellite navigation.[590]
- This lab is involved in efforts to better protect equipment, infrastructure, and people from lightning strikes. This includes the invention of a mobile lightning protection and monitoring vehicle which can be used for better and safer all-weather military training.[591]
- Liu Shanghe won a 1st Class National S&T Progress award for his work on ammunition anti-static theory, leading to safer munitions storage.[592]
- Liu Shanghe has done research into protection of military equipment against EMPs. The lab's 2009 project "Research on equipment EMP simulation and protection technology" [装备电磁脉冲模拟与防护技术研究] won a National S&T Progress 2nd Class Merit [国家科技进步二等奖].[593]
- This lab works with military companies to conduct electromagnetic compatibility testing of military equipment during the design process.[594]
- This lab designs unspecified anti-jamming equipment.[595]
- This lab was involved in the PRC's first astronaut spacewalk in 2008, working to improve spacesuit safety by minimizing electrostatic charge, which could start a fire in the suit's all-oxygen environment. Its research study "Evaluation and Research on Electrostatic and Electromagnetic Safety of Oxygen Environment of Extravehicular Space Suit" [舱外航天服纯氧环境静电与电磁安全性评价研究] was awarded a Military S&T Progress 2nd Class Merit [军队科技进步二等奖].[596]

**Leadership and Key Personnel:**

- Director: Chen Yazhou [陈亚洲][597]
    - Also Deputy Director of Chinese Institute of Electronics Electromagnetic Compatibility Committee [电磁兼容分会副主任委员][598]
- Deputy Directors: Pan Xiaodong [潘晓东][599]; Hu Xiaofeng [胡小锋][600]

*Key Personnel*

- Liu Shanghe [刘尚合][601]
    - Former Director of this lab
    - PLA Corps Leader Grade senior civilian cadre
    - CAE Academician
    - Expert on electromagnetic compatibility and protection, considered a pioneer of electrostatic safety engineering and electromagnetic environment effects on equipment
    - Also serves as Director of Military-Civil Fusion Electromagnetic Environment Effects Center [军民融合电磁环境效应中心]
    - Once intentionally shocked himself with 71,000 volts to make a point about the human body's ability to survive extreme voltage

**Notable Collaborations:**

*Domestic*

- Between 2008 and 2010, this lab collaborated with the Army Military Transportation University [陆军军事交通学院] School of Vehicle Engineering in Tianjin to conduct tests on military vehicle equipment performance, damage patterns, and countermeasures in a complex electromagnetic environment. The tests improved electromagnetic shielding and filtering devices after finding some military vehicles had weak anti-jamming capabilities for electronic control units, leading to failures such as being unable to start [打不着火] or windshield wiper malfunction.[602]
- The lab took part in a September 2008 exercise in the Nanjing Military Region, testing equipment capabilities in a complex electromagnetic environment.[603]
- This lab is associated with the Military-Civil Fusion (MCF) Electromagnetic Environment Effects Center [军民融合电磁环境效应中心]. This Center is a joint effort of this lab, Shijiazhuang Tiedao University [石家庄铁道大学], and China Tonghao Research and Design Academy Group [中国通号研究设计院集团]. The Center focuses on national defense, rail transport, and Hebei regional development, using MCF to advance electromagnetic compatibility and electromagnetic protection.[604]
- This lab co-sponsored the 2021 National Complex Electromagnetic Environment Technology and Applications Academic Conference [2021 全国复杂电磁环境技术及应用学术会议]. Speakers came from National University of Defense Technology, Naval Engineering University, CAS Beijing Institute of Applied Physics and Computational Mathematics [北京应用物理与计算数学研究所], CASC Beijing Institute of Satellite Environment Engineering [北京卫星环境工程研究所], and the CSSC China Ship Research Design Center [中国舰船研究设计中心], as well as this lab. The conference discussed topics with military applications, including intelligent electromagnetic frequency operations technology, network electromagnetic space attack and defense technology, and complex electromagnetic environment characteristics faced by weapons and equipment.[605]

*International*

- This lab has co-hosted the annual China-US International Symposiums on Electrostatic Protection and Standardization [静电防护与标准化国际研讨会]. The 4th (2015) symposium was hosted along with CAST, the U.S. Trade and Development Agency, the U.S. National Standards Institute, and the U.S. Electrostatic Discharge Association. Reps of the CASC 514th RI (Beijing Dongfang Institute of Measurement and Testing [北京东方计量测试研究所]) and U.S. company IBM were also present. The symposium discussed standardization and electrostatic discharge related to intelligent manufacturing, internet of things, and smart hardware. The 5th symposium in 2016 also featured representation from the SASTIND Explosives Measurement Station [国防科技工业火炸

药一级计量站]. The 8th symposium in 2019 featured most of the same institutions on both sides, as well as the CASC Institute of Standardization [中国航天标准化研究所] (708th RI) and the CAST Space S&T Information Institute [北京空间科技信息研究所] (512th RI), as well as others.[606]

- In 2019 this Lab co-organized the 2019 Asian Electromagnetics Conference [2019 亚洲电磁学国际会议]. PRC participants included the PLA National University of Defense Technology, CAEP, and AVIC. Foreign speakers and participants came from the U.S. (Metatech), Germany (Helmut Schmidt University; the same researcher formerly worked for the French Network and Information Security Agency), Korea (Korea Institute for Defense Analyses, Korea Aerospace University, Inha University; a Korean speaker is also affiliated with the Agency for Defense Development, although his affiliation in 2019 is unclear), Sweden (SAAB), and Switzerland (Swiss Federal Technology Institute of Lausanne).[607]

**Lab Equipment:**

- Electromagnetic environment simulation room capable of simulating a wide range of natural and artificial electromagnetic signals, and with rooms for testing a wide range of devices, up to and including military vehicles.[xliv]
- Has a field electromagnetic environment test site in the suburbs (presumably just beyond Shijiazhuang) which is capable of simultaneously simulating multiple types of high-intensity electromagnetic signals
- Lightning and nuclear electromagnetic pulse field simulation system (described as a small room in the shape of a triangular cone and completely covered in metal to shield electromagnetic signals)
- Reverberation room
- Electrostatic simulation system
- Gigahertz transverse electromagnetic wave transmission room
- Continuous wave electromagnetic environment simulation system
- Electromagnetic compatibility testing equipment includes a B ultrasound machine, photoelectric electrocardiograph, vital signs monitor and other health equipment
- Electrostatic simulation and testing room to study electrostatic testing and protection technology[608]

**Address**:

PLA Engineering University Shijiazhuang Campus, No. 97 Heping West Road, Xinhua District, Shijiazhuang, Hebei Province [河北省石家庄市新华区和平西路 97 号][609]

[xliv] Small number of pictures of equipment available.

**Known Aliases:**

- National Laboratory of Electromagnetic Environment Effects [电磁环境效应国家级重点实验室]
    - This is the far more common name for this lab.
- Defense S&T Key Laboratory of Electromagnetic Protection [电磁防护国防科技重点实验室]
    - This is listed as the lab's name in the "official" online list of Defense S&T Key Labs, but is actually a far less common name.
- Key Laboratory of Electromagnetic Protection [电磁防护重点实验室]
- Defense S&T Key Laboratory of Simulation and Protection Technology for Strong Electromagnetic Field Environments [强电磁场环境模拟与防护技术国防科技重点实验室]
- Army Engineering University Shijiazhuang Campus Defense S&T Key Lab" [陆军工程大学石家庄校区国防科技重点实验室]
- *Not* to be confused with the Defense S&T Key Laboratory of Electromagnetic Environmental Effects and Electro-Optical Engineering [电磁环境效应与电光工程国防科技重点实验室], which is a different lab.

## 24. Defense S&T Key Laboratory of Electromagnetic Environment Effects and Electro-Optical Engineering

**Official English Name:** Unknown

**Chinese Name:** 电磁环境效应与电光工程国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Multi-domain (Air, likely others)

Equipment:

- Electronic Warfare
- *Secondary: Aircraft*

Functional Field:

- Electromagnetics
- *Secondary: Communications Technologies, Optoelectronics, Terahertz Technologies*

**Affiliations:**

- PLA Army Engineering University [中国人民解放军陆军工程大学]

**Key Data:**

- Established: possibly 2010
- Total Funding: Unknown
- Personnel: Unknown[610]
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab may have been established around 2010.[611] While there is little public information, it appears to be focused on a range of research related to the electromagnetic spectrum, including electromagnetic defense and equipment survivability in strong electromagnetic environments, electromagnetic compatibility, jamming, and electronic warfare.

The Army Engineering University oversees two Defense S&T Key Labs focused on the electromagnetic spectrum which closely overlap one another in mission and research. The other is the DSTKL of Electromagnetic Environment Effects [电磁环境效应国防科技重点实验室] (a.k.a. the DSTKL of Simulation and Protection Technology for Strong Electromagnetic Field

Environments [强电磁场环境模拟与防护技术国防科技重点实验室] or the DSTKL of Electromagnetic Protection [电磁防护国防科技重点实验室]). This overlap may be due to the fact that today's Army Engineering University was formed in 2017 from the former Army University of Science and Technology in Nanjing, which oversaw this lab, and the Ordnance Engineering College in Shijiazhuang, which oversaw the other lab. Now that the two have merged, this lab likely serves as the major electromagnetic lab for the University's Nanjing campus, while the other serves the same role at the Shijiazhuang campus. It is possible the two may merge in the future to improve costs and efficiencies, but for now they appear to remain as two distinct labs. For instance, both labs are listed separately when attending a 2019 conference.[612] Likewise, a 2020 conference includes both labs, referring to the latter as the "Army Engineering University Shijiazhuang Campus Defense S&T Key Lab" [陆军工程大学石家庄校区国防科技重点实验室].[613] The Chinese Institute of Electronics [中国电子学会] also includes committee members from both labs.[614]

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- Electromagnetic defense, equipment survivability, electromagnetic compatibility
- Research on protection of microelectronics against lightning, including on aircraft[615]
- Research on terahertz sensing[616]

**Notable Applications:**

None found

**Leadership and Key Personnel:**

No leadership found

*Key Personnel:*

- Shi Lihua [石立华][617]
    - Key senior researcher
    - Expert on lightning physics, time-domain measurements, electromagnetic compatibility and protection technology
- Chen Bin [陈彬][618]
    - Important senior researcher from lab's founding

**Notable Collaborations:**

*Domestic*

- This lab co-organized the 2024 First National Electromagnetic Frontier Cross-Technology Conference [第一届全国电磁前沿交叉技术大会]. The conference was primarily organized by the Chinese Society of Electronics and the Electromagnetic Technology Committee of the Chinese Society of Military Industry [中国兵工学会电磁技术专业委员会]. Topics included electromagnetic compatibility, protection, materials, and other new technologies for communications (including 5G, high-speed transmission, and connection of smart devices), radar (including radar accuracy, EW, and anti-jamming technology), electronic countermeasures, and energy. There were a huge number of co-organizers, which included Zhejiang University (School of Electrical Engineering, Institute of Science and Technology, Institute of Advanced Technology), Southeast University's Institute of Electromagnetic Space Science and Technology, the Chinese Nuclear Society Radiation Physics Division, Norinco 206th RI, CAS Institute of Electrical Engineering, National Key Laboratory of Electromagnetic Space Safety [电磁空间安全全国重点实验室], Technology Innovation Center for Materials and Devices for Extreme Environments (TICMED), Harbin Institute of Technology [哈工大极端环境材料与器件技术创新中心], Tsinghua University's National Engineering Laboratory of Detection Technology for Hazardous and Explosive Materials, Jiliang University, Hangzhou University of Electronic Science and Technology, and multiple National Key Labs.[619]
- In 2017, this lab co-sponsored the Second National Academic Conference on Technology and Application of Complex Electromagnetic Environment [第二届全国复杂电磁环境技术及应用学术会议], along with the Army Ordnance Engineering College Institute of Electrostatic and Electromagnetic Protection [军械工程学院静电与电磁防护研究所], the Key Laboratory of High Power Microwave Technology [高功率微波技术重点实验室], State Key Laboratory of Complex Electromagnetic Environment Effect of Electronic Information System [电子信息系统复杂电磁环境效应国家重点实验室], and the Key Laboratory of Electromagnetic Environmental Effects and Optoelectronic Engineering [电磁环境效应与光电工程重点实验室]. The conference was intended to strengthen PRC research into complex electromagnetic environments, including for military weaponry and space environments.[620]

*International*

- In 2019, Shi Lihua of this lab was vice chairman for the First Plenary Session of the International Academic Committee of the National International Joint Research Center for Transient Electromagnetic Environment and Applications [瞬态电磁环境与应用国家级国际联合研究中心国际学术委员会第一次全体会议]. The session included participation from foreign researchers. While only names with no affiliations were

provided,[xlv] a basic internet search reveals that foreign participants may have been associated with the following institutions: U.S. (Metatech, University of New Mexico), Germany (Helmut Schmidt University, Otto-von-Guericke University Magdeburg), Korea (Hanyang University), Switzerland (EMProtec AG, Armasuisse Science and Technology, the technological center for the Swiss Federal Department of Defence, Civil Protection and Sport), Russia (Joint Institute for High Temperatures), and the UAE (Technology Innovation Institute). The conference featured participation from both PLA Army Engineering University electromagnetic labs.[621]

**Lab Equipment:**

None found

**Address**:

Nanjing, Jiangsu Province 211101 [江苏省南京市][622]

**Known Aliases:**

- National Key Laboratory on Electromagnetic Environmental Effects and Electro-Optical Engineering
- 电磁环境效应与光电工程重点实验室

[xlv] Full list of names available.

## 25. Defense S&T Key Laboratory of Electromechanical Engineering and Control

**Official English Name:** Science and Technology on Electromechanical Dynamic Control Laboratory[623]

**Chinese Name:** 机电工程与控制国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Multi-Domain (Air, Ground)

Equipment:

- Munitions
- *Secondary: Non-Ballistic Missiles*

Functional Field:

- Munitions Technologies
- *Secondary: Simulation & Modeling*

**Affiliations:**

- Beijing Institute of Technology (BIT) [北京理工大学]
- China Ordnance Industries Group Corporation (Norinco) [中国兵器工业集团]
    - Xi'an Electromechanical Information Technology Institute [西安机电信息技术研究所]
        - *a.k.a. Norinco 212th Research Institute [212 研究所]*

**Key Data:**

- Established: 1992
- Total Funding: Unknown
- Personnel: over 30 (just BIT)[624]
- Official start of operations: 1996
- Floor Space: 9,600 sqm

**Lab Overview:**

This lab is focused on R&D of various mechanical and electromechanical fuzes, via both fuze simulations and dynamic analysis of environmental simulations and tests. It has been awarded for its development of mortar fuzes.[625]

The lab has branches in Beijing, overseen by Beijing Institute of Technology, and Xi'an, overseen by Norinco's Xi'an Electromechanical Information Technology Institute (a.k.a. Norinco 212th RI). Its primary headquarters is in Xi'an. The Xi'an Electromechanical Information Technology Institute is focused on electromechanical system integration technology, near-field target characteristics research and testing technology, electromechanical, optical, magnetic, acoustic, and composite detection technologies, and dynamic properties testing technology. It is the PRC's premier institute focused on weapon fuze technology. It also conducts research into electronic jamming and anti-jamming technology, special energy, physical and digital simulation technology, and miniaturized high-overload telemetry technology. Its products include maritime, meteorological, and port control radars, satellite and microwave communications devices, and various civilian applications.[626]

**Further Information:**

- This lab is also frequently referred to as the State/National Key Laboratory of Electromechanical Dynamic Control [机电动态控制国家重点实验室]. There is sufficient evidence to believe this is the same lab:
    - Both lab names can be found being used interchangeably.
    - Both are described as being founded in 1996 and being joint BIT-212th RI labs.
    - Chen Xi is associated with both labs.[627]

**Research Direction:**

1. Mechanical and electromechanical fuzes [机械引信、机电引信]
2. Fuze system simulations [引信系统仿真]
3. Dynamic properties analysis of multiple types of environmental simulations and tests [动态特性分析多种环境模拟试验][628]

**Notable Applications:**

- This lab has developed unidentified mortar fuzes.[629]
- Given the work of its parent Xi'an Electromechanical Information Technology Institute, this lab likely aids in development of a wide range of fuzes, including mechanical, electronic, laser, infrared, magnetic, acoustic, etc. This includes fuzes for everything from artillery and small munitions to air-to-air missiles. Fuze safety and security also seems to be an area of interest.[630]

**Leadership and Key Personnel:**

- Director: Chen Xi [陈曦][631]

- Academic Committee Director: Ma Baohua [马宝华][632]
- Deputy Directors: Tan Huimin [谭惠民][633]; Dang Ruirong [党瑞荣][634]
    - Tan Huimin is also Director of the Beijing Branch

**Notable Collaborations:**

*Domestic*

- This lab collaborates with the China Ordnance Society [中国兵工学会] and the Xi'an Electro-mechanical Institute [西安机电信息研究所] to publish an academic journal, the *Journal of Detection & Control* [探测与控制学报].[635]

*International*

- The lab's parent institution, the 212th RI, has allegedly established extensive contacts with multiple countries, including the U.S. No further information was given.[636]
- In 2019, this lab co-organized the 2nd IEEE International Conference on Unmanned Systems (IEEE ICUS 2019) [第二届 IEEE 国际无人系统大会], along with Beijing Institute of Technology, the China Command and Control Society [中国指挥与控制学会], the U.S. Institute of Electrical and Electronics Engineers (IEEE), and others. Beside IEEE, foreign participants came from the U.K. (Cranfield University, University of Manchester), Canada (Concordia University, Germany (University of Hambug, the Netherlands (Delft University of Technology), and Singapore (Nanyang Technological University). Notable PRC participants also came from PLA National University of Defense Technology, CASIC, and Northwestern Polytechnical University. Topics included AI and image processing, space intelligent unmanned systems, unmanned system payload technology, and complex system control and intelligent cooperation, among others.[637]
- At least two lab personnel were involved in organizing the 2024 International Symposium on Antennas, Propagation and Electromagnetic Theory (ISAPE) [天线、传播与电磁理论国际会议]. Foreign committee members included those from the U.S. (University of Illinois Chicago) and U.K. (University of Liverpool).[24-18]. Speakers came from the U.S. (Duke University), U.K. (Durham University, speaking on 6G deployment in mmwave and sub-THz bands, and University of Liverpool), Canada (University of Montreal), Italy (University of Sienna, speaking on metasurface antennas and RIS in space and in 6G), Finland (Aalto University), Japan (Chiba University, speaking on antennas for drone, airborne, HAPS, and spaceborne synthetic aperture radar), and Korea (Pohang University of Science and Technology).[638]
- In 2023, this lab played a role in organizing the 2023 25th Annual Conference and 14th International Conference of the Chinese Society for Micron Nanotechnology (CSMNT2023) [中国微米纳米技术学会第二十五届学术年会暨第十四届国际会议]. Other organizers included the Chinese Society of Micro and Nano Technology [中国微米纳米技术学会], Harbin Institute of Technology, and Tsinghua University, among others.

PRC researchers from the PLA National University of Defense Technology, CETC 11th and 55th RI, Norinco 213th RI, CSSC 705th RI, Northwestern Polytechnical University, and Beihang University. Foreign presenters came from the U.S. (Cal Tech) and Spain (Universitat Politècnica de Catalunya).[639]

**Lab Equipment:**

- The lab has 140m RMB of fixed assets (including 110m RMB of equipment assets).[640]
- The lab's facilities and equipment include:
  - Full ballistic synthetic environment laboratory
  - Domestic advanced gas gun group
  - Accelerometer calibration device up to 200,000g
  - Motion and dynamics analysis software such as ADAMS and ANSYS
  - Signal processing and microwave analysis software such as MENTOR and ANSOFT
  - Micro-mechanical testing equipment, including high-performance vector network analyzers, spectrum analyzers, microwaves, millimeter-wave RF monitoring equipment, and X-ray inspection imaging systems[641]

**Address**:

No. 6 Jixiang Road, Xi'an, Shaanxi Province [陕西省西安市吉祥路 6 号][642]

**Known Aliases:**

- Key Laboratory of Electromechnical Dynamic Control [机电动态控制重点实验室]
- National Key Laboratory of Electromechnical Dynamic Control [机电动态控制国家级重点实验室]
- State Key Laboratory of Electromechnical Dynamic Control [机电动态控制国家重点实验室]
- State Key Laboratory of Mechatronics Engineering and Control [机电工程与控制国家级重点实验室]
- National Key Laboratory of Mechatronic Engineering and Control [机电工程与控制国家重点实验室]
- National Key Laboratory of Electromechanical Engineering and Control
- National Laboratory for Mechatronic and Control
- National Lab of Mechatronic Engineering and Control

## 26. Defense S&T Key Laboratory of Electronic Information Control

**Official English Name:** Unknown

**Chinese Name:** 电子信息控制国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Multi-domain (Air, Ground, Maritime)

Equipment:

- Electronic Warfare
- *Secondary: Air/Missile Defense, Non-ballistic Missiles, Radar*

Functional Field:

- Multiple (Countermeasures, Electromagnetics, Intelligent Technologies, Millimeter Wave Technologies, Simulation & Modeling, Stealth Technologies)

**Affiliations:**

- China Electronics Technology Group Corporation (CETC) [中国电子科技集团]
  - Southwest Institute of Electronic Equipment (SWIEE) [西南电子设备研究所]
    - *a.k.a. CETC 29th Research Institute [29 研究所]*

**Key Data:**

- Established: 1993
- Total Funding: Unknown
- Personnel: Unknown[643]
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research into electronic warfare (EW), with possible foci on EW systems simulation technology and new concepts, theories, and technologies for EW.

This lab was originally known as the Defense S&T Key Laboratory of Electronic Countermeasures [电子对抗国防科技重点实验室]. Around 2006, it changed its name to the Defense S&T Key Laboratory of Information Comprehensive Control [信息综合控制国防科技重点实验室], and changed to its current name around 2012.[644]

The lab's parent institution, the CETC Southwest Institute of Electronic Equipment (SWIEE) (a.k.a. the CETC 29th Research Institute), specializes in electronic warfare research, and is able to design, develop, and produce electronic information systems equipment for land, sea, air, and space platforms, as well as for missiles. It may have worked closely with the former PLA GSD 4th Department (4PLA), which has since been absorbed by the PLASSF.[645] It is on the U.S. Commerce Department Entity List for export control.[646]

**Further Information:**

- The lab has its own journal, *Electronic Information Countermeasures Technology* [电子信息对抗技术], previously known as Electronic Countermeasures Technology [电子对抗技术], founded in 1986 (which could suggest that the predecessor to this lab had been founded at that time). The journal studies new concepts, theories and technologies for electronic warfare [电子战] and information warfare [信息战].[647]
- The lab also has or had another publication called *International Electronic Warfare* [国际电子战] (previously called 电子战技术文选).[648]

**Research Direction:**

1. Electronic warfare system simulation technology [电子战系统仿真技术]
2. New concepts, theories, and technologies for electronic warfare [电子战概念、新理论、新技术][649]

*Other notable research areas:*

- Stealth and anti-stealth technology
- Airborne Sensor Systems
- Detection and warning for air-to-air missiles
- Aircraft countermeasures against missiles
- Path planning for aircraft penetration against enemy radar network
- MIMO Radar
- Multi-false-targets jamming
- Airborne location and positioning
- Interferometry
- Millimeter wave reconnaissance technology[650]

**Notable Applications:**

The lab's research has been put to the following uses, including:

- Simulation of radar signals of various systems in order to form complex battlefield electromagnetic signals in the laboratory for assessment tests
- Electronic countermeasures, jamming, and anti-jamming equipment
- AI signal recognition technology
- GPS and phased array jamming technology, and other jamming/interference technologies
- Integrated air defense electronic warfare systems
- A PLAN C3I-EW system[651]

**Leadership and Key Personnel:**

- Director: He Tao [何涛][652]
- Deputy Directors: Zhang Li [张礼]; Gu Jie [顾杰][653]

**Notable Collaborations:**

*Domestic*

- A survey of the lab's research in two scientific databases reveals extensive cooperation with the PLAAF, PLAN, PLAA, PLASSF, PLARF, and the Chengdu Military Representative Office, mainly having to do with electronic warfare and the technologies described in the Research Direction section.

*International*

- From the 1990s to an unspecified date, this lab allegedly carried out work in cooperation with Russia, including analyzing the combat effectiveness of electronic warfare equipment [电子战装备作战效能分析] and early warning aircraft jamming modeling and computer simulation development [对预警机干扰的建模和计算机模拟开发].[654]

**Lab Equipment:**

None found

**Address**:

None found, possibly co-located with the 29th RI at No. 496 Yingkang West Road, Jinniu District, Chengdu, Sichuan Province [四川省成都市金牛区营康西路 496 号][655]

**Known Aliases:**

- Key Laboratory of Electronic Information Control [电子信息控制重点实验室]
- Defense Key Lab of Electronic Information Control [电子信息控制国防重点实验室]
- GF S&T Key Lab of Electronic Information Control [电子信息控制 GF 科技重点实验室]
- State Key Lab of Electronic Information Control [电子信息控制国家重点实验室]
- National Key Lab of Electronic Information Control [电子信息控制国家级重点实验室]
- Key Laboratory of Electronic Countermeasures [电子对抗重点实验室]
- State Key Laboratory of Electronic Countermeasures [电子对抗国家重点实验室]
- Defense Key Lab of Electronic Countermeasures [电子对抗国防重点实验室]
- Key Laboratory for Information Comprehensive Control [信息综合控制重点实验室]
- National Information Control Laboratory/Lab (NICL)
- State Key Laboratory of Information Comprehensive Control [信息综合控制国家重点实验室]
- Key Laboratory of Electronic Information Comprehensive Control [电子信息综合控制重点实验室]
- Electronic Information Comprehensive Control Laboratory
- National Electronic Countermeasures Laboratory
- National EW Laboratory (NEWL)
- National Key Laboratory of Electronic Warfare
- National Key Laboratory of Electronic Countermeasure
- Science and Technology on Electronic Information Control Laboratory
- Key Electronic Information Control Lab

## 27. Defense S&T Key Laboratory of Electronic Information Equipment Systems Research

**Official English Name:** Unknown

**Chinese Name:** 电子信息装备体系研究国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Space

Equipment:

- Computers
- *Secondary: Space Vehicles*

Functional Field:

- Communications Technologies
- *Secondary: Cyber Technologies, Intelligent Technologies*

**Affiliations:**

- PLA Strategic Support Force Space Engineering University [航天工程大学][xlvi]

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This Lab conducts research into a range of technologies related to communications and data engineering, networks and network security, and information systems. This includes research into satellite communications and data networks, AI, and big data processing. Previously subordinate to the PLA Equipment Academy [解放军装备学院], it was transferred to the PLASSF

[xlvi] Following the PLASSF's breakup in 2024, this may now be a part of the Aerospace Force

Space Engineering University, and now may be under the newly created Aerospace Force following the PLASSF's 2024 breakup.

**Further Information:**

- In 2020, a researcher for this lab, Pei Zhongmin [裴忠民], wrote a book published by Defense Industry Press on network information systems [网络信息体系]. It includes sections on ground and space-based networks, intelligent information environments, and data mining.[656]
- This lab is likely the same as the Key Laboratory of Complex Electronic Systems Simulation [复杂电子系统仿真重点实验室], mainly due to similar missions and overlapping personnel. For instance, Li Xinming [李新明] is associated with this lab at a time when he was still known to be Director of the Electronic Information Equipment Systems Lab, and Pei Zhongmin is also associated with both Labs.[657]

**Research Direction:**

One unofficial source names the research direction as follows:

1. Network information systems
2. Aerospace equipment systems
3. Autonomous controllable information technology
4. Systems science
5. Aerospace engineering
6. Information and communications engineering[658]

*Other Notable Research Areas:*

- Wireless networking for military information systems[659]
- Satellite communications and satellite comms networks[660]
- Simulations of space information systems[661]
- Network information systems[662]
- Cognitive computing systems for big data[663]
- Using big data to aid in strategic early warning and intelligence analysis[664]
- Remote sensing satellite target localization and recognition[665]
- Multi-source heterogeneous data integration (processing large amounts of data from multiple sensors or pieces of equipment, including integrating from heterogeneous sources that cannot communicate with one another, which otherwise restricts combat effectiveness)[666]

**Notable Applications:**

None found

**Leadership and Key Personnel:**

- Director: Li Xinming [李新明][667]
- Deputy Director: Li Zhi[李智][668]
    - Deputy Director of lab in 2012, possibly dated
    - Expert on space security
- General Secretary: Yang Chaoying [杨超英][669]

**Notable Collaborations:**

*Domestic*

- This lab has established long-term strategic partnerships with SASTIND, CASC, and Beihang University.[670]
- This lab has ongoing collaboration with Shenyang Ligong University on unidentified national defense projects.[671]
- This lab has a joint cooperative relationship with Chengdu Calabar Information Technology Co. [成都卡莱博尔信息技术股份有限公司] which does work in big data, AI, and data engineering, in which this lab provides unspecified technical support.[672]
- In 2015, this lab signed a strategic cooperation agreement with Beijing Shudun Technology Co. [北京数盾信息科技有限公司] to establish a Trusted Network (Computing) Joint Laboratory [可信网络（计算）联合实验室] in Beijing. The joint lab will focus on design of information security equipment systems and trusted network architectures, as well as trusted network technology R&D, including toward military weapons and equipment. Beijing Shudun specializes in data encryption, cryptography, and security, including cloud and mobile internet security. The agreement will utilize MCF.[673]

**Lab Equipment:**

None found

**Address**:

1 Bayi Rd., Huairou District, Beijing 101416 [北京市怀柔区八一路 1 号][674]

**Known Aliases:**

- National Laboratory of Electronic Information Equipment System
- Key Laboratory of Electronic Information Equipment Architecture [电子信息装备体系研究重点实验室]
- National Key Laboratory of Complex Electronic System Simulation [装备学院复杂电子系统仿真重点实验室]
- 复杂电子系统仿真国防科技重点实验室
- 信息国防重点实验室

## 28. Defense S&T Key Laboratory of Electronic Measurement Technology

**Official English Name:** Unknown

**Chinese Name:** 电子测试技术国防科技重点实验室

**Post-2024 Name**: possibly National Key Laboratory of Electronic Testing Technology[xlvii] [电子测试技术全国重点实验室][675]

**Research Focus:**

Domain:

- Multi-domain (Space, Ground, Maritime)

Equipment:

- Multiple (Ballistic Missiles, Munitions, Radar, Space Vehicles)

Functional Field:

- Electromagnetics
- *Secondary: Microelectronics, Microwave Technologies, Millimeter Wave Technologies, Sensing, Ship Design, Terahertz Technologies*

**Affiliations:**

- China Electronics Technology Group Corporation (CETC) [中国电子科技集团]
  - East China Electronic Measuring Instruments Research Institute [华东电子测量仪器研究所]
    - *a.k.a. CETC 41st Research Institute [41 研究所]*
- North University of China (NUC) [中北大学]
  - School of Instrument and Electronics [仪器与电子学院]

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: 32 (Taiyuan Branch)[676]
- Official start of operations: 2002
- Floor Space: approx. 10,000 sqm (both campuses combined)

[xlvii] Literal translation, no official name given

**Lab Overview:**

This lab conducts research into various types of testing technology, including dynamic, photoelectric, microwave, millimeter wave, automatic, and electromagnetic information security testing technologies. The lab's research has been utilized in a wide variety of fields that require precision testing for position, attitude, temperature, pressure, speed, impact, penetration, damage, and the electromagnetic spectrum, including the PRC's space, aviation, munitions, radar, and shipbuilding programs.[677]

The CETC East China Electronic Measuring Instruments Research Institute (a.k.a. the CETC 41st Research Institute), established in 1968, claims to be the PRC's only specialized research institute for electronic measuring instruments, and conducts research into microwave/millimeter wave, photoelectric communications, digital communications, and general-purpose measuring instruments and automatic test systems. It also provides testing methods for the development and production of military and civilian electronic components. Its products have been used in satellites, navigation, radar, and China's Shenzhou manned space program. In 2015 it was combined with the CETC 40th RI to form China Electronics Technology Instruments Co., Ltd (CETI) [中电科仪器仪表有限公司/中电科思仪科技股份有限公司/中电仪器] (a.k.a. Ceyear [思仪]).[678]

Under the ongoing reorganization of the PRC's national key lab system, this lab may now be officially known as the National Key Lab of Electronic Measurement Technology [电子测试技术全国重点实验室].

**Further Information:**

- The lab's main campus is located in Qingdao with the 41st Research Institute, with a subordinate branch in Taiyuan with NUC.[679] There seems to be a division of labor between the lab's two branches, with the Qingdao branch in charge of microwave and millimeter wave testing, automatic testing, and electromagnetic information security testing technologies, and the Taiyuan branch in charge of dynamic testing technology. Both are responsible for photoelectric testing technology.[680]
- From 2015-2018, the lab has received an average annual scientific research funding of nearly 100 million RMB. Since 2014 the lab (or possibly just the Taiyuan branch) has undertaken more than 300 high-level scientific research projects from the former PLA GAD, SASTIND, and the Ministry of Science and Technology.[681]
- The Taiyuan branch has disciplines and specialties in the fields of applied physics, sensors, microelectronics, measurement and control, information processing, and automation. The Taiyuan branch is mainly oriented toward the development needs of manned spaceflight, deep space exploration, "assassin's mace" weapons, and other major national projects and key weapons models for national defense.[682]

**Research Direction:**

1. Dynamic testing technology [动态测试技术]
2. Photoelectric testing technology [光电测试技术]
3. Microwave and millimeter wave testing technology [微波毫米波测试技术]
4. Automatic testing technology [自动测试技术]
5. Electromagnetic information security testing technology [电磁信息安全测试技术][683]

The NUC (Taiyuan) branch has its own research direction:

1. Dynamic information acquisition and calibration technology in harsh environments [恶劣环境下动态信息获取与校准技术]
2. Micro-nano sensing and testing technology [微纳传感与测试技术]
3. Transient physical field detection and reconstruction technology [瞬态物理场探测与重建技术]
4. Photoelectric sensor and application technology [光电传感与应用技术][684]

**Notable Applications:**

- The lab's research has provided more than 1,300 sets of test equipment and systems for more than 30 key weapon models for the PLAA, PLAN, and PLAAF, including for space, aviation, ships, and weaponry.[685]
- The lab has provided key testing techniques for manned spaceflight and deep space exploration. Further, since 2003, the lab has been involved in research on measurement tasks related to the Long March 3 rocket. The research results from more than 200 sets of measurement products developed for the rocket have been applied to various types of rocket measurement systems.[686]

**Leadership and Key Personnel:**

- Director: Nian Fushun [年夫顺][687]
- Deputy Director/Taiyuan Branch Director: Xue Chenyang [薛晨阳][688]
    - NPC delegate
    - Visiting scholar at Oxford (U.K) in 2008, MIT (U.S.) in 2011
    - Has carried out industry-university research cooperation with a number of defense companies to promote military-to-civilian technical fusion
    - Xue's team's research has been applied in the Long March rockets, manned spaceflight program, and deep space exploration programs

*Key Personnel:*

- Jiang Wanshun [姜万顺][689]

    - Has worked with Director Nian on terahertz systems. In October 2020, Jiang stated that the lab's millimeter wave and terahertz measurement systems successfully broke a foreign technology embargo.
- Liu Jun [刘俊][690]
    - Previous deputy director
    - Former UC Berkeley visiting scholar
    - National Hundred, Thousand, and Ten Thousand Talents candidate
    - Former GAD inertial technology professional group expert and Secretary-General of the Testing Technology Branch of the China Ordnance Society
    - Research includes Nano/Micro-Electro-Mechanical systems (MEMS/NMEMS) and dynamic testing technologies for weapons systems in harsh environments

**Notable Collaborations:**

*Domestic*

- This lab and the Defense S&T Key Lab of Radar Signal Processing at Xidian University set up a "New-System Radar Research and Test Base" [新体制雷达研究试验基地] in the Qingdao Development Zone in 2005 to research new radar detection technologies, design and manufacture an indigenous new radar system, and develop new informationized weapons and equipment. There is little to no information available on the base after its founding, and only one joint study between the two labs appears to have been published.[691]
- The Institute of Dynamic Measurement and Control and Intelligent Instruments [动态测控与智能仪器研究所] of the North University of China School of Electrical and Control Engineering is overseen by this lab and other NUC entities. It works in measurement and control for the aerospace, armaments, and shipbuilding fields.[692]
- The lab and the Ministry of Education Key Laboratory of Instrumentation Science and Dynamic Measurement [仪器科学与动态测试教育部重点实验室] have collaborated in various projects since 2003, including joint research on measurement tasks related to the Long March 3 rocket [长征三号火箭].[693]

**Lab Equipment:**

None found

**Address**:

None found, possibly co-located with the CETC 41st RI and NUC at No. 98 Xiangjiang Road, Qingdao Development Zone, Shandong Province [山东省青岛开发区香江路 98 号] and No. 3 Xueyuan Road, Taiyuan City, Shanxi Province [山西省太原市学院路 3 号], respectively

**Website**:

https://web.archive.org/web/20190402225600/http://6y.nuc.edu.cn/xsyyj/pthjd/gfkjzdsys.htm

**Known Aliases:**

- (possibly) Defense S&T Key Laboratory of Signal Detection [信号检测国防科技重点实验室]
- (possibly) Key Laboratory of Signal Detection [信号检测重点实验室]
- National Key Laboratory for Electronic Measurement Technology [电子测试技术国家级重点实验室]
- State Key Laboratory for Electronic Measurement Technology [电子测试技术国家重点实验室]
- Key Laboratory for Electronic Measurement Technology [电子测试技术重点实验室]
- Defense Key Laboratory for Electronic Measurement Technology [电子测试技术国防重点实验室]
- China Electronics Technology Instruments Co., Ltd (CETI) Key Laboratory for Electronic Measurement Technology [中电科仪器仪表有限公司电子测试技术重点实验]
- CETC 41st RI Key Laboratory for Electronic Measurement Technology [中国电子科技集团公司第四十一研究所电子测试技术重点实验室]
- North University of China Key Laboratory for Electronic Measurement Technology [中北大学电子测试技术重点实验室]
- North University of China School of Instrument and Electronics Key Laboratory for Electronic Measurement Technology [中北大学仪器与电子学院电子测试技术重点实验室]
- North University of China School of Electronics and Computer Science & Technology Key Laboratory for Electronic Measurement Technology [中北大学电子与计算机科学技术学院电子测试技术国家重点实验室]

## 29. Defense S&T Key Laboratory of Equipment Integrated Support Technology

**Official English Name:** Unknown

**Chinese Name:** 装备综合保障技术国防科技重点实验室

**Post-2024 Name:** possibly National Key Laboratory of Equipment Condition Sensing and Rapid Support[xlviii] [装备状态感知与敏捷保障全国重点实验室][694]

**Research Focus:**

Domain

- Multiple (Air, Maritime)

Equipment:

- Multiple (Aircraft, Helicopters, Underwater Vehicles, Unmanned Systems)

Functional Field:

- Reliability/Environmental Engineering
- *Secondary: Acoustics, Intelligent Technologies, Logistics & Maintenance, Materials, Propulsion, Robotics*

**Affiliations:**

- National University of Defense Technology (NUDT) [国防科技大学]
    - School of Intelligent Science [智能科学学院][695]

**Key Data:**

- Established: at least 1996
- Total Funding: Unknown
- Personnel: Unknown[696]
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research into equipment maintenance support, with a particular focus on maximizing equipment reliability and minimizing breakdowns. This includes research into equipment testing and verification,[697] deformation, fatigue, and loss of function,[698] fault

[xlviii] Literal translation, no official name given

sensing,[699] mechanical vibration,[700] and precision and intelligent equipment maintenance management.[701] The lab's focus is on exploratory and innovative applied basic and key technology research.[702]

While the lab is more commonly referred to as a "Key Lab" rather than a "Defense S&T Key Lab," multiple sources state that it is a national-level lab,[703] making it likely that it is in fact a DSTKL. This would make it one of seven DSTKLs under the PLA National University of Defense Technology. Previously under the NUDT School of Mechanical Engineering and Automation,[704] by late 2017 it had apparently moved to the School of Intelligent Science.[705] While no founding date was given, the lab has been around since at least the 9th Five Year Plan of 1996.[706]

Under the ongoing reorganization of the PRC's national key lab system, this lab may now be known as the National Key Lab of Equipment Condition Sensing and Rapid Support [装备状态感知与敏捷保障全国重点实验室], although this is unconfirmed as of publication.

**Further Information:**

- This lab has subordinate research labs called the Equipment Support Informatization Research Lab [装备保障信息化研究室] and the Equipment Support Situational Awareness Research Lab [装备保障态势感知研究室].[707]
- The lab has a funding mechanism called the "Key Laboratory of Equipment Integrated Support Stable Support Projects" [装备综合保障技术重点实验室稳定支持项目].[708]
- Another lab funding mechanism, the "NUDT Key Laboratory of Equipment Integrated Support Technology Fund" [国防科技大学装备综合保障技术重点实验室基金], sponsored research into intelligent diagnosis and fault prediction of communications equipment [通信装备智能诊断与故障预测研究].[709]

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- Analysis of U.S. ship-based aircraft auxiliary power systems[710]
- Power grid resilience[711]
- Laser detection of aircraft engine blade vibration[712]
- Simulation/modeling of failure dynamics in helicopter components[713]
- Efficient maintenance of UAV clusters in a battlefield environment[714]
- Advanced intelligent unmanned equipment, intelligent structure design and preparation (self-sensing, self-diagnostic, adaptive, etc.), intelligent operation and maintenance of equipment[715]

- High-end ceramic composite materials' failure mechanism and life prediction[716]
- Advanced vibration and noise reduction structure design and preparation[717]
- Equipment testability, including intelligent in-flight testing, in-flight testing to reduce false alarms, and testability verification and evaluation[718]
- Fault protection sensors for UAVs[719]
- Logistics and support management and optimization[720]
- Reliability of maritime robots, include loss of function, deformation, fatigue, and jamming in complex underwater environments[721]
- Unmanned underwater vehicle noise suppression[722]
- Propeller reliability and damage[723]
- Underwater equipment fault diagnosis and health management[724]

**Notable Applications:**

None found

**Leadership and Key Personnel:**

- Director: Yang Yongmin [杨拥民][725]
    - Visiting scholar at UC Berkeley in the U.S. at an undisclosed date
    - Expert on aero-engine and gas turbine equipment, particularly maintenance design, verification, and fault diagnosis
    - Winner of a First Class Military S&T Progress Award [军队科技进步奖] and four second class merits
    - Receives a military stiped [军队一类岗位津贴], and has been recognized as a military equipment repair advanced individual [全军装备维修先进个人][726]
- Deputy Director: Peng Xiaoqiang [彭小强][727]

*Key Personnel:*

- Wen Yilin [温熙森][728]
    - Named as lab "leader"
- Qiu Jing [邱静][729]
    - Named as lab "leader"; co-wrote a book called *Equipment Testability Modeling* [装备测试性建模]
- Chen Zhongsheng [陈仲生][730]
    - From 2011 to 2017, Chen was Deputy Director first of the Equipment Support Informatization Research Lab [装备保障信息化研究室] and then of the Equipment Support Situational Awareness Research Lab [装备保障态势感知研究室]. During this time period, between 2015 and 2016, he also studied at Southampton University in the U.K.

    - Expert on condition monitoring and fault diagnosis of equipment
- Liu Peng [刘鹏][731]
    - Expert on hydrodynamic noise problems, complex equipment fault diagnosis and reliability analysis, and underwater robotics
- Chen Xun [陈循][732]
    - Expert on equipment reliability engineering
    - Studied at Strathclyde University in the U.K.
- Xu Yongcheng [徐永成][733]
    - Professor at this lab until 2015
    - Studied at University of Bristol in the U.K. in 2010-2011
    - Expert on electromchanical equipment condition monitoring, fault diagnosis, lifespan prediction, equipment reliability, repairability, and testing, and vibration control

**Notable Collaborations:**

*International*

- In 2017, lab researcher Wen Qihong [温激鸿] collaborated with the Sorbonne University (Pierre and Marie Curie Campus) in France to research low-frequency and broadband vibration damping characteristics of nonlinear acoustic metamaterials. The results, which an article about the research stated could provide new theories for breaking through technological bottlenecks related to vibration, were published in the journal *Nature Communications*. An article about the collaboration states that vibration and noise control is a key technology for industrial production, transport, and weaponry, improving the reliability of ships, aircraft, and launch vehicles.[734]
- Several personnel have studied in the U.S. and U.K. in recent years. Yang Yongmin studied at UC Berkeley. Chen Zhongsheng, Deputy Director of two of this lab's subordinate research labs, studied at Southampton University in the U.K. from December 2015 to June 2016.[735] Chen Xun studied at Strathclyde University.[736] Xu Yongcheng studied at the University of Bristol.[737]

**Lab Equipment:**

None found

**Address**:

School of Intelligent Science, National University of Defense Technology, 3-1 Ave., Kaifu District, Changsha, Hunan Province [湖南省长沙市开福区三一大道国防科技大学智能科学学院][738]

**Known Aliases:**

- Laboratory of Science and Technology on Integrated Logistics Support [装备综合保障技术重点实验]
- 武器装备综合保障技术国防科技重点实验室
- 武器装备综合保障技术国家级重点实验室

## 30. Defense S&T Key Laboratory of Explosive Combustion

**Official English Name:** National Key Laboratory of Science and Technology on Combustion and Explosion[739]

**Chinese Name:** 火炸药燃烧国防科技重点实验室

**Post-2024 Name:** possibly National Key Laboratory of Energetic Materials[xlix] [含能材料全国重点实验室][740]

**Research Focus:**

Domain:

- Multi-domain (Air, Space, Ground)

Equipment:

- Munitions
- *Secondary: Non-ballistic Missiles, Space Vehicles*

Functional Field:

- Propulsion
- *Secondary: Blast, Impact & Damage, Hypersonic Technologies, Munitions Technologies*

**Affiliations:**

- China Ordnance Industries Group Corporation (Norinco) [中国兵器工业集团]
    - Xi'an Modern Chemistry Research Institute (MCRI) [西安近代化学研究所]
        - *a.k.a. Norinco 204th Research Institute [204 研究所]*
- possibly Nanjing University of Science and Technology [南京理工大学][l]

**Key Data:**

- Established: 1994
- Total Funding: Unknown
- Personnel: Unknown[741]
- Official start of operations: likely 1996
- Floor Space: Unknown

[xlix] Literal translation, no official name given
[l] If this lab is now the National Key Lab of Energetic Materials post-reform.

**Lab Overview:**

The Defense S&T Key Laboratory of Explosive Combustion appears to be focused on projectile propellants for a variety of munitions, ranging from rocket and missile engines to smaller munitions, as well as explosive and energetic materials and studying projectile shock and impact.

This lab is subordinate to the Norinco Modern Chemistry Research Institute (a.k.a. Norinco 204th Research Institute). This Research Institute claims to be the PRC's only institution dedicated to research of explosives and destructive technologies [火炸药及毁伤技术], with a focus on energetic materials, functional materials, special chemical materials, organic chemistry, polymer materials, chemical machinery, and engineering mechanics. This research is applied to military explosives, propulsion, metrology, and ammunition, as well as military and civilian catalytic reaction engineering technology, new opto-electronic materials technology, and fine chemical technology.[742]

Under the ongoing reorganization of the PRC's national key lab system, this lab may now be known as the National Key Lab of Energetic Materials, although this has not been confirmed. If so, it now appears to be jointly manageged by the Norinco 204th RI and Nanjing University of Science and Technology.[743]

**Further Information:**

- This lab is divided into five subordinate research labs and one work station:[744]
  1. *Explosive Pyrolisis Lab* [火炸药热分解研究室]: Researches pyrolisis and dynamics of explosives, as well as the decomposition course and patterns of explosives during combustion.
  2. *(Ammunition) Propellant*[li] *Combustion Lab* [发射药燃烧研究室]: Researches propellant ignition, flash hole [传火] research, ammo propellant burn speed measurements, ammo propellant dynamic simulation, liquid propellant aerosol combustion, new types of propellant and liquid propellant igniter trains, high-pressure static or dynamic combustion laws and combustion principles, and propellant design supply theory.
  3. *Solid (Engine/Rocket) Propellant Combustion Lab* [柜体推进剂燃烧研究室]: Researches solid propellant steady state combustion, unstable combustion formulation principles, smoke plume properties [羽烟特性] and generation principles, combustion performance tuning, combustion catalyst principles, and unstable combustion formulation principles. It researches theories and technology for solid propellants having to do with combustion performance. Its equipment includes a flame structure measurement system [火焰结构测定系统], smoke plume environment box (?) [羽烟环境箱], and flame measurement system [烟焰测定系统].

[li] This Lab uses two different words for "propellant", 发射药 and 推进剂. The former refers to gunpowder propellant inside ammunition, while the latter refers to solid or liquid propellant for larger missiles or rockets.

4. *Explosive Combustion Explosion Lab* [火炸药燃烧爆炸研究室]: Researches principles and influencing factors of solid propellant [推进剂] and ammunition propellant [发射药] in engine and chamber combustion rotating explosive bursts (?) [转爆轰]. It also assesses the safety of new ammunition and engine/rocket propellants [推进剂 and 发射药].
5. *Modern Combustion Diagnostic Technology Lab* [现代燃烧诊断技术实验室]: Researches laser spectroscopy applications for explosive combustion [火炸药燃烧]. Measures temperature and components of transients in gunpowder combustion flames by non-interference diagnostic laser spectroscopy. It provides accurate gunpowder combustion temperature measurement data.
6. *Graphics Work Station* [图形工作站]: provides graphic processing for numerical simulations and data for combustion characteristics.

**Research Direction:**

The lab's research direction is never explicitly stated, but can be reasonably surmised from its five subordinate labs:

1. Explosive Pyrolysis
2. (Ammunition) Propellant Combustion
3. Solid (Engine/Rocket) Propellant Combustion
4. Explosive Combustion Explosion Lab
5. Modern Combustion Diagnostic Technology[745]

*Other Notable Research Areas:*

- Thermal decomposition chemical research[746]

**Notable Applications:**

- This lab's research contributes to a wide range of rocket, missile, and ammunition propellants. Director Zhao Fengqi has written extensively on solid rocket propellants for a wide range of military uses, including for hypersonic missiles (specifically with boron-rich fuel).[747]
- This lab has developed solid-state hydrogen storage materials for military use, potentially for vehicle-mounted equipment, fuel cells, and solid propellants.[748]
- The 2020 launch of a Long March 5 rocket carrying the Tianwen 1 Mars probe utilized a propellant designed by the 204th RI, and it is possible this lab was involved in the research given its mission.[749]

**Leadership and Key Personnel:**

- Director: Zhao Fengqi [赵凤起][750]

*Key Personnel*

- Liu Zijia [刘子如][751]
    - Expert on energetic materials and thermal decomposition chemical dynamics
    - Founding member of lab, possibly retired, over 80 years old now

**Notable Collaborations:**

*Domestic*

- There has been close cooperation for over two decades between this lab and the Chemical Engineering School at Northwestern Polytechnical University.[752]
- In October 2021 this lab took part in a conference held by the Chinese Chemical Society [中国化学会] called the National Seminar on Issues of Public Security in Chemistry [全国 "公共安全领域中的化学问题" 研讨会]. Other participants included the CAEP 903 Institute and the SASTIND Level 1 Chemical Defense Measurements Station [国防科技工业防化一级计量站], among others.[753]

*International*

- The lab's parent institution, the 204th RI, allegedly sends personnel to the U.S., Japan, Germany, Switzerland, Canada, and Russia for further studies and exchanges.[754]

**Lab Equipment:**

- The Explosive Pyrolysis Lab possesses equipment from U.S. company TA, including a high-pressure DSC (Differential Scanning Calorimetry) system, thermogravimeter [热重仪], and other instruments.[755]
- This lab possesses an advanced CARS system.[756]

**Address**:

Possibly co-located with the 204th RI at Jintai Road, Yanta District, Xi'an, Shaanxi Province [陕西省西安市雁塔区金石路][757]

**Known Aliases:**

None found

## 31. Defense S&T Key Laboratory of Fire Control Technology

**Official English Name:** Unknown

**Chinese Name:** 火力控制技术国防科技重点实验室

**Post-2024 Name**: No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Air
- *Secondary: Ground, Maritime*

Equipment:

- Multiple (Aircraft, Ground Vehicles, Helicopters, Surface Vessels, Unmanned Systems)

Functional Field:

- Fire Control
- *Secondary: Countermeasures, Simulation & Modeling, Target Detection/Recognition*

**Affiliations:**

- Aviation Industry Corporation of China (AVIC) [中国航空工业集团]
    - Luoyang Institute of Electro-Optical Equipment [洛阳电光设备研究所]
        - *a.k.a. AVIC Optronics [航空工业光电所]*
        - *a.k.a. AVIC 613th Research Institute [613 研究所]*

**Key Data:**

- Established: 1999
- Total Funding: Unknown
- Personnel: Unknown[758]
- Official start of operations: 2006
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research into various aspects of fire control systems, as well as detection, countermeasures, and targeting displays for airborne, maritime, and ground-based platforms.

The lab's parent institution, the AVIC Luoyang Institute of Electro-Optical Equipment, (a.k.a. AVIC Optronics, a.k.a. the AVIC 613th RI), was established in 1970 and is responsible for research of airborne fire control systems. It produces sensors, IR, and visual spectrum cameras, including the Dragoneye optical pods for attack helicopters and UAVs, night vision goggles,

displays, and Sharp Sight head-mounted displays. It does not appear to be on the U.S. Commerce Department Entity List.[759]

**Further Information:**

- The lab is composed of three subordinate units [单元]: Fire Control Principles Research [火控原理研究], Fire Control Systems Integrated Research [火控系统综合研究], and Target Sensor Simulation [目标传感器仿真].[760]
- This lab and its parent organization were originally subordinate to AVIC I, before AVIC I and AVIC II were re-consolidated in 2008. AVIC I was primarily focused on larger combat aircraft, including fighters and bombers.[761]

**Research Direction:**

1. New principles of fire control [火力控制新原理]
2. Key technologies of fire control systems [火力控制系统关键技术]
3. Closed-loop simulations and integrated test technologies for fire control systems. [火力控制系统闭环仿真和综合试验技术][762]

*Other Notable Research Areas:*

- Control and command[lii]
- Photoelectric detection and countermeasures
- Research into targeting displays
- Research into task distribution for UAV swarm attacks[763]

**Notable Applications:**

- None specifically found, but it is likely this lab has been involved in most modern combat aircraft fire control systems, as well as other recent 613th RI products, such as head-mounted targeting displays.

**Leadership and Key Personnel:**

- Director: Wang Jiangang [王建刚][764]
    - Also serves as Director of 613th RI
- Academic Committee Director: Gu Songfen [顾诵芬][765]
    - CAS and CAE Academician

[lii] 控制指挥, as opposed to "Command and control" [指挥控制]

    - Prominent PRC aircraft designer
- Deputy Director: Chen Xiaodong [陈哨东][766]

**Notable Collaborations:**

*Domestic*

- In 2020, this lab co-hosted the "Model Wings: 3rd China UAV Conference and Exhibition" [尖兵之翼 - 第三届中国无人机大会暨展览会]. Co-hosts included universities with strong military links like Beihang, Nanjing University of Aeronautics and Astronautics, and Northwestern Polytechnical University, as well as the PLA 60th Research Institute.[767]
- In 2009, this lab co-hosted the first annual Academic Conference on National Information Integration [全国信息融合学术年会] with the PLAN Aviation College (now university) [海军航空工程学院], Defense S&T Key Laboratory of C4ISR [C4ISR 技术国防科技重点实验室], and Hangzhou Dianzi University [杭州电子科技大学]. Participants came from National University of Defense Technology, CSIC, and AVIC, among other places.[768]

**Lab Equipment:**

- Utilizes a variety of advanced experimental means, software models, and a large model library to simulate and model fire control systems, optimize designs, develop fire control system software, and simulate target sensors.
- All lab equipment is connected by a fiberoptic network, allowing them to be dynamically combined depending on the experiment.[769]

Lab equipment includes:

- Flight simulators
- Optoelectronic simulation axis rotary table(s)
- Multi-target frequency injection simulation equipment, and other simulation facilities

**Address**:

None found, possibly co-located with parent institution at No. 25 Kaixuan West Road, Xigong District, Luoyang, Henan Province [河南省洛阳市西工区凯旋西路 25 号][770]

**Known Aliases:**

- National Key Laboratory of Fire Control Technology
- National Defence Science and Technology Lab of Fire Control Technology
- Key Laboratory of National Defense Science and Technology on Fire Control Technology

## 32. Defense S&T Key Laboratory of Fuze Dynamic Characteristics

**Official English Name:** Unknown

**Chinese Name:** 引信动态特性国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Multi-domain (Air, Ground, Maritime)

Equipment:

- Munitions
- *Secondary: Ballistic Missiles*

Functional Field:

- Munitions Technology
- *Secondary: Blast, Impact, and Damage*

**Affiliations:**

- China Ordnance Industries Group Corporation (Norinco) [中国兵器工业集团]
  - Xi'an Institute of Mechatronic Information Technology [西安机电信息技术研究所]
    - *a.k.a. Norinco 212th Research Institute*
- Beijing Institute of Technology [北京理工大学]
  - School of Mechatronical Engineering [机电学院]

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research into fuze technologies for various weapons systems in support of the PRC's primary fuze research institute. This includes electromechanical, laser, infrared, radio, magnetic, and acoustic fuzes.[771]

The lab is likely subordinate to two institutions. While never explicitly stated, various sources refer to the lab's "Beijing Branch"[772] and "Norinco Section."[773] The first refers to the Beijing Institute of Technology School of Mechatronical Engineering, alongside the State Key Lab of Explosion Science and Technology [爆炸科学与技术国家重点实验室].[774] The other refers to Norinco's Xi'an Institute of Mechatronic Information Technology (a.k.a. the 212th Research Institute), which was established in 1964 and is the only PRC research institute focused on R&D of weapons fuze technology. It has led both the GAD (now EDD) Fuzing Technology Experts Group and the China Ordnance Society's Fuzing group.[775] Among its accomplishments was developing the PRC's first electromechanical fuze, electronic time fuzes, and stochastic time-delay fuze, as well as developing the PRC's first atomic bomb fuze switch. Today, it is focused on cutting edge fuzes for all PLA services, including infrared, laser, and intelligent fuzes.[776]

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- Researches technologies electromechanical triggered fuzes, laser fuzes, infrared fuzes, radio fuzes, magnetic fuzes, and acoustic fuzes[777]

**Notable Applications:**

- This lab developed a fuze for an unnamed new PLA Rocket Force missile system[778]

**Leadership and Key Personnel:**

- Director: Zou Jinlong [邹金龙]
    - Active since at least 1986
    - Oversaw development of a fuze for a new missile system
    - Served as PLA General Armaments Department fuze expert[779]

**Notable Collaborations:**

*Domestic*

- This lab has partnered with Beijing Institute of Technology and the Ministry of Education Key Laboratory of Bionic Robotics [仿生机器人与系统教育部重点实验室] to establish an "intelligent weapons experimental class" at BIT. The initial class included 30 students conducting research under the director of senior weapons scientists.[780]

**Lab Equipment:**

None found

**Address**:

Xi'an, Shaanxi Province [陕西省西安市]

Beijing [北京市]

**Known Aliases:**

- 国防科技引信动态特性重点实验室

## 33. Defense S&T Key Laboratory of Gallium Arsenide Microwave and Millimeter Wave Monolithic and Modular Circuitry

**Official English Name:** Unknown

**Chinese Name:** 砷化镓微波毫米波单片和模块电路国防科技重点实验室

**Post-2024 Name:** this lab may have merged with the Defense S&T Key Lab of Specialized Integrated Circuits to form a new lab called the National Key Laboratory of Solid State Microwave Devices and Circuits[liii] [固态微波器件与电路全国重点实验室][781]

**Research Focus:**

Domain:

- Multi-Domain (Air, Ground)

Equipment:

- Semiconductors
- *Secondary: Communications Equipment, Radar*

Functional Field:

- Multiple (Microwave Technology, Millimeter Wave Technology)

**Affiliations:**

- China Electronics Technology Group Corporation (CETC) [中国电子科技集团]
  - Nanjing Electronic Devices Institute (NEDI) [南京电子器件研究所]
    - *a.k.a. CETC Guoji South Group Co. Ltd. [中电国基南方集团有限公司]*
    - *a.k.a. CETC 55th Research Institute [第五十五研究所]*

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research into next-generation gallium arsenide (GaN) semiconductors for military and civilian use. GaN is considered superior to traditional, silicon-based

[liii] Literal translation, no official name given

semiconductors. Monolithic-microwave integrated circuits (MMIC) utilizing GaN-based high electron mobility resistors (HEMT) feature higher breakdown strength, faster switching speed, higher thermal conductivity, and lower on-resistance. This allows for better efficiency, smaller size, and lower cost chips.[782] According to a researcher associated with this lab, China's GaN power devices and MMIC have already entered the engineering application stage, and GaN power device technology has achieved self-reliance.[783]

This lab is subordinate to CETC's Nanjing Electronic Devices Institute (NEDI) (a.k.a the CETC Guoji South Group Co. or CETC 55th Research Institute), which specializes in electronic components, including solid-state power devices and RF microsystems, and opto-electronic displays and detection. Its core chips and other components have been used for air defense, early warning, communications, navigation, satellites, and space flight. It has been involved in China's quest for effective domestically-produced semiconductors. It is also involved in development of civilian RF and power electronics, including semiconductor epitaxial materials, power devices, RF devices and circuit modules, surface acoustic wave devices, building intelligence, and multilayer ceramic packages and housings. Its T/R components and radio transceiver modules are used in a range of radars, including aircraft fire control radars, early warning aircraft, and air defense radars.[784] It is blacklisted by the U.S. government, and has been caught attempting to illegally export photoresist and other chip manufacturing chemicals from the United States.[785]

Under the ongoing reorganization of the PRC's national key lab system, there is some evidence that this lab may have merged with the Defense S&T Key Laboratory of Specialized Integrated Circuits of the CETC 13th RI to form a new National Key Lab, the National Key Laboratory of Solid State Microwave Devices and Circuits [固态微波器件与电路全国重点实验室]. While nconfirmed as of this writing, branches of the new lab appear to be active under both the CETC 13th RI in Shijiazhuang[786] and 55th RI in Nanjing.[787] Further, personnel from both former labs appear to be affiliated with this new lab.[788] Another source lists the 55th RI as overseeing the "Nanjing branch" of the new lab, further suggesting there are other branches.[789]

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- Utilizing diamonds to solve the device heat dissipation problem and realize higher output power density, as well as adopting a new type of heterojunction combined with low parasitic 35nm gate length process to improve device operating frequency.[790]
    - The lab is working on several ways to integrate GaN with diamond substrate, including epitaxial GaN material technology on diamond substrate, nanocrystalline diamond passivation technology, GaN epitaxial layer backside growth diamond technology, and diamond substrate GaN HEMT based on transfer technology. Due to the good physical properties of diamond materials, such as high thermal conductivity as well as high electron and hole mobility, GaN microwave power

devices utilizing diamond substrates are considered to be the first choice for the next generation of solid-state microwave power device technology. Currently, the two primary problems to be solved are heat dissipation and ultra-high frequency in high-power GaN HEMT technology.[791]

- In 2021, Chen Tangsheng reported that the lab is still working on GaN HEMT heat dissipation, and have had success with engineering applications, although it is still working through difficulties in the fabrication process. He reports that domestic GaN HEMT and MMIC still need to improve process capabilities and strive to work on production scale expansion and cost control. The lab is exploring the microwave performance advantages of GaN HEMT, and preliminary results in low-temperature bonded diamond GaN. They are currently researching improving the flatness and roughness of diamond substrate, further optimizing the bonding process, reducing bonding interface void rate, and advancing the engineering application of diamond GaN HEMT.[792]
- In 2017, researcher Zhang Kai [张凯] published a paper on "High-Linearity AlGaN/GaN FinFETs for Microwave Power Applications" in IEEE Electron Device Letters, describing recent breakthroughs at this lab in GaN high linearity technology. He proposed using 3D GaN FinFET microwave power devices, which overcomes the bottleneck of GaN planar devices and greatly improves transconductance flatness and GaN device linearity while maintaining high output power and efficiency.[793]
- Work on microwave photonic devices and heterogeneous heterostructure integration technology.[794]

**Notable Applications:**

- One source suggests the lab's T/R components are used in the KLJ-7A phased array fire control radar and YLC-8B mobile early warning phased array radar.[795]

**Leadership and Key Personnel:**

- Director: Chen Tangsheng [陈堂胜]
  - CETC's chief scientist [首席科学家] on process manufacturing [工艺制造]
  - Works on high-power and ultra-high-frequency GaN Microwave Power Devices for military and civil use[796]
  - Graduate of Xi'an Jiaotong University[797]
  - Became director sometime after August 2019, when he was still the lab's executive deputy director[798]

**Notable Collaborations:**

*Domestic*

- This lab has worked with the PLAAF Equipment Department to develop a microwave photonic transmitter/receiver.[799]
- Director Chen Tangsheng is the majority owner of a company called Nanjing CETC Chip Valley High Frequency Device Industrial Technology Research Co. [南京中电芯谷高频器件产业技术研究院有限公司].[liv] The company was established in May 2018 with 13.3m RMB in registered capital. The CETC 55th RI holds 37.59% of shares and exercises significant influence.[800] Likely associated with this company, in 2018 (one month after the initial establishment of the company), the CETC 55th RI and Nanjing municipal government jointly established the CETC Chip Valley & Nanjing High Frequency Devices Industrial Technology Research Institute [中电芯谷暨南京高频器件产业技术研究院], which will play an important role in promoting the leapfrog development of the chip industry in Nanjing. It is focused on building new R&D institutions, state key labs, and S&T innovation incubation zones, and will rely on the 55th RI and this lab. It will focus on five major areas, including new terahertz technology, millimeter-wave chips, optoelectronic integrated devices, carbon nanotubes, and graphene, and carry out research and development of common and key industrial technologies, integration of scientific and technological discoveries, technology transfer and transformation, talent training, and high-tech enterprise incubation.[801] It is the first incubation company focused on terahertz module circuits for space exploration, satellite remote sensing, space comms, and security imaging.[802]

*International*

- In 2023, Chen Tangsheng spoke at the 8th International Forum on Third Generation Semiconductors (IFWS) & the 19th China International Semiconductor Lighting Forum (SSLCHINA), which featured a Japanese Nobel Prize winner, and U.S. professors from Virginia Tech, NC State, and University of Virginia. Chen spoke on nitride semiconductor electronic materials and devices and frequency electronic materials and devices.[803]

**Lab Equipment:**

None found

[liv] Address: Office 1006, Building 4, Nanjing Baixia High-Tech Industrial Park, No. 6 Yongzhi Rd., Qinhuai District, Nanjing [南京市秦淮区永智路 6 号南京白下高新技术产业园区四号楼 1006 室]

**Address**:

Possibly co-located with the CETC 55th RI at No. 524 Zhongshan East Road, Baixia District, Nanjing, Jiangsu Province [江苏省南京市白下区中山东路 524 号][804]

**Known Aliases:**

- Science and Technology on Monolithic Integrated Circuits and Modules Laboratory
- National Key Laboratory of Monolithic Integrated Circuits and Modules [微波毫米波单片集成电路与模块国家级重点实验室]
- 单片集成电路与模块国家级重点实验室
- 砷化镓微波毫米波单片 集成电路与模块国家重点实验室
- 微波毫米波单片集成电路与模块国家重点实验室
- 砷化镓微波毫米波单片集成电路与模块国家重点实验室
- 微波毫米波单片集成电路与模块国防科技重点实验室
- 单片集成电路与模块国家重点实验室
- 微波毫米波单片集成和模块电路重点实验室

## 34. Defense S&T Key Laboratory of Helicopter Rotor Dynamics

**Official English Name:** Unknown

**Chinese Name:** 直升机旋翼动力学国防科技重点实验室

**Post-2024 Name:** National Key Laboratory of Helicopter Dynamics[lv] [直升机动力学全国重点实验室][805]

**Research Focus:**

Domain:

- Air

Equipment:

- Helicopters

Functional Field:

- Aerodynamics
- *Secondary: GNC, Materials, Robotics*

**Affiliations:**

- Nanjing University of Aeronautics and Astronautics (NUAA) [南京航空航天大学]
  - College of Aerospace Engineering Helicopter Department [航空学院直升机系]
- Aviation Industry Corporation of China (AVIC) [中国航空工业集团]
  - Chinese Helicopter Research and Development Institute (CHRDI) [中国直升机设计研究所]
    - *a.k.a. AVIC 602nd Research Institute [602 研究所]*

**Key Data:**

- Established: 1991
- Total Funding: Unknown
- Personnel: 52[806]
- Official start of operations: 1995
- Floor Space: Unknown

[lv] Literal translation, no official name given

**Lab Overview:**

This lab conducts basic theoretical research into various aspects of helicopter design, including helicopter dynamics and control, rotorcraft configurations, vibration noise control, actuator design, and helicopter hardware and software.

The lab is jointly overseen by the Nanjing University of Aeronautics and Astronautics (NUAA) and AVIC's Chinese Helicopter Research and Development Institute (CHRDI) (a.k.a. AVIC 602nd RI). CHRDI, established in 1969, is the PRC's primary center for helicopter model development and is known as the "cradle of Chinese helicopters." It has developed over 40 helicopter models, including the Z-8, Z-9, Z-10, Z-11, and Z-19 military helicopters. NUAA is a major center for helicopter R&D in the PRC, with six labs and the PRC's only dedicated academic department for helicopter research. Over 80 percent of technical backbone and management personnel in the helicopter field in China studied at NUAA. The lab's headquarters is housed at NUAA, with CHRDI hosting a subordinate branch.[807]

Under the ongoing reorganization of the PRC's national key lab system, this lab is now known as the National Key Laboratory of Helicopter Dynamics [直升机动力学全国重点实验室].

**Further Information:**

- The lab has several subordinate research teams:
  - Lu Yang's team is responsible for research into *rotorcraft dynamics and control* [旋翼类飞行器开展动力学与控制]. This includes helicopter vibration noise active and semi-active control technology, advanced materials-based helicopter vibration noise control technology, actuator sensor selection technology, advanced actuator design technology, new concepts for rotorcraft design, helicopter flight safety warning technology measurement and control software, and hardware system development.[808]
  - Zhu Qinghua's team is responsible for research into *overall design of new rotorcraft configurations* [新构型旋翼类飞行器总体设计]. This includes comprehensive overall rotorcraft design technology, overall aerodynamics and control of new helicopter configurations, new concept rotor and multi-robotic vehicles, and airworthiness of light aircraft.[809]
  - Li Jianbo's team is responsible for research into *advanced helicopters and overall analysis of new rotorcraft configurations* [先进直升机和新构型旋翼飞行器总体分析]. Research areas include helicopter overall, aerodynamic, and flight mechanics technology, design technology for unmanned helicopter systems, and optimization of rotorcraft software.[810]
- The lab has 205 graduate students (48 PhD and 157 Master's).[811]

**Research Direction:**

1. Helicopter rotor dynamics and control [直升机旋翼动力学及控制]
2. Helicopter transmission and system dynamics [直升机传动与系统动力学]
3. Overall technologies for new rotorcraft [新型旋翼飞行器总体技术][812]

*Other Notable Research Areas:*

- Helicopter vibration noise active/semi-active control technology
- Advanced materials-based helicopter vibration noise control technology
- Actuator sensor selection technology
- Advanced actuator design technology
- New concept rotorcraft design
- Helicopter flight safety warning technology measurement and control software and hardware system development
- Comprehensive overall rotorcraft design technology
- Overall aerodynamics and control of new helicopter configuration
- New concept rotor and multi-robotic vehicles
- Airworthiness of light aircraft
- Helicopter overall, aerodynamic, and flight mechanics technology
- Unmanned helicopter system integrated design technology
- Optimization of rotorcraft software[813]

*2023 Research funding priorities:*[814]

Each project will receive approximately 300,000 RMB in funding

1. Overall design of the new configuration rotorcraft [新构型旋翼飞行器总体设计]
   (1) Mars unmanned rotorcraft overall design
   (2) New configuration high-speed rotorcraft concept design and evaluation technology
   (3) Transmedia rotorcraft configuration and overall layout design
   (4) Distributed-power rotorcraft overall design
   (5) Electric/Hybrid helicopter overall design
   (6) Helicopter stealth design technology
   (7) Rapid prototyping of new configuration rotorcraft
2. Helicopter aerodynamics and flow control [直升机空气动力学与流动控制]
   (1) Rotor wing non-stationary dynamic stall models
   (2) Helicopter aerodynamic simulation technology for complex configurations and deformable bodies
   (3) Multiphase flow field simulation technology for trans-domain/trans-media rotorcraft
   (4) High-precision simulation technology for helicopter acoustic fields
   (5) Rotor wing active flow control technology

(6) New principles of helicopter aerodynamic noise suppression and applications
(7) Coupled aeroelastic effects of high-performance rotor wing optimization designs

3. Helicopter structural dynamics and vibration control [直升机结构动力学与振动控制]
   (1) Rotor blade aeroelastic dynamics modeling and analysis methods
   (2) Intelligent rotor blade structural design and dynamics analysis techniques
   (3) Helicopter rotor blade/fuselage/landing gear coupling dynamics
   (4) Structural design and dynamics analysis techniques for critical components
   (5) New technologies for helicopter vibration and noise reduction
   (6) Helicopter structural condition monitoring and fault diagnosis techniques
4. Helicopter flight dynamics [直升机飞行动力学]
   (1) Flight dynamics modeling and verification of new configuration rotorcraft
   (2) Accurate prediction and expansion techniques for helicopter surface landing and takeoff envelopes (landing and takeoff wind limit charts)
   (3) Helicopter outboard suspension/towing flight characteristics and oscillation suppression
   (4) Helicopter flock formation jamming characteristics and flight safety;
   (5) Advanced flight test techniques for complex environments/missions;
   (6) Flight dynamics of tethered rotorcraft and their control
5. Helicopter flight control and health management [直升机飞行控制与健康管理]
   (1) Helicopter flight control and management key system design, simulation and verification technology
   (2) New methods and theories for special flight control problems of new configuration rotorcraft
   (3) Advanced flight control system application technology for unmanned helicopters
   (4) Helicopter intelligent perception, planning, cooperative and decision-making control technology
   (5) Helicopter flight control technology and flight safety in special conditions
   (6) Intelligent and fault-tolerant control and mission re-planning of unmanned helicopter formations
   (7) Cooperative maintenance and intelligent optimization for unmanned helicopter formations
6. Coupled dynamic behavior and vibration control for helicopter drive systems [直升机传动系统耦合动力学行为与振动控制]
   (1) Equivalent dynamics simulation of engine-drivetrain-rotor integrated coupling systems and performance analysis
   (2) Nonlinear chaotic vibration control and optimization of helicopter main reducer drivetrains
   (3) Nonlinear chaotic vibration control and optimization of helicopter tail reducer drivetrains
   (4) New principles and application techniques for active/passive control of helicopter drivetrains
   (5) Novel helicopter drivetrain configurations and dynamic behaviors research

7. Efficient lubrication technology for helicopter drive systems [直升机传动系统的高效润滑技术]
    (1) Mechanisms and optimization of micromotion friction and wear behavior for titanium alloy splines
    (2) Prediction of anti-dry running behavior for helicopter driveline bearings and design techniques
    (3) Optimization of helicopter driveline bearing flow fields and high efficiency lubrication design
    (4) Optimization of helicopter driveline end face seal design
    (5) Helicopter main gearbox flow field simulation and high efficiency lubrication methods
8. Advanced test technology for helicopters [直升机先进试验技术]
    (1) Rotor blade non-constant aerodynamic load and noise measurement technology
    (2) Helicopter rotor blade multiphase flow field measurement technology
    (3) Rotor blade dynamic load measurement and identification technology
    (4) Helicopter shutdown component fatigue and impact test technology
    (5) Helicopter active control test technology
    (6) High-speed helicopter flight test technology
    (7) Helicopter energy recycling and utilization technology
    (8) Prototype validation technology for new configuration rotorcraft

**Notable Applications:**

- It is highly likely that this lab has had a hand in research and design of many if not all PRC military helicopters of the past 25 years. Images imply that this lab was associated with the development of the Z-10 and Z-19 attack helicopters and the Z-20 medium-lift utility helicopter. According to another source, this lab has provided research support to the latest models of the Z-8, Z-9, and Z-10 military helicopters.[815]
- One of the founders of the lab, Wang Shicun, was involved in the development of the Z-8, Z-9, and Z-11 military helicopters. The former two came before the creation of this lab however.[816]
- Although outside of this lab's core mission, researcher Zhao Qijun also researches stealth technology and has been involved in the design of the PRC's future 6th-generation stealth aircraft.[817]

**Leadership and Key Personnel:**

- Director: Jiang Bin [姜斌][818]
- Deputy Director: Zhao Qijun [招启军][819]

*Key Personnel*

- Wang Shicun [王适存][820]
  - Lab founder
  - Considered a pioneer and major influence in PRC helicopter design
  - Died in 2011
- Lu Yang [陆洋]
  - Leads a team focused on rotorcraft dynamics and control (see "Further Information" above)
- Zhu Qinghua [朱清华]
  - Leads a team focused on overall design of new rotorcraft structures (see "Further Information" above)
- Li Jianbo [李建波]
  - Leads a team focused on advanced helicopters and overall analysis of new rotorcraft configurations (see "Further Information" above)

**Notable Collaborations:**

*Domestic*

- This lab, along with the NUAA Micro Air Vehicle Research Center [微型飞行器研究中心], is associated with the Nanjing-based private company Taoxun Aviation [韬讯航空], which designs small dual-rotor helicopter drones for both civilian and military use (mainly for patrol, reconnaissance, and security).[821]
- This lab established a "Joint Laboratory of Rotorcraft and Control Technology" [旋翼飞行器及控制技术联合实验室] with the private Chongqing Tonghang Group [重庆通航集团] in 2016. It is focused on solving problems related to rotorcraft and is jointly developing the CG111 single piston light helicopter [单发活塞轻型直升机].[822]
- This lab is closely associated with NUAA's Helicopter Research Academy [直升机研究院], which works closely with PLAA Aviation.[823]

*International*

- This lab is affiliated with the China chapter of the American Vertical Flight Society, and claims to have established joint research centers, cooperative labs, and lecture visits with multiple foreign universities and research institutions.[824]
- Lab leader Zhao Qijun spoke at the 2022 38th China Helicopter Academic Exchange Conference and 6th International Forum on the Civil Helicopter Industry [第 38 届中国直升机学术交流会（线上）暨 2022 第 6 届民用直升机产业国际论坛]. Organizers included Nanjing university of Aeronautics and Astronautics and AVIC. Speakers came from AVIC and Northwestern Polytechnical University, as well as a chief inspector for the PRC's aerospace defense industry [大中华区航空航天国防行业技术总监]. One French

speaker came from Airbus. The event was also co-sponsored by U.S. Pall Corporation, PCB Piezotronics, and French Dassault Systems.[825]

- This lab has hosted the 2nd, 3rd, and 4th International Conferences on Rotorcraft Fundamentals, as well as the annual Asia-Australia Helicopter Conference.[826]
- This lab has signed agreements to create a Joint Research Center for Helicopter Technology [直升机技术联合研究中心] with Glasgow University in the U.K. and an International Joint Research Center for Helicopter Configuration [直升机结构国际联合研究中心] with the University of Nottingham in the U.K.[827]
- This lab has allegedly signed an agreement with the Russian Technological University to create a Sino-Russian Joint Laboratory.[828]

**Lab Equipment:**

The lab's major equipment includes:

- Helicopter low-speed wind tunnel
  - Used to test helicopter aerodynamics and described by one source as the "most mysterious and most important place for helicopter research at NUAA;" currently the busiest piece of equipment in the laboratory.
  - All-steel structure containing a power section, a pressure expansion section, a stabilization section, as well as a closed second test section and an open main test section.
  - The open main test section measures 3.4m x 2.4m, and the closed second test section measures 5.0m x 3.5m, which is equipped with a set of honeycomb rectifiers and two layers of 14-mesh damping mesh.
  - Powered by a 1000 KW DC speed-controlled motor, which drives a fan to generate airflow, and the fan is composed of 8 blades of FRP material.
- Rotor arm model rotor maneuvering flight test machine
  - Used to simulate a variety of helicopter maneuvers as a way of testing rotor aerodynamic characteristics in flight.
- Helicopter model rotor test bench
  - "Indispensable" facility for helicopter rotor wind tunnel tests.
  - Consists of a rotor hub, six-component rotor balance, rotor shaft torque balance, manipulating actuator, DC speed control motor, etc.
  - The test stand can be tilted forward by 20°, the motor power is 55Kw, the maximum speed is 2500r/m.
  - Uses a speed control device from German company Siemens. The speed regulation accuracy is plus or minus 1rpm, according to different test requirements; using an articulated or non-articulated propeller hub, the rotor table leaves a fuselage balance interface and can carry out combined fuselage/rotor tests.
- Rotorcraft flight dynamics and flight control ground simulation verification system

    - Solves the problem of nonlinear real-time flight dynamics and flight control mathematical modeling of rotorcraft full system coupling, and develops a high immersion scenery system and simulated cockpit system.
    - Has high confidence, realistic view, and can conduct flight simulations under various conditions such as day, night, wind, frost, rain, snow, etc.
    - Provides an excellent platform for advanced flight control evaluation and verification of rotorcraft.
- Helicopter vibration and noise active control system
- Maneuvering demonstration helicopter
- Rotor model test system
- Dynamic rotor test bench (six degrees of freedom)
- Vertical water tunnel
- Fatigue test system
- Tiltable rotor test bench
- High-speed co-axial rotor test system
- Wing/body co-stability test bench
- Electronically controlled rotor model test bench
- High-speed culvert vector thrust test bench
- Pressure and velocimetry instruments[829]

**Address**:

Building A5, NUAA Minggugong Campus, No. 29 Yudao Street, Qinzhun District, Nanjing, Jiangsu Province [江苏省南京市秦淮区御道街 29 号南航明故宫校区 A5 楼][830]

**Website**:

https://aero.nuaa.edu.cn/2017/0224/c9601a78296/page.htm

**Known Aliases:**

- National Key Laboratory of Rotorcraft Aerodynamics [直升机旋翼动力学国家级重点实验室]
- National Key Laboratory of Science and Technology on Rotorcraft Aeromechanics
- Science and Technology on Rotorcraft Aeromechanics Laboratory
- 中国直升机设计研究所直升机旋翼动力学重点实验室

## 35. Defense S&T Key Laboratory of Helicopter Transmission Technology

**Official English Name:** Unknown

**Chinese Name:** 直升机传动技术国防科技重点实验室

**Post-2024 Name**: No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Air

Equipment:

- Helicopters

Functional Field:

- Vehicle Parts & Technology

**Affiliations:**

- Nanjing University of Aeronautics and Astronautics (NUAA) [南京航空航天大学]
  - College of Mechanical & Electrical Engineering [机电学院]
- Aero Engine Corporation of China (AECC) [中国航空发动机集团]
  - Hunan Aviation Powerplant Research Institute [湖南动力机械研究所]
    - *a.k.a. 608th Research Institute [608 研究所]*

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown[831]
- Official start of operations: 2018
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research into helicopter transmissions, which are a key component of the PRC's goal of building a new generation of helicopters with high power-to-weight ratio, high speed-reduction ratio, high survivability, high reliability, and easy maintenance. This lab is among the newest Defense S&T Key Labs on the list, having been ratified by SASTIND and the CMC Equipment Development Department in April 2018.[832]

The lab is jointly managed by the Nanjing University of Aeronautics and Astronautics (NUAA) and AECC's Hunan Aviation Powerplant Research Institute (a.k.a. the AECC 608th

Research Institute). NUAA is a major center for helicopter R&D, with six labs related to helicopters and the PRC's only dedicated academic department for helicopter research. Over 80 percent of technical backbone and management personnel in the helicopter field in China studied at NUAA. The AECC 608th RI, founded in 1968, is the PRC's primary institute for research into helicopter engines and transmissions.[833]

**Further Information:**

- The lab has subordinate labs for High Power Density Gearing [高功率密度齿轮传动], Friction and Lubrication [摩擦与润滑], Intelligent Manufacturing [智能制造], Precision Machining [精密机械加工], and Additive Manufacturing [增材制造].[834]
- The lab has a presense in the Medium and Small Aviation Engine Cluster [中小航空发动机集群] in Zhuzhou, Hunan Province.[835]

**Research Direction:**

1. High power density gear transmission technology [高功率密度齿轮传动技术]
2. Friction and lubrication technology [摩擦与润滑技术]
3. New transmission configurations and new materials for gear transmissions [新型传动结构及新材料齿轮传动技术][836]

**Notable Applications:**

- This lab is probably still too new to have seen its research applied to many projects, but its official introduction made clear that it is dedicated to helping create a new generation of advanced helicopters. It is thus likely that this lab will have a hand in any post-2018 PRC military helicopter projects.

**Leadership and Key Personnel:**

- Director: Zhu Rupeng [朱如鹏][837]
- Academic Committee Director: Yin Zeyong [尹泽勇][838]
- Deputy Directors: Zhu Di [朱荻]; Nie Meijun [廖梅军][839]
    - CAS Academician

**Notable Collaborations:**

None found

**Lab Equipment:**

None found

**Address**:

The likeliest address is in Building A6, NUAA Minggugong Campus, No. 29 Yudao Street, Qinzhun District, Nanjing, Jiangsu Province [江苏省南京市御道街 29 号][840]

**Website**:

http://cmee.nuaa.edu.cn/2019/1220/c11625a190575/page.htm

**Known Aliases:**

- National Key Laboratory of Science and Technology on Helicopter Transmission [直升机传动技术国家级重点实验室]

## 36. Defense S&T Key Laboratory of High-Energy Beam Processing Technology

**Official English Name:** Laboratory for High Energy Density Beam Processing Technology[841]

**Chinese Name:** 高能束流加工技术国防科技重点实验室

**Post-2024 Name**: No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Air
- *Secondary: Space*

Equipment:

- Aircraft
- *Secondary: Space Vehicles*

Functional Field:

- Manufacturing
- *Secondary: Laser Technologies, Materials, Plasma Technologies, Propulsion*

**Affiliations:**

- Aviation Industry Corporation of China (AVIC) [中国航空工业集团]
    - Manufacturing Technology Institute (MTI) [制造技术研究院]
        - *a.k.a. AVIC Manufacturing Institute [制造院]*

**Key Data:**

- Established: 1993
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: 1996
- Floor Space: Unknown[842]

**Lab Overview:**

This lab conducts research into advanced manufacturing techniques for new materials used in aircraft, aerospace, electronics, armaments, and other defense products. This includes new technologies for processing, welding, hole making, cutting, coating, and surface modification.[843] Key research areas include laser, electron beam, ion beam, and plasma processing technologies for new materials and structures.[844] As of 2021, the lab is reportedly the only research institution in

the PRC that owns all three of laser processing, electron beam processing, and plasma processing technologies, and is unique in its ability to integrate all three into its research. The PRC has laser processing technology as a national priority for high-tech industrialization.[845]

The lab's parent institution, the Beijing Aeronautical Manufacturing Technology Research Institute (BAMTRI) [北京航空制造工程研究所] (a.k.a. the AVIC 625th RI), was reconstituted into the AVIC Manufacturing Technology Institute (MTI) in 2016. MTI specializes in advanced manufacturing for aviation and national defense, with a focus on aviation materials, manufacturing process technologies, and specialized equipment for the PRC's new aircraft, aero-engines, missiles, and other aviation equipment. MTI also provides advanced manufacturing technology for aerospace, electronics, armaments, shipping, and other national defense industries.[846] It is on the U.S. Commerce Department Entity List for export control.[847]

**Research Direction:**

1. High-energy beam processability and process optimization technology for new materials and difficult-to-process materials [新型材料及难加工材料高能束流可加工性及工艺优化技术]
2. New processing methods and key process equipment for laser beams, electron beams, and plasma beams with new structures [新结构的激光束、电子束、等离子束的新加工方法及关键工艺装备]
3. Improving high-energy beam source performance, processing control, and quality monitoring technology [提高高能束流束源性能及加工过程控制和质量监控技术][848]

*Other Notable Research Areas:*

- High-energy beam current processing technology
- High-energy beam welding technology
- High-energy beam surface engineering technology
- High-energy beam rapid manufacturing technology[849]

**Notable Applications:**

- The lab has developed special equipment for high-energy beam processing which has been widely used in aviation, aerospace, electronics, armaments and other defense and civil industries. This includes equipment for laser welding and cutting, laser hole making, (vacuum) electron beam welding, thermal spraying, ion implantation, abrasive flow processing/abrasive flow machine tools, and powder feeders.[850]
- This lab developed a high-temperature wearable coating for an aero-engine turbine outer ring, a key component. for aero-engine gas circuit sealing.[851]
- The lab developed a laser/electron beam precision additive forming for aerospace equipment.[852]

- This lab has made breakthroughs in aircraft and rocket engine laser-selective and electron beam-selective melting and forming for complex structures.[853]

**Leadership and Key Personnel:**

- Director: Li Zhiqiang [李志强][854]
    - Also President of AVIC MTI
- Deputy Director: Gong Shuili [巩水利][855]

*Key Personnel:*

- Guan Qiao [关桥][856]
    - CAE Academician

**Notable Collaborations:**

*Domestic*

- Per a search of two scientific databases, this lab has collaborated on materials research with numerous PLAAF institutions, including the PLAAF Beijing Military Representative Office (on alloys and welding technology for gas turbines and aero-engines), the PLAAF Equipment Department, Air Force Aviation University, and the PLAAF Military Representative Office for the Shenyang Aircraft Corporation.
- This lab has collaborated with numerous defense industry partners, including X'an Aero Engine Group, Chengdu Aircraft Industry Co., Shenyang Liming Aero Engine Co., Harbin Dong'an Engine Co, Shaanxi Aircraft Industry Group, Guizhou Liyang Machinery Factory, CALT, CASIC 3rd Academy, Dongfang Steam Turbine Co., and Norinco 52nd RI.[857]

*International*

- This lab has hosted most or all iterations of the International Conference on Power Beam Processing Technologies (ICPBPT) [高能束流加工技术国际学术会议] with The Welding Institute (TWI) of the U.K., with various international participants from the University of Nebraska – Lincoln in the U.S., Royal Academy of Engineering and Manchester University in the U.K., Toshiba Corporation in Japan, and others from Germany, Korea, and Ukraine.[858]
- This lab co-organized the 2023 International Conference on Lightweight Materials and Manufacture [2023 轻质材料与轻量化制造技术国际会议]. Foreign participants came from the U.K Royal Academy of Engineering, French National Academy of Technological Sciences (speaking on 3D printing of high-strength and lightweight alloys), Italy's University of Palermo, Poland's Insitute of Fundamental Technologies, and Singapore's Institute of Manufacturing Technology.[859]

**Lab Equipment:**

The lab's high-energy beam processing equipment includes:[lvi]

- Laser processing technology for laser drilling, laser welding, and laser cutting, including CNC laser machines.
- Electron beam processing technology for electron beam brazing, electron beam welding, electron beam surfi-sculpting, electron beam freeform fabrication, and electron beam melting, including electron beam welders.
- Electron guns
- Electron beam processing power supply
- Plasma processing technology, including spray systems and power feeders, air spray pump shell, plasma spray ingot plate, and plasma spray high speed robots
- Microwave plasma omni-directional ion implantation and deposition equipment.[860]

Other equipment/processes include:

- Laser direct deposition for damage repair of integral impellers
- Electron beam fusion deposition of titanium alloy structural parts
- Ion coating equipment
- Laser shock peening equipment
- Dual beam laser welding equipment
- Additive manufacturing parts[861]

**Address**:

No. 1 Chaoyang Road, Chaoyang District, Beijing [北京市朝阳区朝阳路 1 号][862]

**Website**:

https://web.archive.org/web/20210121070642/https://www.avicmti.avic.com/gxwm/xfbs/cdsys/index.shtml

**Known Aliases:**

- National Key Laboratory for High-Energy Beam Processing Technology [高能束流加工技术国家级重点实验室]
- Key Laboratory for High-Energy Beam Processing Technology [高能束流加工技术重点实验室]

[lvi] Further technical details and photos of much of this equipment is available upon request.

- Laboratory for High Energy Density Beam Processing Technology [高能束流加工技术研究室]
- State Key Laboratory of High-Energy Beam Processing Technology
- Science and Technology on Power Beam Processes Laboratory

## 37. Defense S&T Key Laboratory of High-Power Microwave Electronic Vacuum Component Technology

**Official English Name:** Unknown

**Chinese Name:** 大功率微波电真空器件技术国防科技重点实验室

**Post-2024 Name:** possibly National Key Laboratory of Microwave Electronic Vacuum Components[lvii] [微波电真空器件全国重点实验室][863]

**Research Focus:**

Domain:

- Air

Equipment:

- Radar

Functional Field:

- Electromagnetics
- *Secondary: Microwave Technologies, Millimeter Wave Technologies, Terahertz Technologies*

**Affiliations:**

- University of Electronic Science and Technology of China (UESTC) [电子科技大学]
  - School of Electronic Science and Engineering [电子科学与工程学院][lviii]
- China Electronics Technology Group Corporation (CETC) [中国电子科技集团]
  - 12th Research Institute [12 研究所]

**Key Data:**

- Established: 1992
- Total Funding: Unknown
- Personnel: 27 (UESTC only)[864]
- Official start of operations: 1998
- Floor Space: 4,320 sqm (UESTC only)

**Lab Overview:**

This lab was established with the goal of accelerating R&D of high-power microwave, millimeter wave, and electronic vacuum devices required for the creation of advanced electronic

[lvii] Literal translation, no official name given
[lviii] Formerly under the UESTC School of Physical Electronics

equipment.[865] Beginning in the 1990s, there was a growing realization that semiconductors, which had replaced vacuum tube technology beginning in the 1960s, were not always able to meet the growing demands placed on high-precision radars. Researchers thus began looking at high-power microwave electronic vacuum technology for future military radars, electronic warfare, directed energy weapons, and space communications.[866] Further research areas include millimeter-wave and terahertz vacuum electronic devices, millimeter-wave space traveling wave tubes, quantum frequency scale devices, vacuum microelectronic devices, high-power cyclotron devices, electromagnetic simulation technology, cathode technology, microfabrication technology, and the research of new processes and materials. Today, it is the only national-level lab for vacuum electronics in China.[867]

The lab was expanded and upgraded (possibly to its current status as a Defense S&T Key Lab) in 2005. It has branches in Beijing (under the 12th Research Institute, responsible for manufacturing and tube production) and Chengdu (Under UESTC, responsible for basic theoretical research, key technology breakthroughs, and personnel training). The Beijing branch serves as the main headquarters.[868] Under the ongoing reorganization of the PRC's national key lab system, this lab may now be known as the National Key Laboratory of Microwave Electronic Vacuum Components [微波电真空器件全国重点实验室].

UESTC is the top university in China for specialized research into these technologies, and claims to be the only university in China capable of conducting high level research and computer simulations on high-power microwave and millimeter-wave devices via both cold and thermal testing.[869] The CETC 12th RI was established in 1957 and is focused on microwave electronic vacuum devices for both military and civilian products.[870]

**Further Information:**

- The lab received an initial investment of 2m RMB in research funds. It was expanded and improved in 2004 and 2008, and its mission expanded into the research of high-power microwave devices, micro-vacuum electronics, microwave and millimeter wave sources, new cathodes and their applications in microwave tubes, and research of new materials and processes in the application of microwave tubes.[871]
- During the 11th Five Year Plan (2006-2010), this lab was tasked with building new high-power microwave, millimeter wave, and short millimeter wave research platforms, terahertz wave spectral analysis systems and signal detection platforms, exploring theories for new electromagnetic materials and new radiation mechanisms based on new millimeter wave cyclotron devices, and designing methods to lay a foundation for the application of new technologies in the terahertz spectrum frequency.[872]
- The lab has a subordinate Microwave and Millimeter Wave Devices and Applications Team [微波毫米波器件及应用团队], which focuses on high-power microwave and millimeter wave devices, electromagnetic biological effects and imagin, and microwave

energy applications. It has 12 team members. It was allegedly the first in the world to observe inverse Cherenkov radiation.[873][lix]

**Research Direction:**

1. Theories and technology for high-power microwave and millimeter wave devices [大功率微波毫米波器件的理论和技术]
2. Theories, technologies, and devices for micro-vacuum electronics [微真空电子学的理论，技术和器件]
3. High-power microwave and millimeter wave sources [大功率微波毫米波源的理论，技术，器件和应用]
4. High-emission density and long-life cathodes, field emission array cathodes, and other new cathodes and their applications [高发射密度和长寿命阴极，场发射阵列阴极，其他新型阴极及其应用]
5. Applications for new microwave tube materials and processes [新材料，新工艺在微波管中的应用研究][874]

*Other Notable Research Areas:*

- Space traveling wave tubes and cesium beam tubes
- Millimeter wave traveling wave tubes (Ka-band and W-band)
- Terahertz vacuum radiation sources
- Microfabrication technology (DRIE and LIGA)
- Vacuum micro and nanoelectronics
- High-power cyclotron devices
- Microwave tube CAD
- High current density cathodes
- Microwave power modules
- CVD diamonds
- High-power devices and micro processing technology of electronic vacuum devices[875]

**Notable Applications:**

- This lab, and in particular Liu Shenggang (see below) and his team, made critical advances toward producing superior millimeter-wave radars, particularly in the development of the PRC's first domestically-produced cyclotron, which is critical for millimeter wave radar. Liu's team also developed the world's first dual-band cyclotron, which allows high-power millimeter-wave radar and electronic jamming systems to work simultaneously in multiple millimeter-wave bands. The PRC wishes to use millimeter wave to render adversary stealth

[lix] A full list of team members is available.

aircraft visible to radar. Millimeter wave devices can also be used for secure communications and large-scale wireless data transmission. The JY-27 anti-stealth radar utilizes this technology.[876]

- The lab has also been involved in the development of terahertz radar, another key technology for defeating stealth that the PRC has been developing. The PLA also views terahertz technologies as a critical component of electronic warfare.[877]
- In recent years, the lab has developed several new technologies for the first time in the PRC, including the first W-band pulsed and continuous wave traveling wave tubes, the first Ka-band space traveling wave tube, the first millimeter wave space traveling wave tube with a whole-tube efficiency over 50 percent, the first Ka-band cyclotron traveling wave tube, and the first 220GHz cyclotron tube.[878]

**Leadership and Key Personnel:**

- Director: Yan Tiechang [闫铁昌][879]
- Deputy Directors: Cai Jun [蔡军]; Gong Yubin [宫玉彬],[880] Feng Jinjun [冯进军][881]
    - Cai Jun also serves as Director of the lab's Beijing Branch
    - Gong Yubin also serves as Director of the lab's Chengdu Branch
    - In 2019, Feng became the first scientist from Asia to win the John R. Pierce award for excellence in vacuum electronics. In 2018, he participated in the 8th IEEE International Symposium on Microwave, Antenna, Propagation, and EMC Technologies.[882] He was the Co-chair of the 8th U.K., Europe, China Millimeter Waves and Terahertz Technology Workshop (UCMMT) in Cardiff, U.K. in 2015 and a General Co-Chair of the 9th UCMMT in 2016. He is a Fellow of Institute of Engineer and Technology (IET), UK.[883]

*Key Personnel:*

- Liu Shenggang [刘盛纲][884]
    - Academician and major influence in this lab's founding and work, known as the "Father of Vacuum Electronics in China"
    - Developed PRC's first domestically-produced cyclotron, which was a critical component in the development of millimeter wave radars
    - Founded the High Energy Electronics Research Institute [高能电子学研究所]

**Notable Collaborations:**

*Domestic*

- This lab's annual academic conference in December 2016 featured representatives from the CETC 12th and 14th RIs (the 14th RI being a major institute for military radar research),

the Nanjing 772 Factory [南京 772 厂], the CAS Institute of Electronics [中科院电子所], and the Chengdu 776 Factory [成都 776 厂].[885]

- This lab may be associated in some way with the CETC 12th RI's Vacuum Company [真空公司], also known as the Beijing Vacuum Electronic Technology Co. [北京真空电子科技总公司].[886]

*International*

- This lab claims to be an internationally influential institute in the field of vacuum electronics, having cooperative relationships with multiple unnamed foreign research institutions.[887]
- In 2015, Deputy Director Feng Jinjun chaired the International Vacuum Electronics Conference. In 2019, Feng became the first scientist from Asia to win the John R. Pierce award for excellence in vacuum electronics. In 2018, he participated in the 8th IEEE International Symposium on Microwave, Antenna, Propagation, and EMC Technologies.[888] He was the Co-chair of the 8th U.K., Europe, China Millimeter Waves and Terahertz Technology Workshop (UCMMT) in Cardiff, U.K. in 2015 and a General Co-Chair of the 9th UCMMT in 2016. He is a Fellow of Institute of Engineer and Technology (IET), U.K.[889]

**Lab Equipment:**

- This lab has 22.4m RMB of fixed assets and 18.2m RMB of equipment.[890]
- The 12th RI is equipped with a domestically-produced 18-40G Power Amplifier-RS103,200V/m Test [18-40G 功率放大器-RS103,200V/m 测试]. It has a series of microwave power amplifiers in different frequency bands, covering frequencies from 1 to 100GHz, with continuous wave output power from tens to hundreds of watts and pulse output power from hundreds of watts to tens of kilowatts, forming a multi-series microwave power amplifier product used in various experiments, tests, industrial chemicals, scientific research, communications, and other fields. These include TA-K-50/100/150C01A (18 to 26.5GHz 50/100/150W) and TA-Ka-40/100/150C01A (26.5 to 40GHz 40/100/150W). It is also equipped with at least 10 pulse amplifiers: 1. TA-C-800P01A (4-8GHz 800W); 2. TA-CKu-2kP01A (6-18GHz 2000W); 3. TA-X-8kP01A (8-10GHz 8000W); 4. TA-X-4k/6kP01A (8-11GHz 4000/6000W); 5. TA-Ku-700P01A (14-17GHz 700W); 6. TA-Ka-600/800/1kP01A; 7. (26.5-40GHz(1G) 600/800/1000W); 8. TA-W-150P01A (80-100GHz（4G）150W); 9. TA-CKu200/X1kCP01A; 10. (6 to 18GHz 200W and X（1GHz）1000W). These are manufactured by Beijing Jiazhao Huaming Electronic Technology Co. [北京嘉兆华明电子科技有限公司].[891]

**Address**:

Possibly co-located with UESTC at No. 4 Section 2 Jianshe North Road, Chengdu, Sichuan Province [四川省成都市建设北路二段四号] and the 12th RI in Zhongguancun, Haidian District, Beijing [北京市海淀区中关村]

**Known Aliases:**

- Key Laboratory of High-Power Vacuum Electronic Technology [大功率微波电真空器件技术重点实验室]
- National Key Laboratory of Microwave Vacuum Electronic Technology [微波电真空器件国家级重点实验室]
- Vacuum Electronics National Laboratory
- National Key Laboratory of High-Power Vacuum Electronics
- National Laboratory of Vacuum Electronics

## 38. Defense S&T Key Laboratory of High-Power Microwave Technology

**Official English Name:** Unknown

**Chinese Name:** 高功率微波技术国防科技重点实验室

**Post-2024 Name**: No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Multi-domain (Air, Ground, Maritime)

Equipment:

- Electronic Warfare

Functional Field:

- Electromagnetics

**Affiliations:**

- China Academy of Engineering Physics (CAEP) [中国工程物理研究院]
    - Institute of Applied Electronics [应用电子学研究所]

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research into high-power microwave systems, including microwave emissions, reception, transmission, and control, toward the development of both EMP weaponry and shielding.[892]

The lab's parent institution, the Institute of Applied Electronics, is under the Chinese Academy of Engineering Physics (CAEP), which is the primary institution tasked with the PRC's nuclear weapons development. The Institute of Applied Electronics conducts research into technologies and equipment related to lasers, microwaves, complex electromagnetic environments, free electronic lasers, terahertz spectrum technology, and radiation imaging.[893]

**Further Information:**

- The Northwest Institute of Nuclear Technology (NINT) [西北核技术研究所] also hosts a National Key Laboratory of High-Power Microwave Technology [高功率微波技术国家级重点实验]. Despite having the same name, there is no evidence the two labs are connected. NINT is likely also subordinate to PLASSF Base 21 (Unit 63650) in Malan, Xinjiang, meaning this second lab was subordinate to the PLASSF prior to its April 2024 breakup.[894]
- This lab may also occasionally be known as the Defense S&T Key Lab High-Power Laser Technology [高功率激光技术与物理重点实验室]. If true, this lab has also conducted research into free-electron lasers.[895]

**Research Direction:**

1. High-power microwave source technology [高功率微波源技术]
2. High-power microwave emission and reception technology [高功率微波发射与接收技术]
3. High-power microwave transmission and control technology [高功率微波传输与控制技术]
4. High-power microwave protection technology [高功率微波防护技术][896]

**Notable Applications:**

- This lab (or possibly its NINT counterpart of the same name) is allegedly developing a new conventional EMP munition [电磁脉冲武器] that destroys local electronic signals, eliminating all enemy combat capabilities which rely on these signals. It is advertised for its ability to knock out a U.S. carrier battle group. This research was conducted in collaboration with Hunan Vanguard Group [湖南云箭集团], which is designing munitions for the J-20 combat aircraft. This new EMP munition may be employed by the J-20.[897]
- This lab (or possibly its NINT counterpart of the same name) is also allegedly involved in the development of the WB-1 ground-based microwave weapon. This weapon can reportedly be used against both humans (causing immense but non-lethal pain) or electronics at ranges of up to 1 km. It can be used for riot control, or at sea to enforce maritime claims in the South and East China Seas. As with its airborne EMP munitions, the lab is collaborating with Hunan Vanguard Group.[898]

**Leadership and Key Personnel:**

None found

**Notable Collaborations:**

*Domestic*

- This lab collaborated with Hunan Vanguard Group [湖南云箭集团] on a new conventional EMP weapon which would be employed by the J-20, as well as on the WB-1 ground-based microwave weapon (see above).
- Likely military sources of collaboration include the Institute of High-Power Microwave Technology [高功率微波技术研究所] at the National University of Defense Technology, the Key Laboratory of High-Power Microwave Technology at the Northwest Institute of Nuclear Technology, which is subordinate to PLASSF Base 21, and the PLASSF Information Engineering University.[899]
- In 2017, this lab co-hosted the 5th National Pulsed Power Conference [第五届全国脉冲功率会议]. Among the attendees were personnel from the National University of Defense Technology.[900]

**Lab Equipment:**

None found

**Address**:

No. 64 Mianshan Road, Youxian District, Mianyang, Sichuan Province [四川省绵阳市游仙区绵山路 64 号][901]

**Known Aliases:**

- Key Laboratory of High-Power Microwave Technology [高功率微波技术重点实验室]
- Defense S&T Key Lab High-Power Laser Technology [高功率激光技术与物理重点实验室]
- Science and Technology on High Power Microwave Laboratory

## 39. Defense S&T Key Laboratory of High-Power Semiconductor Lasers

**Official English Name:** State Key Laboratory of High Power Semiconductor Laser[902]

**Chinese Name:** 高功率半导体激光国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Multi-Domain (Air, Ground)

Equipment:

- Semiconductors
- *Secondary: Munitions*

Functional Field:

- Multiple (GNC, Materials, Laser Technologies, Optoelectronics)

**Affiliations:**

- Changchun University of Science and Technology (CUST) [长春理工大学]
    - School of Opto-Electronic Engineering [光电工程学院]

**Key Data:**

- Established: 1994
- Total Funding: Unknown
- Personnel: 36[903]
- Official start of operations: 1997
- Floor Space: at least 5,900 sqm

**Lab Overview:**

This lab conducts research into high-power semiconductor laser physics, including for new semiconductor and laser materials and devices. Its research has been applied to a variety of areas, including guidance systems and smart munitions.

**Further Information:**

- The lab has subordinate research offices for Semiconductor Materials [半导体材料研究室], Opto-Electronics [光电子器件研究室], and Opto-Electronic Technology

Applications [光电子技术应用研究室], as well as a Semiconductor Process Research Platform [半导体工艺研究平台].[904]

- The lab's academic committee [学术委员会] has members from a variety of other state, defense, and industry research institutes, including the former PLA GSD 54th Research Institute (part of the PLASSF from 2016 until April 2024) [原总参 54 所], the CAS Institute of Semiconductors [中科院半导体研究所], the CAS Suzhou Institute of Nano-Tech and Nano-Bionics (SINANO) [中科院苏州纳米所], Norinco's 209th RI [兵器 209 所], CETC's 11th RI [中电 11 所], and CASC's China Academy of Aerospace Electronics Technology [中国航天电子技术研究所].[905]

**Research Direction:**

1. High-power semiconductor laser active materials and physical properties [高功率半导体激光器有源材料及其物性]
2. High power semiconductor laser devices and their model optimization design [高功率半导体激光器件及其模型优化设计]
3. High power semiconductor laser device process and evaluation methods [高功率半导体激光器件工艺及其评价方法]
4. High power semiconductor laser output properties and testing [高功率半导体激光器输出特性及测试][906]

*Other Notable Research Areas:*

- Epitaxial growth theory and technology of gallium antimonide (GaSb) materials[907]

**Notable Applications:**

- The beam-riding guidance semiconductor laser transmitter [驾束制导半导体激光发射器] developed by this lab was successfully used in an unnamed PLA main battle tank system.[908]
- A laser sensor component [激光敏感器组件] developed by this lab has been used in an unnamed model of PLAAF terminal sensitive submunition (appears to be a type of smart munition) [空军某型号末敏子弹药] and will be utilized by multiple other weapons platforms.[909]
- In terms of semiconductor laser research, the lab has developed semiconductor laser single tubes [半导体激光器单管] with output power of over 10 watts, and fiber coupling modules [光纤耦合模块] greater than 100 watts. Its high-frequency modulation [高频调制], pulse output [脉冲输出] and other semiconductor laser components [半导体激光器组件] are at the leading level for China.[910]

**Leadership and Key Personnel:**

- Director: Ma Xiaohui [马晓辉][911]
- Academic Committee Director: Wang Lijun [王立军][912]
- Deputy Directors: Wei Zhipeng [魏志鹏]; Zou Yonggang [邹永刚][913]
    - Visiting scholar at UCLA in 2013-2014

**Notable Collaborations:**

*Domestic*

- The lab published several articles with the PLA GAD Armored Forces Changchun Region Military Representative Office [总装备部装甲兵驻长春地区军事代表室].[914]

*International*

- In 2015, the lab co-hosted, along with several other institutions such as the Harbin Institute of Technology and the CETC 11th RI, an International Conference on opto-electronics and Microelectronics [光电子与微电子国际学术会议]. The conference had over 200 participants from multiple countries and regions and was supported by the NSFC, the Chinese Society for Optical Engineering [中国光学工程学会], and the Harbin branch of the U.S. Institute of Electrical and Electronics Engineers (IEEE) Electron Devices Society's (EDS) [美国 IEEE-EDS 哈尔滨分会].[915]
- The lab's website mentions collaborations with domestic and foreign schools as well as international meetings without providing further details.[916]

**Lab Equipment:**

- The lab has a total of 120 million RMB worth of equipment and assets [设备资产].[917]
- The lab has a scientific research and office floor space of 3,800 square meters, a clean (bench) lab [超净实验室] floorspace of 1,500 square meters, and a production & development platform [生产开发平台] with 600 square meters of floorspace, with 200 of which being clean (bench) lab [超净实验室] floorspace.[918]

The lab's equipment includes:

- MBE (molecular-beam epitaxy), MOCVD (metal organic chemical vapor deposition) and other advanced semiconductor material epitaxial growth equipment [半导体材料外延生长设备]
- SEM (scanning electron microscope)
- XRD (X-ray diffraction?), PL (photoluminescence) and other complete material analysis and testing methods [完善的材料分析检测手段]

- Electron beam evaporation, magnetron sputtering, chip cleavage, placement, laser welding, parallel sealing welding, comprehensive testing, and other process equipment [电子束蒸发、磁控溅射、芯片解理、贴片、激光焊接、平行封焊、综合测试等工艺设备][919]

**Address**:

A209, Science and Technology Building, No. 7186 Weixing Road, Changchun, Jilin Province [吉林省长春市卫星路 7186 号科技大厦 A209][920]

**Website**:

https://web.archive.org/web/20190913190700/http://hpld.cust.edu.cn/

https://web.archive.org/web/20210328205429/http://hpld.cust.edu.cn/index.htm

**Known Aliases:**

- State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology
- State Key Laboratory on High-Power Semiconductor Lasers [高功率半导体激光国家重点实验室]
- National Key Laboratory on High Power Semiconductor Laser [高功率半导体激光国家级重点实验室]
- Key Laboratory on High Power Semiconductor Laser [高功率半导体激光重点实验室]
- Defense Key Laboratory on High Power Semiconductor Laser [高功率半导体激光国防重点实验室]

## 40. Defense S&T Key Laboratory of Human Factors Engineering

**Official English Name:** (possibly) National Key Laboratory of Human Factors Engineering[921]

**Chinese Name:** 人因工程国防科技重点实验室

**Post-2024 Name:** National Key Laboratory of Human Factors Engineering[lx] [因工程全国重点实验室][922]

**Research Focus:**

Domain:

- Space
- *Secondary: Air, Maritime*

Equipment:

- Space Vehicles
- *Secondary: Aircraft*

Functional Field:

- Manned Spaceflight
- *Secondary: Reliability/Environmental Engineering*

**Affiliations:**

- PLA China Astronautic Scientific Research and Training Center [中国航天员科研训练中心]
- (possibly) Tsinghua University [清华大学]
    - Institute of Human Factors Engineering and Intelligent Interaction [人因工程与智能交互研究所][923]

**Key Data:**

- Established: 2011
- Official start of operations: Unknown
- Total Funding: Unknown
- Floor Space: Unknown[924]
- Personnel: Unknown

[lx] Literal translation, no official name given

**Lab Overview:**

This lab was established in March 2011 as the PRC's only national-level lab focused on human factors engineering (HFE). HFE is the design of machine and environmental systems for human use, taking into account human physiology and psychology to maximize performance, comfort, and safety. It employs physiology, psychology, anthropometry, biomechanics, computer science, and systems science.[925] According to lab director Chen Shanguang, China still lags behind the cutting edge in HFE, and there is still a significant gap in research between China and more advanced countries in this field.[926]

This lab is primarily concerned with HFE for the PRC's manned space program, designing space vehicles and equipment allowing astronauts to work in extreme operating environments such as zero-gravity, confined environments, and high-radiation environments. This work includes spacecraft and spacesuit design, life support systems, equipment design, R&D of human-machine interaction and interfaces, and medical research into space physiology.[927] The lab's research has been utilized in the Shenzhou spacecraft and Tiangong space station, among others.

In addition to manned spaceflight, the lab also conducts research aimed at supporting the PRC's major economic strategies and defense needs in the fields of aerospace (including combat aircraft cockpits), maritime, nuclear energy, and high-speed rail, designing human-machine interactive devices, life support systems, personal protective equipment, and personnel power enhancement technologies [人员能力增强技术].[928] The lab is dedicated to incorporating HFE into major national economic and defense industrial strategies such as Made in China 2025, incorporating HFE into artificial intelligence, brain and cognition research, and human-computer integration.[929]

Since its founding in 2011, this lab has been subordinate to the China Astronautic Scientific Research and Training Center, a PLA organization which has the dual missions of selecting and training astronauts as well as conducting research on manned spaceflight.[930]

While often obfuscated, there is ample evidence that this lab was founded as a defense lab (for example, an undated photo of the lab's entrance shows it using its DSTKL name and logo[931]), and it has been periodically referred to as such in public as recently as 2021-2022.[932] Sources make clear that much of its work is defense-oriented.[933] The lab is subordinate to a PLA organization, and Director Chen Shanguang is apparently a PLA Major General, although he does not usually appear publicly in uniform.[934] As of 2023, however, the lab may now be going by the name "National Key Laboratory of Human Factors Engineering" [人因工程全国重点实验室], placing it under the ostensibly civilian National Key Lab system. It also now appears to be jointly managed by both the China Astronautic Scientific Research and Training Center (as evidenced by Chen's continuing status as Director in 2024[935]) and Tsinghua University's Institute of Human Factors Engineering and Intelligent Interaction [人因工程与智能交互研究所]. It is directly managed by Tsinghua's Department of Industrial Engineering [工业工程系], with input from its School of Aerospace and Aviation [航天航空学院], Computer Department [计算机系], Nuclear Research Institute [核研院], Electronics Department [电子系], Psychology Department [心理学系], and Fine Arts Department [美术学院].[936]

Under the ongoing reorganization of the PRC's national key lab system, this lab is now known as the National Key Lab of Human Factors Engineering [因工程全国重点实验室].

**Further Information:**

- CSSC has a Ship Human Factors Engineering Center [舰船人因工程中心], which it calls "PRC's only Defense S&T Key Lab for human factors engineering". This confusing phrasing leaves it unclear as to whether these institutions are affiliated.[937]

**Research Direction:**

1. Basic human factor theory
2. Frontier technologies of human factors engineering
3. Integration of complex human-machine systems
4. Life-support engineering in special environments[938]

*Other Notable Research Areas:*

- Environmental control, bioprotection during lunar exploration program[939]
- Recycling of gas and water resources, garbage treatment in a space capsule[940]
- Research on space medicine, astronaut stress[941]

**Notable Applications:**

- The lab's research and designs have been utilized by the Shenzhou series of spacecraft and Tiangong space station.
- In 2022, this lab and the Lingang Laboratory [临港实验室] led a project called "Search for Space Brain" [求索太空脑计划]. The project was intended for development of the PRC space station and its need for better research on the workings of the human brain and nervous system in space. It focused on five research areas: brain development and aging under the special environment of space, drug metabolism of brain diseases, biorhythms and sleep-wakefulness, cognitive maps, and neurological mechanism and regulation of group brain cooperation in space environment; each of these 5 areas received up to 6m RMB in funding.[942] [lxi]
- Other inventions from this lab include:
    - Development of a space pen[943]
    - Robotics for on-orbit-assembly[944]
    - Aircraft ejection seats, with PLAAF researchers[945]
    - Brain-computer interaction devices in space[946]

[lxi] Further details are available.

**Leadership and Key Personnel:**

- Director: Chen Shanguang [陈善广][947]
    - Formerly served as deputy chief designer of PRC's manned spaceflight engineering[948]
    - PLA Major General[949]
    - Involved in design of combat aircraft cockpits[950]
- Tsinghua Branch Director: Zhang Wei [张伟][951]
- Deputy Director: Wang Chunhui [王春慧][952]

**Notable Collaborations:**

*Domestic*

- In 2023, this lab established a joint research institute with Central South University [中南大学], called the Institute of Human Factors Engineering [人因工程研究院]. This institute will research human factors engineering for aerospace, weaponry and military equipment, and maritime uses. One focus will be on dual-use technologies and improving integration between military and civilian uses.[953]
- In 2019, the lab worked with researchers of Xiangtan University [湘潭大学] on recycling of gas and water resources in a space capsule, as well as garbage treatment.[954]
- In 2019, this lab co-organized the China Human Factors Engineering Summit Forum [中国人因工程高峰论坛], along with the China Manned Space Engineering Office [中国载人航天工程办公室] and Sun Yat-sen University. The forum was notable for its discussion of plans to build a 3-man space station by 2022.[955] This appears to be a regular forum which is organized by this lab, bringing together both civilian and military experts to promote and incorporate HFE into the PRC's major national economic strategies (including Made in China 2025) and defense industry.[956]
- In 2023, personnel from this lab discussed cooperation and resource sharing with the Department of Psychology at Zhejiang University, primarily in areas like psychology, cognition, and brain science.[957]
- In 2012, this lab signed an agreement to work with a neural engineering team at Tianjin University on in-orbit brain-computer interaction devices and technologies. The technologies developed were eventually used by the PRC's manned space missions Tiangong II and Shenzhou XI. The source described this work as the first of its kind, surpassing the US and West.[958]
- In 2022, this lab collaborated with the Lingang Laboratory [临港实验室] led a project called "Search for Space Brain" [求索太空脑计划] (see "Notable Applications").

**Lab Equipment:**

None found

**Address**:

None found, possibly co-located with parent org at No. 1 Yuanmingyuan West Road, Haidian District, Beijing [北京市海淀区圆明园西路 1 号][959]

**Known Aliases:**

- 人因工程全国重点实验室
- 人因工程国家级重点实验室
- 人因工程国家重点实验室
- 人因工程重点实验室

## 41. Defense S&T Key Laboratory of Hydroacoustic Countermeasure Technology

**Official English Name:** National Key Laboratory of Science and Technology on Underwater Acoustic Antagonizing[960]

**Chinese Name:** 水声对抗技术国防科技重点实验室

**Post-2024 Name:** (likely) National Key Laboratory of Underwater Acoustic Antagonizing[lxii] [水声对抗技术全国重点实验室][961]

**Research Focus:**

Domain:

- Maritime

Equipment:

- Underwater Vehicles
- *Secondary: Unmanned Systems*

Functional Field:

- Acoustics

**Affiliations:**

- China State Shipbuilding Corporation (CSSC) [中国船舶集团]
  - Institute of Ship Electronic Equipment [上海船舶电子设备研究所]
    - *a.k.a. CSSC 726th Research Institute*

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research on acoustics for underwater warfare, including detection, measurement, and jamming of underwater signals in submarines, torpedoes, and unmanned underwater vehicles.

[lxii] Literal translation, no official name given

The lab's parent institution, the CSSC Shanghai Institute of Ship Electronic Equipment (a.k.a. the 726th Research Institute), conducts research on hydroacoustic engineering, including hydroacoustic countermeasures, navigation, signal processing, and detection.[962]

Interestingly, one source suggests that this unit may also be subordinate to the PLAN Southern Theater Command Test Area [试验区] in Zhanjiang, Guangdong.[963] The lab does appear to have a branch in Zhanjiang[964] and has co-authored articles with this unit,[965] so it is possible the two have a formal relationship.

Under the ongoing reorganization of the PRC's national key lab system, this lab is likely now known as the National Key Lab of Hydroacoustic Technology [水声对抗技术全国重点实验室].

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- Unmanned underwater vehicle development[966]
- Simulation of jamming against torpedoes (with PLA Unit 91388)[967]
- Acoustic arrays[968]
- Strategies for helicopters with dipping sonar to search for submarines[969]
- Vector hydrophone auto-calibration for acoustic measurement (with SASTIND's Hydroacoustic Primary Measuring Station [国防科技工业水声一级计量站])[970]
- AUV mother ship design and launch mechanisms[971]
- Underwater small target detection and recognition[972]
- Incoming torpedo trajectory (with the PLAN Dalian Naval Academy)[973]

**Notable Applications:**

None found

**Leadership and Key Personnel:**

- Director: Dong Yangze [董阳泽]
    - Deputy Committee Director of Chinese Acoustics Society Hydroacoustics Branch [中国声学学会水声学分会副主任委员]
    - Visiting professor at Norwegian University of Science and Technology 2013-2014
    - Holds 2 national defense patents[974]
- Deputy Director/Academic Committee Deputy Director: Du Xuanmin [杜选民]
    - Also Deputy Director of CSSC 726th RI

- Helped develop ship torpedo alarm sonar, hydroacoustic countermeasure system, and a harbor proximity underwater alert detection system, winning multiple Defense S&T Progress Awards
- Has solved problems with towed line array port and starboard resolution, high-speed motion target adaptive detection and identification, and nonlinear sonar engineering application[975]

*Key Personnel:*

- Wu Kaiming [吴开明]
  - Researcher working on project named "Military Marine Geography in Underwater Warfare"[976]
- Li Songwen [李颂文]
  - Researcher focused on hydroacoustic signal processing, underwater acoustic imaging and nonlinear hydroacoustics[977]

**Notable Collaborations:**

*Domestic*

- This lab co-sponsored the 2019 Hydroacoustic Countermeasures Technology Academic Exchange Conference [2019 水声对抗技术学术交流会], alongside the Defense S&T Key Lab of Underwater Information and Control [水下信息与控制国防科技重点实验室]. Personnel came from the PLAN, CSSC, CETC, CAS, and other institutions.[978]

*International*

- Along with several other defense labs, including the DSTKL of Sonar Technology, DSTKL of Hyrdoacoustic Technology, and DSTKL of Underwater Measurement & Control Technology, this lab co-organized the 2021 IEEE/OES China Ocean Acoustics Conference [中国海洋声学国际会议]. Other organizers included Harbin Engineering University (including being co-chaired by prominent defense researcher Yang Desen, an expert in sonar technology at the DSTKL of Hydroacoustic Technology). The conference focused on underwater acoustics and acoustical oceanography, ocean sound propagation, marine sediment acoustics, problems of ocean noise and reverberation, sonar modeling, signal detection and estimation, acoustical sensors and arrays, underwater acoustic communications, polar acoustics, and other related fields. The conference's scientific committee included researchers from the PLA's Naval Research Academy and Dalian Naval Academy alongside U.S. institutions such as Penn State University, University of Washington, Lehigh University, University of Mississippi, UMass Dartmouth, and University of Hawaii, University of Bath and Loughborough University in the U.K., University of Algarve in Portugal, National Taiwan University, University of Oslo, and

University of Victoria in Canada. PLA Navy personnel took part throughout. A professor from UMass Dartmouth spoke on advances in broadband underwater acoustic transducers and navigation, and a professor from Northeastern University spoke on acoustic communication. U.K., Canadian, and Norwegian researchers also gave talks.[979]

**Lab Equipment:**

None found

**Address**:

Beijing 100094 [北京市][980]

Shanghai 201108[981] or 201203[982] [上海市]

Zhanjiang, Guangdong Province 524022 [广东省湛江市][983]

**Known Aliases:**

- Key Laboratory of Underwater Acoustic Warfare Technology
- Science and Technology on Underwater Acoustics Antagonizing Laboratory
- 水声对抗技术重点实验室

## 42. Defense S&T Key Laboratory of Hydroacoustic Technology

**Official English Name:** National Key Laboratory of Underwater Acoustic Science and Technology[984]

**Chinese Name:** 水声技术国防科技重点实验室

**Post-2024 Name:** National Key Laboratory of Hydroacoustic Technology[lxiii] [水声技术全国重点实验室][985]

**Research Focus:**

Domain:

- Maritime

Equipment:

- Underwater Vehicles

Functional Field:

- Acoustics
- *Secondary: Communications Technologies, GNC, Sensing, Target Detection/Recognition*

**Affiliations:**

- Harbin Engineering University (HEU) [哈尔滨工程大学]
    - College of Underwater Acoustic Engineering [水声工程学院]

**Key Data:**

- Established: 1993
- Total Funding: Unknown
- Personnel: 79[986]
- Official start of operations: 1997
- Floor Space: 24,452 sqm[987]

**Lab Overview:**

The Defense S&T Key Laboratory of Hydroacoustic Acoustic Technology conducts research on a variety of topics related to underwater acoustics, including underwater acoustic physics, communications, target detection and positioning, noise control and stealth, and transducer technology.

[lxiii] Literal translation, no official name given

Under the ongoing reorganization of the PRC's national key lab system, this lab is now known as the National Key Lab of Hydroacoustic Technology [水声技术全国重点实验室].

**Further Information:**

- This lab is currently (as of an unknown date, likely after 2017) responsible for 202 projects with total funding of 222.64M RMB. Between 2012-17 it undertook over 400 projects worth over 470m RMB. In recent years it has produced 428 PhD and 1,265 master's graduates.[988]
- The School of Underwater Acoustic Engineering has at least nine subordinate research teams, most or all of which are led and staffed by personnel from this lab:[989]
    - *Ocean Acoustics Research Team* [海洋声学研究团队] (501 Team)
        - Led by Yang Shi'e [杨士莪] and Pu Shengchun [朴胜春].
        - Engaged in research on ocean acoustics, hydroacoustic propagation, ocean environment noise field and reverberation field characteristics, submarine sediment layer acoustics, very low frequency remote sound detection, detection of weak signals in water, extraction and identification of target features in water, and array signal processing.
    - *Underwater Target Properties Testing and Control Research Team* [水中目标特性测试与控制技术团队] (502 Team)
        - Ten-member team led by Yang Desen [杨德森].
        - Research focus on naval acoustic frequency characteristics testing and control, vibration noise testing for submarines, torpedoes, and other underwater vehicles, noise source testing and identification, and underwater targeting.
        - Has carried out successful research in the areas of underwater structure excited vibration acoustic radiation mechanisms and prediction, vibration noise testing and analysis, noise source testing and identification, underwater target acquisition and analysis, and underwater vector acoustics.
        - Research funding of 100m RMB over the last ten years.
    - *Underwater Vibration and Noise Research Team* [水下振动噪声研究团队] (503 Team)
        - Ten-member team led by Professors Li Qi [李琪] and Shang Dejiang [商德江].
        - Research on physical mechanisms of underwater noise sources and noise fields, as well as radiation, measurement, identification and control of underwater structure vibration noise.
        - Has made key progress in underwater complex sound source radiation and sound power measurements based on reverberation methods, propeller acoustic shield design, acoustic insulation performance testing, and others.
    - *Hydroacoustic Transducer Research Team* [水声换能器研究团队] (504 Team)
        - Five-member team led by Professor Lan Yu [蓝宇].

        - Research on hydroacoustic transducer and base arrays, underwater acoustic systems, acoustic sensors and acoustic finite element analysis.
    - *Hydroacoustic Positioning and Target Detection Research Team* [水声定位与目标探测研究团队] (505 Team)
        - At least 15-member team led by Professor Liang Guolong [梁国龙].
        - Research on hydroacoustic detection, positioning, navigation, countermeasures, signal processing, unmanned acoustic systems, and imaging sonar.
        - Developed the first set of unmanned passive detection sonars and the first set of three-dimensional imaging sonars in China.
        - This team's hydroacoustic positioning, navigation and underwater measurement equipment has been incorporated into almost all new models of torpedoes, mines and submarines in China.
    - *Seafloor Target Characterization Detection Research Team* [海底目标特性探测研究团队] (506 Team)
        - At least eight-member team led by Professor Li Haisen [李海森].
        - Research on acoustic remote sensing of underwater spatial environments, information and sensitive target characteristics, detection of seafloor topography and geomorphology, underwater target localization, and imaging and information transmission.
        - Applications include ocean mapping, marine fisheries, and oil pipeline detection.
    - *Hydroacoustic Communication and Network Technology Research Team* (507 Team)
        - Led by Professor Qiao Gang.
        - Research on hydroacoustic communications and networks, hydroacoustic detection, hydroacoustic positioning, hydroacoustic OFDM high-speed communications, spread spectrum communications, bionic communications, digital voice communications, hydroacoustic communications network technology, bionic detection, and distributed positioning.
    - *Deep Sea Underwater Information Technology Research Team* [深海水下信息技术研究团队] (508 Team)
        - 18-member team led by Professor Sun Dajun [孙大军].
        - Research on deep-sea hydroacoustic positioning and navigation, deep-sea hydroacoustic detection, and deep-sea remote hydroacoustic communications networking.
        - Applications include deep-sea resource investigation, scientific research, oil and gas resources development, and national defense.
        - Has aided in development of PRC's deep-sea submersibles, including the Jiaolong and cable-controlled submersible Sea Dragon. and deep-sea underwater acoustic tugs.

        - Currently working on ten projects worth over 60m RMB.
    - *Polar Acoustics and Simulation Technology Research Team* (509 Team)
        - Seven-member team led by professor Yin Jingwei [殷敬伟].
        - Research on hydroacoustic technology in polar environments, hydroacoustic physics in complex propagation media, environmental cognitive hydroacoustic communications, multidimensional information perception of underwater targets, high performance simulation of hydroacoustic systems, and underwater measurement and analysis equipment.
- In 2017, this lab received 200 million RMB in funding for facilities maintenance, underwater acoustic technology funding, key laboratory development and improvement funding, and acoustic stealth project funding. It has constructed an underwater acoustic experimental complex building and updated all fundamental experimental facilities and most of its experimental equipment.[990]
- The Underwater Acoustics Engineering College put out a promotional music video, "Underwater Acoustics Await You!" which features shots of the inside of the college building. It can be found at https://www.bilibili.com/video/av55647544/.

**Research Direction:**

1. Underwater acoustic physics
2. Underwater acoustic target detection and positioning
3. Underwater acoustic transducer technology
4. Underwater acoustic communications technology[991]

*Other Notable Research Areas:*

- Underwater target noise control technology
- Remote target detection technology
- Vector array underwater early warning technology
- Reverberation-based radiation noise measurement technology
- Underwater Beidou acoustic positioning technology
- Bionic camouflage underwater acoustic communications technology
- Polar acoustic technology[992]

**Notable Applications:**

- This lab has been involved with development of hydroacoustic positioning, navigation, and measurements technologies for underwater warfare, including for submarines, torpedoes, and mines.[993]
- This lab is also involved in other research with strategic significance, including Polar research and underwater stealth technology.

- This lab was involved in development of the Jiaolong [蛟龙] and Hailong [海龙] deep-sea submersibles.[994]

**Leadership and Key Personnel:**

- Director: Qiao Gang [乔钢] (2021)[995]
- Deput Director: Mo Shiqi [莫世奇] (2021)
    - Awarded multiple Defense S&T Progress awards[996]
- A list of the lab's academic committee as of 2021 is available. It includes scholars from NUDT, the PLAN Research Academy, PLAN Submarine Academy, Naval University of Engineering, CSSC 715th and 726th RI, CASC 1st Academy, and CAS Institute of Acoustics, among others.[997]

*Key personnel:*

- Yang Desen [杨德森][998]
    - Leading PRC scholar in underwater acoustics, with expertise in Sonar and underwater vehicle stealth
    - Member of PLA GAD Submarine Vibration and Noise Reduction Technology Specialist Team [解放军总装备部潜艇减振降噪技术专业组] and PLAN Equipment Department Underwater Target Properties and Transmission Technology Team [解放军海军装备部水中目标特性与传输技术组]
    - Visiting Scholar at the U.S. Woods Hole Oceanographic Institution in 1998-99
- Sun Dajun [孙大军]:[999]
    - Former Director of this lab
    - Specializes in underwater positioning, navigation, communications, sensing, and underwater information support technology, with breakthroughs in high-precision underwater acoustics positioning
    - Involved in development of SOA research vessels Xuezhe 1, Dayang 1, and Xiangyang 9, as well as Jialong deep-sea submersible.
- Shang Dejiang [商德江][1000]
    - Specializes in underwater acoustic signal paths and sonar system environments, underwater acoustic target sensing and positioning, and stealth technology
    - Conducted research at U.S. Auburn University in 2010

**Notable Collaborations:**

*Domestic*

- In 2024, this lab established the "Deep-sea Unmanned Equipment Industry Alliance [深远海无人装备产业联盟] with the Defense S&T Key Lab of Hydroacoustic Technology and Harbin Engineering University. It also included a first bath of nine enterprises, including Hainan Sound Deep Blue Marine Technology Co. [海南声科深蓝海洋技术有

限公司], Hainan Water Sound Marine Technology Co. [海南水之声海洋科技有限公司], and Hainan Ai Rui Ao Technology Co. [海南艾锐奥科技有限公司].The alliance will bring together industry and research resources and talent to focus on unmanned equipment technology R&D in service of the PRC's national ocean power strategy [国家海洋强国战略].[1001]

- The Underwater Target Properties Testing and Control Research Team [水中目标特性测试与控制技术团队] (see "Further Information" above) is a joint effort between this lab and the Key Laboratory of Marine Information Acquisition and Security.[1002]
- This lab has taken a leading role in several conferences with strategic significance: in 2017, it co-hosted a conference on acoustics with the Acoustical Society of China [中国声学学会] and Harbin Engineering University (HEU), in which speakers talked about the creation of a blue-water navy and the importance of acoustics to China's underwater security. In 2019, it co-sponsored another conference on Oceanic Information Technology and Equipment, with HEU and the HEU Key Laboratory of Marine Information Acquisition and Security, which was attended by PLAN personnel.[1003]

*International*

- In May 2024, this lab co-sponsored the China International Conference on Ocean Acoustics [2024 中国海洋声学国际会议], along with the Hanjiang Laboratory, State Key Laboratory of Acoustic Field Information, MoE Key Laboratory of Polar Ocean Acoustics and Technology Applications, MIIT Key Laboratory of Acquisition and Security of Marine Information, and the Heilongjiang Province Key Laboratory of Marine Information Technology. Yang Desen of this lab, notable for his work in underwater vehicle stealth technology and work with the PLA on sub vibration and noise reduction, played a prominent role in the conference proceedings, calling for expanded international cooperation. Researchers came from the U.S., Japan, Korea, Taiwan, Singapore, and Russia, among other countries. A professor from National Taiwan University gave a presentation on a new method of passive acoustics to locate whales. A professor from National University of Singapore gave a presentation on distributed underwater acoustic sensing, including new techniques for detecting and monitoring vibrations in the environment using fiber-optic cables, as well as sharing information on emerging demodulator technologies and customized cables for sensing. A professor from Keio University in Japan gave a presentation on how structural characteristics of hollow-core optical fibers can be used to realize low-latency technology beyond 5G.[1004]
- This lab co-sponsored, along with five other acoustics key labs, the 2016 IEEE Oceanic Engineering Society China Marine Acoustics Symposium [IEEE/OES 中国海洋声学研讨会], which featured participation of both foreign and domestic experts. The six key labs involved in hosting this event were the Key Labs of Underwater Acoustic Technology, Underwater Acoustic Countermeasures, Underwater Measurement and Control Technology, Acoustic Fields and Acoustic Information, and Ship Vibration and Noise. The event was held in Harbin and co-hosted by Harbin Engineering University and the Belgian

Université Libre de Bruxelles. The Chinese language announcement for this symposium explicitly connects the hydroacoustic research of this symposium to the PRC's national strategy of becoming an oceanic power for economic development, national sovereignty, and military power. The event was the brainchild of Professor Yang Desen of this lab, and a researcher at Université Libre de Bruxelles. A similar conference was scheduled to be held in 2021.[1005]

- In April 2020, this Lab co-hosted the International Forum of Ocean Information 2020 with HEU, the Key Laboratory of Marine Information Acquisition and Security, and the Heilongjiang Ocean Information Technology Key Laboratory. This international conference featured numerous PRC speakers work or have worked on defense projects or have served as defense consultants. Topics of interest included weapons and equipment assessment technology and military intelligent anaysis, as well as dual-use reseach on AUVs, acoustic surveys of the American and Canadian west coasts, polar acoustic detection and communications, fiber-optic sensing, and mine hunting sonar. Foreign researchers came from the U.S. (Harvard University, NOAA, Embry-Riddle Aeronautical University), U.K. (University of Southampton, University of York), Canada (Dalhousie University, University of British Columbia, University of Ottawa), France (Le Mans University), Switzerland (University of Bern), Taiwan (National Taiwan University), Singapore (A*STAR), Turkey (Armelsan Defence Technologies), and Russia (Russian Far Eastern Federal University). Researchers from this lab collaborated on a 2017 Paper on underwater wireless sensor networks with researchers from University of Houston and Embry-Riddle Aeronautical University in the U.S.[1006]
- Researchers from this lab collaborated on a 2019 paper with Southampton University in the U.K.: "Simulation and experimental validation of near-range high-speed hydroacoustic millimeter wave communications" [近程高速水声毫米波通信仿真与试验验证].[1007]
- As of 2013, the School of Underwater Acoustics Engineering to which this lab is subordinate claims to have undergraduate exchange programs with MIT, as well as with universities in France and Belgium. It is unclear if these programs are still extant, as HEU was placed on the U.S. Commerce Department Entity List for export control in 2020.[1008]

**Lab Equipment:**

- The lab has equipment valued at 206 million RMB, including:
    - High frequency standard hydrophones from U.S. company Teledyne, including models RESON TC 4014, RESON TC 4035, RESON TC 4038, RESON TC 4040
    - Hydrophones and other equipment from Danish company Bruel & Kjaer, including models BK8103, BK8104, BK8105, BK8106, PULSE dynamic signal analyzer model BK3660-D-100, and Signal Conditioning Amplifier models BK2692, BK2694
    - Full-frequency non-anechoic pool
    - Low-frequency anechoic pool
    - High-frequency channel pool (including high-frequency anechoic pool)

- Gravity low-noise water holes
- High-pressure test device
- Reverberation room and sound isolation room
- Circulating reverberation pool
- Standard emission transducer
- L series linear power amplifier
- Impedance analyzer[1009][lxiv]

**Address**:

Underwater Acoustics Building [水声楼] at Harbin Engineering University, No. 145 Nantong Road, Nangang District, Harbin, Heilongjiang Province [哈尔滨市南岗区南通大街 145 号][1010]

**Website**:

https://web.archive.org/web/20220810090023/http://uast.hrbeu.edu.cn/index.htm

**Known Aliases:**

- Key Laboratory of Underwater Acoustic Technology [水声技术重点实验室]

[lxiv] More detailed descriptions of equipment capabilities and parameters, along with photos of some of the equipment and facilities, is available on request.

## 43. Defense S&T Key Laboratory of Hydrodynamics

**Official English Name:** Unknown

**Chinese Name:** 水动力学国防科技重点实验室

**Post-2024 Name:** National Key Laboratory of Hydrodynamics[lxv] [水动力学全国重点实验室]

**Research Focus:**

Domain:

- Maritime

Equipment:

- Multiple (Non-Ballistic Missiles, Munitions, Surface Vessels, Underwater Vehicles)

Functional Field:

- Ship Design

**Affiliations:**

- China State Shipbuilding Corporation (CSSC) [中国船舶集团]
    - China Ship Scientific Research Center [中国船舶科学研究中心]
        - *a.k.a. CSSC 702nd Research Institute*
- Harbin Engineering University [哈尔滨工程大学]
    - School of Ship Engineering [船舶工程学院]

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab appears to be focused on the external design of ships, underwater submersibles, and underwater munitions. This includes areas such as hull drag and load reduction and improvements to vessel efficiency and stability, with particular emphasis on extreme environments

[lxv] Literal translation, no official name given

such as frozen seas and the deep sea. It is focused on serving the needs of China's major national strategies, a likely reference to China's ambitions in the Arctic and far seas.[1011]

CSSRC was established in 1951 and is the PRC's largest institution for the design and development of military and civilian ships, including high-performance ships and deep-sea vessels. It is particularly focused on vessel hydrodynamics, structural mechanics, vibration, noise, anti-impact, and anti-explosion research.[1012]

While traditionally associated with CSSC's China Ship Scientific Research Center (a.k.a. CSSRC, a.k.a. the CSSC 702nd Research Institute), in 2023 a new lab, the nearly identically named National Key Laboratory of Hydrodynamics [水动力学全国重点实验室], passed inspection as a joint venture of CSSRC and Harbin Engineering University. This appears to be a reorganization of the same lab, and since 2023 it has publicly gone by this new name.[1013] Given the strong military affiliations of both CSSC and HEU, it is unlikely that this lab has actually switched over to civilian research, even if it has been officially reconstituted as an ostensibly civilian national key lab.[1014]

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- Ice loads on ship hulls[1015]
- Manned submersibles[1016]
- Sub-launched missiles in ice water[1017]
- A range of current issues in hydrodynamics, including turbulence, nonlinear waves, cavitation two-phase flow, sea ice mechanics, and hydrodynamic data[1018]

The lab's 2020 Research funding priorities were as follows:[1019] [lxvi]

1. Hydrodynamic and free surface simulation method and validation study for high-speed surface ships under large maneuvers [高速水面舰船大机动下的水动力与自由面模拟方法与验证研究]

   Research Objective: Aiming at the difficulty of accurate simulation of complex motion and flow field under large maneuvering of high-speed surface ships, establish a numerical simulation method of self-propelled maneuvering motion of high-speed ships under full rudder angle maneuvering in slewing and Z-shape motion, and analyze the characteristics of hydrodynamic force and free-surface flow field change of the ship during large maneuvering motion, so as to provide reference for the maneuvering safety assessment of the ship's design.

[lxvi] Further details on research avenues, objectives, and funding is available.

2. Air film drag reduction on superhydrophobic surface based on wetting step effect [基于润湿阶跃效应的超疏水表面气膜减阻技术]

   Research Objective: Aiming at the actual demand of drag reduction and efficiency in the field of shipbuilding, as well as the problem of superhydrophobic surface air film loss in the practical application of engineering, in-depth analysis of the mechanism of the wetting step effect, carry out research on the superhydrophobic surface air film drag reduction technology based on the wetting step effect, explore the method of maintaining the stability of the superhydrophobic surface air film in turbulent flow, and establish an effective method of superhydrophobic surface air film drag reduction in the case of high Reynolds number (Re > 107), and improve the applicability of air film stabilization method under turbulence. To improve the applicability of the air film stabilization method in turbulent flow, and to provide technical reserve and support for the development of drag reduction and efficiency technology in the field of ship hydrodynamics.

3. Research on Calculation and Verification Methods of Stern-First Icebreaking Resistance of Hulls [船体艉部先行破冰阻力的计算与验证方法研究]

   Research Objective: Aiming at the new ship ice navigation mode of stern-first ice-breaking and its demand for ice-breaking resistance calculation in ship design and optimization, relying on the test conditions of ice pool, we reveal the generation mechanism and composition of stern-first ice-breaking resistance by carrying out the model test of stern-first ice-breaking resistance of typical ship types. On this basis, through the theoretical derivation of ice mechanics and regression analysis of the test data, the calculation method of the transom ice-breaking resistance is established, and the reliability of the calculation results is verified by the model test results, so as to provide effective technical support for the research and development of the high-grade two-way sailing polar ships.

4. Research on the Conformational Design and Load Reduction Performance of Object Impact Water Buffer Components [物体撞水缓冲组件构型设计及降载性能研究]

   Research Objective: To carry out the program design of buffer components (structure, shape and buffer parts) for the need of buffer load reduction of objects hitting water, to study the stress-strain situation of buffer components in the process of hitting water, to obtain the relationship between the speed of hitting water and the mechanical parameters constituting the composite materials of the buffer components and the influence law, to analyze the effect of load reduction of the buffer components, and to develop a prototype of buffer components in principle; and to evaluate the effect of load reduction of buffer components. The load-lowering effect of the cushioning component and its fracture performance are assessed through modeling tests.

**Notable Applications:**

None found

**Leadership and Key Personnel:**

- Director: Yan Kai [颜开]
    - Has served as both Director and Academic Committee Director at various unknown dates[1020]

**Notable Collaborations:**

*Domestic*

- In 2024, this lab co-organized the 13th National Academic Conference on Fluid Mechanics [第十三届全国流体力学学术会议], along with the Chinese Society of Theoretical and Applied Mechanics Fluid Mechanics Committee [中国力学学会流体力学专业委员会], Harbin Engineering University, the National Key Laboratory of Hydroacoustic Technology [水声技术全国重点实验室], and the Frontier Science Center of Extreme Marine Wave Field [极端海洋场波动场前沿科学中心]. Research topics included turbulence and stability, multiphase flow and non-Newtonian fluid dynamics, hydrodynamics, high temperature gas dynamics, seepage mechanics, industrial fluid dynamics, experimental fluid dynamics, computational fluid dynamics, micro- and nanoscale flow, electromagnetic fluid dynamics, transmedia fluid dynamics, underwater explosive mechanics, wind engineering and aerodynamics, and intelligent fluid mechanics.[1021]
- In 2024, this lab co-organized the 9th National Conference of Marine Computational Fluid Dynamics [第九届全国船舶与海洋工程 CFD 会议]. Other organizers included Huazhong University of Science and Technology, Taihu Laboratory of Deep-sea Technology and Science [深海技术科学太湖实验室], Hubei Key Laboratory of Ship and Ocean Hydrodynamics [船舶和海洋水动力湖北省重点实验室], and the Shanghai Key Laboratory of Ship Engineering [上海市船舶工程重点实验室].[1022] [lxvii]
- In 2017, this lab co-sponsored the 14th National Academic Conference on Hydrodynamics and the 28th National Symposium on Hydrodynamics [第十四届全国水动力学学术会议暨第二十八届全国水动力学研讨会], along with the School of Automotive Engineering of Jilin University, the Hydrodynamics Specialized Group of the Chinese Society of Theoretical and Applied Mechanics [中国力学学会水动力学专业组], the Committee of Ship Mechanics of the Chinese Society of Shipbuilding Engineering [中国造船工程学会船舶力学委员会], Beijing Oulan Science and Technology Development Co. [北京欧兰科技发展有限公司], and others. Research topics included computational fluid dynamics, hydrodynamic experimental and testing technology, industrial fluid dynamics, ocean engineering, hydrodynamics and geophysics of the marine environment, water

[lxvii] A list of committee members is available.

conservancy, and hydropower and river dynamics. A Korean researcher from Seoul National University was among the presenters, speaking on violent sloshing flows in LNG cargo design.[1023]

*International*

- In 2024, this lab co-organized the 7th Symposium on Computational Marine Hydrodynamics [第七届 CMHL 船舶与海洋工程计算水动力学国际研讨会] along with Shanghai Jiao Tong University and the Taihu Laboratory of Deep-sea Technology and Science. It included international experts, including from the U.S. University of Massachusetts Amherst (who presented on mooring systems for offshore wind and marine energy), University of Strathclyde in the U.K., Nihon University in Japan, Universitat Politècnica de Catalunya in Spain, Ecole Centrale de Nantes in France, University of Duisburg-Essen in Germany, Delft University of Technology in the Netherlands, University of Lisbon in Portugal, and the National University of Singapore. PRC researchers from CSSC, SJTU, and Zhejiang university also presented.[1024]

**Lab Equipment:**

None found

**Address**:

Wuxi, Jiangsu Province 214082 [江苏省无锡市][1025]

**Known Aliases:**

- 水动力学全国重点实验室
- 水动力学国家重点实验室
- 水动力学国家级重点实验室
- 水动力学重点实验室

## 44. Defense S&T Key Laboratory of Hypersonic Ramjet Technology

**Official English Name:** Unknown

**Chinese Name:** 高超声速冲压发动机技术国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Multi-Domain (Air, Space)

Equipment:

- Multiple (Aircraft, Non-Ballistic Missiles, Space Vehicles)

Functional Field:

- Hypersonic Technology
- *Secondary: Aerodynamics, Materials, Propulsion*

**Affiliations:**

- National University of Defense Technology [国防科技大学]
  - School of Aerospace Science and Engineering [航天科学与工程学院]
- (likely) China Aerodynamics Research and Development Center (CARDC) [中国空气动力研究与发展中心]
  - Hypersonic Flight Vehicle Technology Research Institute [高超声速飞行器技术研究所]
- (likely) China Aerospace Science and Industry Corporation (CASIC) [中国航天科工集团]
  - Beijing Institute of Power Machinery [北京动力机械研究所]
    - *a.k.a. CASIC 31st Research Institute*

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab is dedicated to development of hypersonic flight vehicles. While primarily focused on propulsion and hypersonic engine development, it conducts research on all components of

hypersonic vehicle design, including aerodynamics, materials, and cooling. Based on its online presence, the lab is notable for being highly active in co-sponsoring and organizing a variety of conferences related to hypersonic technologies.

There is a lack of clarity around the lab's exact subordination. The National University of Defense Technology, China Aerodynamics Research and Development Center (CARDC), and CASIC Beijing Institute of Power Machinery (a.k.a. the CASIC 31st Research Institue) all oversee key labs with this name, and while it is likely that they are all branches of the same lab, this was not explicitly stated in any public sources. The CARDC lab is occasionally referred to as the "Mianyang branch," and the CARDC lab Director is noted as the lab's overall Deputy Director, implying it is one branch of a multi-branch lab.[1026] Another source shows at least one researcher being affiliated with both the CARDC and NUDT labs.[1027] Finally, the CARDC branch is referred to as a "national-level" lab,[1028] as is the NUDT branch, and it is unlikely there would be two national-level labs with the same name. Less certain is whether the CASIC lab is also affiliated with this lab. Perhaps the best piece of evidence connecting the CASIC lab to the other two is a 2011 report on a conference organized by this lab, which lists the CASIC 31st RI, CARDC, and NUDT as the first three participating institutions.[1029]

The National University of Defense Technology and CARDC are both military institutions, making this lab directly subordinate to the PLA. The CASIC 31st RI is a research institute focused on R&D of aerospace engines, including small and medium-sized turbojet engines, turbofan engines, solid and liquid rocket engines and ramjet engines, super-combustion ramjet engines, and new combined engines for missiles and unmanned aerial vehicles.[1030]

**Further Information**:

- The lab's fund, called the "Annual Open Fund of the Key Laboratory of Hypersonic Ramjet Technology" [高超声速冲压发动机技术重点实验室年开放基金], supports scientific and technological personnel engaged in basic research on the overall design, flow, combustion, and thermal protection technologies of supersonic/hypersonic engines. The research cycle is generally 1-2 years, with theoretical analysis and numerical simulation generally receiving support of up to 150,000 RMB, and experimental research receiving funding of up to 250,000 RMB.[1031]

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

Research is centered around R&D of hypersonic flight vehicles and their various components. This includes:

- Hypersonic propulsion, engine and inlet design[1032]

- Scramjet engine simulations using AI[1033]
- Hypersonic aerodynamics[1034]
- Hypersonic thermodynamics and cooling[1035]

**Notable Applications:**

None found

**Leadership and Key Personnel:**

- Director: Sun Mingbo [孙明波][1036]
    - NUDT Professor
    - Was previously Deputy Director in 2016
    - Conducts research on hypercombustion ramjet engine technology, hypersonic combustion, and flow mechanisms[1037]
- Deputy Director: Zheng Baiheng [郑日恒][1038]
    - Leading researcher at Beihang University
    - Official positions include advisor to CASIC technology committee, editor-in-chief of academic journal *Propulsion Technology* [推进技术], vice-chairman of the Space Propulsion Committee of the International Astronautical Federation
    - Received his PhD from Cambridge University in U.K. as part of the Sino-British Friendship Scholarship, then did post-doc at University of Leeds
    - Has conducted research on PRC hypersonic vehicles, particularly new engine types

*Key Personnel:*

- Shen Chibing [沈赤兵]
    - Lab researcher and NUDT professor
    - Studied at University of Manchester in U.K. 2006-2007
    - Conducts research on rocket combined propulsion technology, propulsion system combustion theory and combustion diagnosis technology
    - Wrote the book *Liquid Rocket Engine Nonlinear Static Characteristics and Response Characteristics* [液体火箭发动机非线性静特性与响应特性][1039]
- Bai Handan [白菡尘]
    - In 2011, served as the lab Deputy Director, and Director of the Mianyang Branch
    - Researches hypersonic ram engine internal flow gas dynamics, bimodal ram engine working process and combustion organization technology, hypersonic propulsion, and vehicle integration design methodology[1040]

**Notable Collaborations:**

*Domestic*

- In 2018, this lab co-organized the China Academic Conference of Air and Space Power Composites and Applications [中国复合材料学会空天动力复合材料及应用专业委员会] along with the Chinese Society for Composite Materials [中国复合材料学会], Specialized Committee on Composites and Applications of Aerospace Dynamics [空天动力复合材料及应用专业委员], Institute of Aerospace Special Materials and Process Technology [航天特种材料及工艺技术研究所], Beijing Institute of Space and Astronautical Technology [北京空天技术研究所], and State Key Laboratory of Impact Environment Materials Technology [北京理工大学冲击环境材料技术国家级重点实验室]. It focused on advanced preparation technology for ceramic matrix composites.[1041] [lxviii]
- In 2018, this lab co-organized the First China Air and Space Propulsion Technology Forum [首届中国空天推进技术论坛] along with the Chinese Academy of Engineering Mechanical and Transportation Engineering Department [中国工程院机械与运载工程学部], the CASC 6th Academy, Beihang University, Harbin Institute of Technology, Northwestern Polytechnical University, the PLARF Engineering University, and multiple other institutions.[1042]
- In 2016, this lab co-organized the 18th National Hypersonic Aerodynamic/Thermal Symposium [第十八届全国高超声速气动力/热学术交流会] with Zhejiang University School of Aeronautics and Astronautics (and ZJU's Center for Proximity Space Vehicle Technology [临近空间飞行器技术中心]) and the Chinese Aerodynamic Society [中国空气动力学会]. It featured participation from CARDC, the CASC Beijing Propulsion Institute [北京动力研究所] (aka the CASC 11th RI), and the CASC China Institute of Space Power Technology [中国航天空气动力技术研究院]. Research areas included hypersonic vehicle design, hypersonic propulsion, test technology, materials, and multi-physics field coupling of gas/heat/structure/control of hypersonic vehicles.[1043]
- In 2015, this lab co-hosted the 17th Chinese Symposium on Aerodynamics and Physical Gas Dynamics [第十七届中国空气动力学物理气体动力学学术交流研讨会] and the 3rd Symposium on Coupled Internal and External Flows of Hypersonic Ram Engines [第三届高超声速冲压发动机内外流耦合流动研讨会] with the Physical Gas Dynamics Committee of the Chinese Society of Aerodynamics [中国空气动力学学会物理气体动力学专业委员会]. It featured participation from the CAS Institute of Mechanics, National University of Defense Technology, and the CAEP Beijing Institute of Applied Physics and Computational Mathematics [北京应用物理与计算数学研究所].[1044]

[lxviii] More details, including precise research topics, are available.

*International*

- In 2021, the lab co-hosted the 2nd International Symposium on Thermal-Fluid Dynamics (ISTFD 2021) with Beijing Institute of Technology, Xi'an Jiaotong University, the National Key Lab of Plasma Power [等离子体动力学国家重点实验室] (this is likely an alias of the DSTKL of Aviation Plasma Power, a defense lab run by the PLA Engineering University), the National Key Lab of Power Engineering Multiphase Flow [动力工程多相流国家重点实验室], and Sheffield Hallam University in the U.K. It featured participation from 14 countries, including the U.S., U.K., Canada, Japan, South Korea, Portugal, Sweden, Singapore, Russia, South Africa, Egypt, and Oman. Key guests and presenters came from U.S. Rutgers University (who gave a lecture titled "Heat transfer analysis in ni-water nanofluid-filled glass louver for solar energy harvesting and daylighting,"), Oxford University in the U.K. (who gave a lecture entitled "Harnessing scale interactions: locally embedded two-scale solutions for micro-structured surfaces,"), the Experimental Multiphase Flow Laboratory at the Imperial College of Science and Technology in the U.K. (who gave a lecture entitled "Advanced laser and infared-based measurements for new insights into flows with phase change"), and the University of Pretoria in South Africa (who gave a lecture titled, "Are our trusted turbulent flow equations accurate and/or appropriate?"). Other speakers came from the British Heat Transfer Society and Brunel University in the U.K. and the Russian Academy of Sciences. Participating institutions included: Oklahoma State University (U.S.), Brunel University (U.K.), University of Lisbon (Portugal), Sheffield Hallam University (U.K.), Zagazig University (Egypt), University of Leeds (U.K.), National University of Singapore, University of Nottingham (U.K.), University of British Columbia (Canada), University of Macau (Macao), and Lund University (Sweden). PRC participants included the National University of Defense Technology, PLA Air Force Engineering University, CASC 5th Academy, Beihang University, Northwestern Polytechnical University, Nanjing University of Aeronautics and Astronautics, Harbin Engineering University, CAS Institute of Engineering Thermophysics, CAS Institute of Process Engineering, CAS Institute of Physics and Chemistry, Peking University, Shanghai Jiao Tong University, Harbin Institute of Technology, Tsinghua University, University of Chinese Academy of Sciences, Huazhong University of Science and Technology, Sun Yat-sen University, the Xi'an Institute of Thermal Engineering Research Co. [西安热工研究院有限公司], and many others. Research topics included thermal and fluid dynamics, especially numerical theories and methods, experimental techniques and applied research on aerodynamics, combustion, and multiphase flow in conjunction with aviation, aerospace, and energy power.[1045]
- In 2018, this lab co-hosted the 9th Asian Joint Conference on Propulsion and Power (AJCPP 2018) [第九届亚洲推进与动力联合会议], along with Chinese Society of Engineering Thermophysics [中国工程热物理学会] (CSET), Japan Society of Aeronautical and Space Sciences (JSASS) [日本航空与空间科学学会], the Korean Society of Propulsion Engineers [韩国推进工程师协会] (KSPE), and the Xiamen University College of Aeronautics and Astronautics. This is a leading regional conference

on vehicle propulsion and power, and topics included aerospace/mechanical engineering, thermo-fluid/electromagnetic/plasma physics, structure/material design and fluid mechanics, aero-engine, rocket engine (solid/liquid/hybrid), electric propulsion and advanced propulsion technology, propulsion systems and reusable launchers, structure and material technology, engine components and performance (turbomachinery/combustor), combustion/diffusion/turbulent mixing, computational fluid dynamics, measurement and control/ground test technology, and operability and maintenance. Foreign participants came from Japan, South Korea, Russia, and Germany. This included researchers from University of Tokyo, Korea Aerospace University, and the University of Munich. PRC participants came from the CAS Institute of Engineering Thermophysics, Xi'an Jiaotong University, the CASC China Academy of Launch Vehicle Technology, and AECC.[1046]

**Lab Equipment:**

None found

**Address**:

None found, likely branches in Changsha, Mianyang, and Beijing

**Known Aliases:**

- Science and Technology on Scramjet Laboratory
- 高超声速冲压发动机技术国防重点实验室
- 高超声速冲压发动机技术国家级重点实验室
- 高超声速冲压发动机技术国家重点实验室
- 高超声速冲压发动机技术重点实验室

## 45. Defense S&T Key Laboratory of Inertial Technology

**Official English Name:** Unknown

**Chinese Name:** 惯性技术国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Space
- *Secondary: Air*

Equipment:

- Space Vehicles
- *Secondary: Ballistic Missiles, Non-ballistic Missiles*

Functional Field:

- GNC

**Affiliations:**

- Beihang University [北京航空航天大学]
  - School of Instrumentation and Optoelectronic Engineering [仪器科学与光电工程学院]
- China Aerospace Science and Industry Corporation (CASIC) [中国航天科工集团]
  - 3rd Academy Beijing Automation & Control Equipment Institute [三院北京自动化控制设备研究所]
    - *a.k.a. CASIC 33rd Research Institute [33 研究所]*

**Key Data:**

- Established: 2010
- Total Funding: Unknown
- Personnel: 101 (as of 2012)[1047]
- Official start of operations: 2011
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research primarily into precision navigation and guidance instruments for aerospace, including satellites and missiles.

A previous incarnation of the lab, the Aviation Gyroscope and Inertial Navigation Research Office [航空陀螺及惯性导航"研究室], was established in the 1950s at the suggestion of Qian Xuesen, the "Father of Chinese Rocketry," to meet the inertial guidance needs of China's first nuclear bomb and satellite programs. It contributed significantly to China's early missile and aerospace programs.[1048]

Today, the lab is jointly administered by Beihang University's School of Instrumentation and Optoelectronic Engineering and CASIC's Beijing Automation & Control Equipment Institute (a.k.a. the CASIC 33rd Research Institute). The 33rd RI is primarily tasked with R&D of missile inertial and control systems. It is on the U.S. Commerce Department Entity List for export control.[1049]

**Further Information:**

- The lab is divided into two underground floors with ten functional laboratories.[1050]

**Research Direction:**

No formal research direction found. Notable research areas include:

- Magnetic suspension/levitation
- Magnetic bearing
- Permanent magnetic synchronous motors
- Magnetic force
- Fiber optics/gyro
- (Strapdown) inertial navigation systems
- Accelerometers
- Motors and rotors[1051]

**Notable Applications:**

- In 2007, the lab developed new technologies for satellite attitude control and energy storage dual-purpose flywheel technology.[1052]
- In 2008, the lab developed a small high-precision CMOS star sensor technology.[1053]
- In 2009, the lab developed a new high-precision fiber optic gyroscope.[1054]

- In 2013, a radiation-resistant, highly reliable fiber optic gyroscope developed by this lab was successfully launched with a satellite, and a multi-axis integrated fiber optic gyroscope prototype developed by the lab successfully completed a flight test mission.[1055]
- The lab has made breakthroughs in many key technologies for small high-precision fiber optic gyroscopes for munitions, including significant progress in quartz/silicon MEMS gyroscopes, vibrating beam accelerometers, high-overload long-range MEMS inertial navigation, SERF atomic spin gyroscopes, nuclear magnetic resonance gyroscopes, and atomic interference gyroscopes.[1056]
- The lab (or at least a team led by the lab's director) successfully researched magnetic levitation inertial flywheel technology, improving satellite lifespan and attitude stability control accuracy, and may have also successfully developed magnetic levitation control torque/moment gyroscopes.[1057]

**Leadership and Key Personnel:**

- Director: Fang Jiancheng [房建成][1058]
    - CAS Academician
    - Beihang Executive Vice President
    - Director since lab's establishment
    - GNC expert, with focus on spacecraft attitude control magnetic levitation inertial actuators and inertial navigation technology
    - Director of Sino-U.K. Space Science & Technology Joint Laboratory [中英空间科学技术联合实验室] since its establishment in 2007
    - Instructor at PLAN Submarine Academy conventional submarine department from 1988-1993

**Notable Collaborations:**

*Domestic*

- Since 2015, this lab has had a Branch Office at CASC's 803rd Research Institute [航天803所分室], also known as the CASC 8th Academy Control Institute [中国航天科技集团公司八院控制所] or the Shanghai Aerospace Control Technology Research Institute [上海航天控制技术研究所]).[1059]
- The lab jointly founded Nanjing Shenwei Photoelectric Tech Research Institute Co. Ltd. [南京申威光电技术研究院] with the Nanjing Economic and Technological Development Zone Management Committee [京经济技术开发区管委会] and the Hunan Rate Control Technology Co., Ltd. [湖南率为控制科技有限公司]. This research institute works on intelligent perception, photoelectric reconnaissance, and unmanned driving technology with the aim of developing China's intelligent unmanned equipment, vehicle transport, and

opto-electronic reconnaissance equipment for future military individual combat systems.[1060]

- The lab also appears to be involved in Aviation Gyro (Beijing) Photoelectricity Technology Co., Ltd. [中航捷锐（北京）光电技术有限公司], a joint venture between Beihang and the AVIC 618th Research Institute [618 所] whose products are used in aerospace, shipping, armaments, electronics and other defense industries.[1061]

*International*

- Despite being immersed in the PRC's military research system, lab Director Fang Jiancheng is also Director of the PRC Branch of the Joint Sino-U.K. Space Science & Technology Laboratory [中英空间科学技术联合实验室].[1062]

**Lab Equipment:**

No Information

**Address**:

- Block B, New Main Building, Beihang University, No. 37 Xueyuan Road, Haidian District, Beijing [北京市海淀区学院路 37 号北京航空航天大学新主楼 B 座][1063]

**Website**:

https://web.archive.org/web/20190521030532/http://yqgdxy.buaa.edu.cn/content.jsp?urltype=news.NewsContentUrl&wbtreeid=1089&wbnewsid=1824

**Known Aliases:**

- Inertial Technology Key Laboratory of National Defense Science and Technology
- National Key Laboratory of Inertial Technology [惯性技术国家级重点实验室]
- State Key Laboratory of Inertial Technology [惯性技术国家重点实验室]
- Key Laboratory of Inertial Technology [惯性技术重点实验室]

## 46. Defense S&T Key Laboratory of Information System Security Technology

**Official English Name:** Unknown

**Chinese Name:** 信息系统安全技术国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Multi-Domain

Equipment:

- Computers
- *Secondary: Unmanned Systems*

Functional Field:

- Cyber Technologies
- *Secondary: Communications Technologies, Intelligent Technologies*

**Affiliations:**

- PLA Academy of Military Sciences [中国人民解放军军事科学院]
    - Institute of Systems Engineering [系统工程研究院]

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research into cybersecurity for the PLA. Research is mainly geared toward cyber defense and network security, as well as adjacent topics such as utilizing AI/ML in network defense and secure networking of unmanned intelligent systems. While it publicly emphasizes its role in cyber defense, this lab also appears to develop techniques and technologies for offensive cyber operations.

The lab is subordinate to the PLA Academy of Military Sciences' Institute of Systems Engineering. This Institute conducts research into a wide range of disciplines, including computer science, military logistics and equipment, biomedical engineering, and public health and epidemic

prevention.[1064] Previously, the lab was subordinate to the Beijing Institute of Systems Engineering [北京系统工程研究所], but was likely transferred to its current spot around 2016 or 2017, possibly as part of a larger series of reforms which reorganized the Academy of Military Sciences in 2017.[1065]

**Research Direction:**

- No formal research direction found

*Other Notable Research Areas:*

- Cyber attack and defense techniques[1066]
- Autonomous communication and networking for UAVs[1067]
- Utilizing AI/ML in software vulnerability analysis[1068]
- Cyber attack strategic early warning[1069]

**Notable Applications:**

None found

**Leadership and Key Personnel:**

No leadership found

*Key Personnel:*

- Yong Ting [雍婷]
    - Research on network security protocols, intelligent unmanned systems security[1070]
- Zhang Jingjing [张京京]
    - Research on deep learning, artificial Intelligence and Adversarial Attack and Defense[1071]

**Notable Collaborations:**

*Domestic*

- In 2020, this lab co-hosted the first Command and Control Cybersecurity Conference [指挥控制网络安全大会] along with the China Command and Control Society [中国指挥与控制学会], the Institute of Network Information under the PLA Academy of Military Sciences Institute of Systems Engineering [军事科学院系统工程研究院网络信息研究所], Beihang University College of Cyberspace Security [北京航空航天大学网络空间安

全学院] and Beihang University Hangzhou Innovation Institute [北京航空航天大学杭州创新研究院]. Topics of interest included building network security as part of a deterrent against U.S. cyber and nuclear war [筑牢网络空间安全防线，应对美国网络核战争威慑]. Other topics included command and control network security, future military network technology and strengthening networks for military use as part of military-civil fusion, unmanned system security, intelligent information sensing, targeting, tracking, and data fusion for maritime targets, infrastructure security, vulnerability mining, 5G network security, intelligent detection of security vulnerabilities. Other participants included the National Internet Emergency Response Center, Zhejiang University, Southeast University, Huazhong University of Science and Technology, 360 Group, Baidu, Huawei, and ACE.[1072]

- Since 2018, this lab has co-hosted the Zongheng network cybersecurity innovation forum and exhibition [“纵横”网络空间安全创新论坛暨展览大会]. The 2018 conference's theme was "military and civil working hand in hand to build cybersecurity." Other hosts included the PLAAMS Institute of Systems Engineering, CETC Institute of Electronic Science [中国电子科技集团有限公司电子科学研究院], Defense S&T Industry Network Security Innovation Center [国防科技工业网络安全创新中心], TechXcope [远望智库], and the CEC 6th Research Institute [中国电子信息产业集团有限公司第六研究所].[1073] In 2021, it held the Zongheng Cup [纵横杯] network security competition along with the CEC Great Wall Co. [中电长城网际系统应用有限公司] and Beijing Integrity Technology Co. [北京永信至诚科技股份有限公司] which featured teams from multiple major universities.[1074] [lxix] The competition featured network attack and defense and vulnerability mining, as well as incorporating AI into network attack and defense. It was found that AI was more effective than human competitors, but also that its need for long-term training means it is still behind human players in some areas for the time being.[1075]

*International*

- In 2022, this lab co-hosted the 7th International Conference on Data Science in Cyberspace (IEEE DSC 2022) [第七届国际网络空间数据科学大会], along with IEEE, the Chinese Academy of Engineering and Chinese Society for Chinese Language and Information [中国中文信息学会], Guilin University of Electronic Science and Technology [桂林电子科技大学], and the Pengcheng Laboratory [鹏城实验室]. It was co-chaired by Zhang Yanchun of Guangzhou University, who was a Thousand Talents Program scholar. The conference focused on use of big data in cyberspace to improve society and "ensure security." It also featured international participants from Florida Atlantic University in the U.S. and University of Tsukuba in Japan. Subjects included network attack and defense, situational awareness, deep learning algorithms and applications, intelligent systems, data mining, data security, knowledge representation and discovery, and information management.[1076] Similarly, this lab co-hosted the 6th International Conference on Data

[lxix] A list of teams and universities is available.

Science in Cyberspace (IEEE DSC 2021) [第六届国际网络空间数据科学大会] with IEEE, Pengcheng Laboratory, the Chinese Academy of Engineering, and Chinese Society for Chinese Language and Information. Participants came from the U.S., Italy, and Australia. U.S. professors from Emory University and the University of Texas at Dallas gave lectures. A professor from University of Melbourne spoke on perturbations in deep neural networks. A professor from the University of Insubria in Italy spoke on frame-based blockchain technology for solving policy and security problems in commerce.[1077]

- In 2014, this lab co-hosted the International Conference on Information and Network Security (ICINS 2014) with the Institute of Engineering Technology in the U.K., as well as the Communications Society of China, and Center for Information Security of Beijing University of Posts and Telecommunications. The conference focuses on the latest advances in information and network technologies, including secure processing, storage, and sharing of information.[1078]

**Lab Equipment:**

None found

**Address**:

Likely Beijing

**Known Aliases:**

- National Key Laboratory of Science and Technology on Information System Security
- 信息系统安全技术国家重点实验室
- 信息系统安全技术国家级重点实验室
- 信息系统安全技术重点实验室

## 47. Defense S&T Key Laboratory of Information Systems Engineering

**Official English Name:** Unknown

**Chinese Name:** 信息系统工程国防科技重点实验室

**Post-2024 Name:** National Key Laboratory of Information Systems Engineering[lxx] [信息系统工程全国重点实验室][1079]

**Research Focus:**

Domain:

- Multi-domain (Air, Space, Ground, likely others)

Equipment:

- Command & Control Systems
- *Secondary: Computers, Non-Ballistic Missiles, Space Vehicles, Unmanned Systems*

Functional Field:

- Communications Technologies
- *Secondary: Cyber Technologies, Information Processing, Intelligent Systems, Sensing, Target Detection/Recognition*

**Affiliations:**

- PLA National University of Defense Technology [中国人民解放军国防科技大学]
  - School of Systems Engineering [国防科技大学系统工程学院]
- China Electronics Technology Group Corporation (CETC) [中国电子科技集团]
  - Nanjing Institute of Electronic Engineering (NRIEE) [南京电子工程研究所]
    - *a.k.a. CETC 28th Research Institute*
- China Aerospace Science and Industry Corporation (CASIC) [中国航天科工集团]
  - CASIC 4th Academy 17th Research Institute [第四研究院十七所]

**Key Data:**[lxxi]

- Established: 2006[1080]
- Total Funding: >70m RMB[1081]
- Personnel: Unknown
- Official start of operations: 2009[1082]
- Floor Space: ~3,300 sqm[1083]

[lxx] Literal translation, no official name given
[lxxi] Note: both funding and floor space figures come from an unofficial source, likely citing an official source that has since been deleted.

**Lab Overview:**

This lab is the PRC's only national-level lab focused on command and control (C2) research.[1084] Officially, it is tasked with improving applied basic research into top-level design and systems integration of C2 and information systems.[1085] Since its establishment around 2006, it has become a key platform for the PLA's process of "informatization" via the development of C2 and information systems utilizing big data and AI. This included the development of a major new military C2 system in 2015.[1086] Research into integration of military information systems[1087] and C4ISR architecture models[1088] were particular areas of interest soon after the lab's founding, just as the PLA was moving toward more uniform command and control systems. This lab was added to the US Commerce Department BIS entity list in December 2022.[1089] This was an unusual move; typically, BIS only blacklists parent institutions, but apparently saw fit to specify this lab.

The roots of this lab date back to 1979, when the NUDT School of Systems Engineering was first established by PRC scientist and systems engineering pioneer Qian Xuesen.[1090] PLA officials involved in the founding of this lab, including Liu Zhong [刘忠] and Zhang Weiming, cite the 1991 Gulf War as a major catalyst for the establishment of this lab, as they were both shocked and impressed by U.S. C2 systems and realized they far outpaced PRC capabilities. Seeing the slow pace of development and lack of a comprehensive C2 research infrastructure, Zhang Weiming proposed the establishment of a Defense S&T Key Lab devoted to command and control in 2002. The lab was finally established in 2006 as a joint effort between NUDT's School of Information Systems and Management,[lxxii] the CETC 28th Research Institute, and the CASIC 17th Research Institute, and passed final inspection in 2009.[1091] Under the ongoing reorganization of the PRC's national key lab system, this lab is now known as the National Key Lab of Information Systems Engineering" [信息系统工程全国重点实验室].

One of the lab's founders, Liu Zhong, has stated that the lab's early years were focused on studying foreign C2 systems. Liu himself studied at the University of Portsmouth in the U.K. in 2005, and upon returning immediately worked to apply the advanced concepts he had learned there to the PLA's C2 systems.[1092] Since being established, the lab claims to have taken on over 30 major national and military infrastructure projects and become an important research center for PLA command information system theory and technology development.[1093]

According to a recent interview with Director Zhang Weiming, the lab's focus has increasingly shifted from centralized C2 systems to edge C2 [边缘指挥控制]—that is, moving C2 to the "edge" of the network and bringing it closer to the end user on the battlefield, a useful trait in a fast-moving, highly dispersed modern warfare environment. This theory is focused on empowering lower level commanders at the front line and giving greater autonomy to more junior levels, which may be part of the PLA's larger series of reforms intended to encourage more autonomy and initiative at lower levels. Using high-speed networks and AI enables a more agile response, allowing units to independently obtain information on enemy and friendly force

[lxxii] The lab was apparently transferred to the School of Systems Engineering at a later date.

deployment and equipment, independently search for resources and partners, and flexibly coordinate with one another, even if cut off from centralized C2.[1094]

The CASIC 17th Research Institute, established in 1968, researches solid launch vehicle control systems and control system integration. It develops control, measurement, and launching systems, and targeting systems for solid launch vehicles.[1095]

The CETC Nanjing Institute of Electronic Engineering (NRIEE) (a.k.a. the CETC 28th Research Institute), established in 1964, conducts R&D of military information and C2 systems, particularly overall system design, software development, and comprehensive systems integration. It has developed C2 systems for all PLA services and forces, the Central Military Commission, and the Joint Theater Commands.[1096]

**Further Information:**

- This lab is sometimes referred to as the "Defense S&T Key Laboratory of C4ISR," or simply the "Key Laboratory of C4ISR." Overlaps in mission, personnel,[1097] and parent institutions appear to confirm that these two labs are the same.
- At its establishment, the lab had 4 research offices: Military Requirements and Architecture Technology [设军事需求与体系结构技术], Command and Control Technology [指挥控制技术], Information Integration and Decision Aid Technology [信息集成与辅助决策技术], and Military Intelligence Analysis Technology [军事情报分析技术].[1098]
- The lab has a subordinate office called the "Knowledge Systems Engineering Technology Research Office [知识系统工程技术研究室].[1099]
- This lab has hosted its own forum, the Key Laboratory of Information Systems Engineering C4ISR Technology Forum for Defense Science and Technology [信息系统工程国防科技重点实验室 C4ISR 技术论坛]. There were at least 5 iterations as of 2013.[1100]

**Research Direction:**

The lab's 4 subordinate offices at its founding hint at a possible official Research Direction:[1101]

1. Military Requirements and Architecture Technology [设军事需求与体系结构技术]
2. Command and Control Technology [指挥控制技术]
3. Information Integration and Decision Aid Technology [信息集成与辅助决策技术]
4. Military Intelligence Analysis Technology [军事情报分析技术]

*Other Notable Research Areas:*

- Complex networks[1102]
- C2 of joint operations and system-of-systems confrontation[1103]
- C4ISR[1104]

- Military information system architecture design method and application analysis[1105]
- Satellite information systems[1106]
- Anti-ship missile route planning algorithms[1107]
- Integration of military information systems[1108]
- C4ISR architecture models[1109]

The labs public research priorities for 2023 were as follows:[1110] [lxxiii]

1. Architecture Exploratory Sequential Optimization Design Technology
2. Manned/Unmanned Aircraft Formation Combat Task Assignment Technology for Edge Charging
3. Network Attack and Defense Game Modeling and Decision-making Technology
4. Interpretable Reasoning Methods of Strategic Posture Trends among Important Countries
5. Research on Causal Exploration and Reasoning Methods of Adversary's Response Actions in Strategic Games
6. Research on Cognitive Coherence Theory and Its Application in Situation Visualization
7. Methods of Strike Ordering of Key Nodes of Heterogeneous Cascade Target Systems
8. Cooperative Search and Fusion Sensing Technology for Unmanned Clusters
9. Target Wide Area Continuous Tracking and Seamless Coverage Situational Awareness Technology for Critical Time Periods
10. High-precision Strong Immunity Constellation-Vehicle Cross-domain Cooperative Control Technology
11. Intelligent Planning and System Verification Technology for Complex Killing Networks

**Notable Applications:**

- In December 2015, the PLA completed 5 years of R&D on a major new C2 system. NUDT and this lab appear to have played a central role in this system.[1111]
- Around 2009, this lab's CASC branch developed a digital intelligent security command system [数字化智能安防指挥系统] as part of an MCF innovation project. It aids in security emergency command, planning command, assisted decision making for operations, and connecting alarms, video surveillance, access control, fire prevention, remote monitoring and command, real-time mapping and analysis, and other functions.[1112]

**Leadership and Key Personnel:**

- Director: Zhang Weiming [张维明]
    - Lab director since 2009
    - Member of the Discipline Review Group of the PRC State Council
    - Head of a defense science and technology group of the CMC Science and Technology Committee

[lxxiii] A much more detailed document with priorities, research targets, and funding is available.

    - Chairman of the C4ISR Theory and Technology Committee of the Chinese Society of Command and Control
    - Research focused on edge computing and edge C2; has worked to improve battlefield C2 and command information systems for over 30 years
    - Corps-deputy grade Major General
    - Published the influential volume "Principles of Command and Control" [指挥与控制原理][1113]
- Director of NUDT Branch: Zhu Cheng [朱承]
    - Deputy director of the C4ISR Theory and Technology Committee of the Chinese Society of Command and Control
    - Expert of the CMC Science and Technology Committee and PLA Equipment Development Department[1114]
- Deputy director of CASIC branch: Liu Yan [刘琰]
    - CASIC 17th RI Director
    - Executive director of the Chinese Society of Command and Control
    - Research interests include the overall design of complex information system projects, multi-flight vehicle collaborative control technology, and multi-flight vehicle intelligent decision-making technology[1115]
- Deputy Director: Tang Jiuyang [唐九阳][1116]
- Deputy Director (possibly of CETC Branch): He Chenglong [贺成龙][1117]
- Standing Committee Deputy Director: Yi Kan [易侃][1118]
- Academic Committee Deputy Director: Sha Jichang [沙基昌]
    - NUDT professor
    - Graduate of MIT in U.S.[1119]
- Director of Knowledge Systems Engineering Technology Research Office [知识系统工程技术研究室]: Zhao Xiang [赵翔][1120]

*Key Personnel:*

- Zhou Yun [周鋆]
    - Received his PhD from Queen Mary University of London in the U.K.
    - Currently a professor at NUDT
    - Researches machine learning and Bayesian network theory[1121]
- Yang Yi [杨昊]
    - NUDT graduate student researching countermeasure machine learning and model robustness[1122]

**Notable Collaborations:**

*Domestic*

- Per an unofficial source, the lab has a strategic cooperation agreement with Beijing Fengsheng Boyuan Technology Co. [北京峰盛博远科技有限公司], a tech company under the Forsun Group [峰盛集团] conglomerate, for talent training, joint information security labs, and research on topics of national interest in information security. (The original source for the claim could not be found).[1123]
- This lab has worked with multiple PLA units:[1124]
    - PLA Unit 63863 and Nanjing University of Technology, on models to efficiently assess the credibility of large quantities of open-source intelligence[1125]
    - PLA Unit 91286, on satellite information systems[1126]
- This lab worked with Xidian Universiy to develop AI applications for the military, including using AI to improve self-adaptive decision making for C2 systems in a rapidly changing battlefield environment.[1127]
- This lab, as part of the NUDT School of Information Systems and Management, co-hosted the 2022 National Big Data and Computational Intelligence Challenge [2022 全国大数据与计算智能挑战赛], along with the Laboratory of Big Data and Decision-making [大数据与决策实验室] under the same school. Other organizers included the PLA Guizhou Military District, Guiyang Party Committee and municipal government, CASIC 706th RI, CETC 28th RI, and Zhongruan Information Systems Engineering Co. [中软信息系统工程有限公司]. The competition is intended to solve key bottlenecks in the fields of big data and AI. This year's challenge focused on three problems: domain event detection with high robustness requirements, semantic retrieval of news text data and intelligent Q&A, and real-time correlation of radar signals-based trajectories and track merging tasks.[1128]
- This lab co-hosts a periodic C4ISR Theory and Technology Summit Forum [C4ISR 理论与技术高峰论坛]:
    - In 2019, forum speakers came from Southeast University, the PLARF Research Academy, and Sun Yat-sen University, and spoke on the topics of joint combat command and control system development and thinking, field sensing and remote operation of robotics and applications in the aerospace and military fields, large-scale operation and control systems and large-scale applications in the military field, applications of big data and artificial intelligence in command and control, applications of artificial intelligence technology in command and control, mixed reality-based equipment control and cooperative command technology, and the development of joint combat command and control systems. It also included research on the applications of artificial intelligence technology in command and control, mixed reality-based equipment control and collaborative command technology, and C4ISR systems. More than 200 experts came from different industries such as military academies, military research institutes, local universities, and military SOEs.[1129]

- The 2020 forum was co-hosted with Sun Yat-sen University. Presenters came from the National Defense University, Chinese Academy of Military Sciences, CETC, and Baidu, and spoke on future air-based networks, intelligent decision-making, and intelligent C2.[1130]
- The 11th forum was held in 2023 and was co-hosted with the Chinese Society of Command and Control [中国指挥与控制学会]. This iteration included several interesting presentations. A researcher from the CASIC 17th RI gave a report called "Development Trends of Future Kill Network", which introduced future trends and possible limitations of kill networks for foreign militaries before and after 2027. A researcher from the University of Electronic Science and Technology gave a report called "Micro-watt-level Highly Concealed Battlefield Real-time Sensing System", which introduced a low-cost, small-size, large-scale and rapid covert deployment of dust-level battlefield sensing nodes, allowing the PLA to "fight against concealed enemies with concealed reconnaissance nodes." Supplemented with an intelligent situational awareness platform, it can complement existing reconnaissance means to make up for blind spots and enhance sensing capabilities in urban combat. A researcher from the CAS Institute of Automation gave a report called "Research and Practice of Key Elements of Group Intelligent Decision Making," including for unmanned clusters. Chen Tao of this lab gave a report called "Preliminary Exploration of Intelligent Design of Combat Systems", analyzing the problems and deficiencies of traditional combat system design methods, introducing the exploratory work done around the design of troop formations and communication architectures. Finally, a researcher of CETC 28th RI reported on "Military Application and Development of Interpretable AI."[1131]

- In 2023, this lab co-hosted the 10th China Conference on Command and Control [第十届中国指挥控制]. The conference had the theme of "space-ground integrated network fusion, joint all-domain intelligent coordination" [天地一体网络融合，联合全域智能协同]. Other organizers included the China Association for Science and Technology [中国科学技术协会], Chinese Society of Command and Control [中国指挥与控制学会], Norinco 207th RI, CASIC 17th RI, Key Lab of Opto-electrical Control Technology [光电控制技术重点实验室], National Engineering Lab of Integrated Command Dispatch Technology [一体化指挥调度技术国家工程实验室], and Beijing Dongjian Future Forum Company [北京洞见未来会展有限公司]. Presenters came from Beihang University, CAS Institute of Automation, PLAN Research Academy, Academy of Military Sciences, PLAAF Research Academy, Beijing University of Posts and Telecommunications, and CASIC).[1132][lxxiv]

*International*

- Several researchers associated with this lab presented at the 2023 6th IEEE International Conference on UAV Systems [2023 第六届 IEEE 国际无人系统大会]. These included

[lxxiv] A more detailed list of presentations and presenters is available.

NUDT Branch Director Zhu Cheng, Zhou Yun, and Yang Yi (see "Prominent Personnel" for more on all). Notably, several of Zhu Cheng's military affiliations (with the exception of his primary role as an NUDT professor) are omitted in the English translation.[1133]

- As of 2015, researcher Hou Lulin [侯绿林] is affiliated with both this lab and the University of Western Australia. Hou worked with other lab researchers on controlability of complex networks. Hou has also worked on route planning algorithms for anti-ship missiles.[1134]

**Lab Equipment:**

None found

**Address**:

North Gate of No.1 Courtyard, National University of Defense Technology, 3-1 Avenue, Kaifu District, Changsha, Hunan Province [长沙市开福区三一大道国防科技大学一号院北门][1135]

**Known Aliases:**

- Defense S&T Key Laboratory of Information Technology [信息技术国防科技重点实验室]
- Key Laboratory of Information Systems Engineering (KLISE)
- Information System Engineering Laboratory
- Defense S&T Key Laboratory of C4ISR [C4ISR 技术国防科技重点实验室]
- C4ISR 技术国防重点实验室
- C4ISR 技术重点实验室
- C4ISR 技术国家级重点实验室
- C4ISR 技术国家重点实验室
- 信息系统工程国防重点实验室
- 信息系统工程重点实验室
- 信息系统工程国家重点实验室
- 信息系统工程国家级重点实验室

## 48. Defense S&T Key Laboratory of Infrared and Ultraviolet Technology

**Official English Name:** Unknown

**Chinese Name:** 红外紫外技术国防科技重点实验室

**Post-2024 Name**: National Key Laboratory of Infrared Sensing[lxxv] [红外探测全国重点实验室]

**Research Focus:**

Domain:

- Multi-domain

Equipment:

- Likely wide range of electromagnetic and sensing equipment

Functional Field:

- Electromagnetics
- *Secondary: Millimeter Wave Technologies, Sensing, Terahertz Technologies*

**Affiliations:**

- Chinese Academy of Sciences [中国科学院]
  - Institute of Technical Physics [上海技术物理研究所]
- China Ordnance Industries Group Corporation (Norinco) [中国兵器工业集团]
  - Kunming Institute of Physics [昆明物理研究所]
    - *a.k.a. Norinco 211th Research Institute*
- China Electronics Technology Group Corporation (CETC) [中国电子科技集团]
  - North China Institute of Optoelectronics [华北光电技术研究所]
    - *a.k.a. CETC 11th Research institute*

**Key Data:**

- Established: 2023[1136]
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: Unknown

[lxxv] Literal translation, no official name given

**Lab Overview:**

There is only one reference to the Defense S&T Key Laboratory of Infrared and Ultraviolet Technology, in a 2019 announcement of the construction of a new base for the CETC 11th Research Institute which was set to house this lab.[1137] While no further mention of this lab is made, in 2023 the CETC 11th RI announced the establishment of a national-level lab with a similar name, the "National Key Laboratory of Infrared Sensing" [红外探测全国重点实验室] which may be the same lab under a different guise. This new lab held its first academic committee meeting in September 2023 and is jointly managed by the CETC 11th RI, the Norinco 211th RI, and the Chinese Academy of Sciences' Shanghai Institute of Technical Physics. It is intended to solve bottlenecks in the field of infrared research.[1138]

It is possible that the CETC 11th RI planned a Defense S&T Key Lab, which was reimagined and reorganized as an ostensibly civilian National Key Lab, likely as part of the ongoing reforms to both the NKL and DSTKL systems. Evidence suggests that this lab is not currently classified as a DSTKL.[1139] However, its affiliation with Norinco and CETC, both major defense companies, indicates a military mission. It appears to conduct a combination of civilian, dual-use, and military research, for example in space exploration[1140] and electromagnetic sensing.[1141] Further, one source refers to it as the "National Key Laboratory of Military Infrared Sensing,"[1142] again suggesting a fundamentally military mission.

The CETC North China Institute of Optoelectronics[lxxvi] (a.k.a. the CETC 11th Research Institute) was founded in 1956 and is focused on R&D of electronic components and materials, particularly in laser and infrared materials, devices, and systems.[1143]

The Norinco Kunming Institute of Physics (a.k.a. the Norinco 211th Research Institute) was founded in 1958 and is focused on R&D of infrared and thermal imaging technology, including infrared detectors, Dewar materials, cooling, infrared optics and coatings, infrared telescopes, infrared testing technology, electronic signal processing, and optical-mechanical scanning.[1144] In 2010, it was reorganized and became part of Norinco North Night Vision Science & Technology Research Institute Group (a.k.a. the Night Vision Institute) [北方夜视科技研究院集团有限公司].[1145] An academic journal source confirms that the Night Vision Institute was involved in the construction of this lab.[1146]

The CAS Shanghai Institute of Technical Physics was established in 1958 and is focused on infrared physics and optoelectronic technology, particularly development of airborne infrared and optoelectronic payloads, infrared imaging and signal processing, infrared detectors, space active optoelectronic technology, and remote sensing information processing.[1147]

**Research Direction:**

No formal research direction found

[lxxvi] Translation is author's own.

*Other Notable Research Areas:*

- Infrared sensing technology[1148]

**Notable Applications:**

None found

**Leadership and Key Personnel:**

- Director: Chen Jianxin [陈建新]
    - Also deputy director of CAS Shanghai Institute of Technical Physics[1149]
- Academic Committee Director: Wang Jianyu [王建宇] (2023)[1150]
- Deputy Director: Zhao Jun [赵俊]
    - Defense S&T outstanding youth fund recipient[1151]

**Notable Collaborations:**

*Domestic*

- The lab appears to be affiliated with the CETC 53rd RI and CASIC 8358 RI in its infrared work.[1152]
- The lab works closely with the National Key Laboratory of Infrared Science and Technology [红外科学与技术全国重点实验] in research and training.[1153]
- In 2024, this lab co-organized the 5th Infrared Technology and Applications Conference [第五届红外技术及其应用大会] with its parent organization, the Shanghai Institute of Technical Physics, and the Infrared Technology and Applications Committee of the Optical Engineering Society of China [中国光学工程学会红外技术及应用专业委员会]. Research topics included Infrared Materials and Devices, Advanced Infrared Optics, New Infrared System Detection and Recognition Technology, Optoelectronic Sensing/RF Electronics and Microsystems, Advanced Infrared System Test and Evaluation Technology, Terahertz Detection Technology, Industrial automation and Non-destructive Testing applications, Environmental Monitoring and Gas Detection, Biomedical and Healthcare Applications, Intelligent/Assisted Driving Applications, Space/Aerospace Remote Sensing Detection Applications, and Detection/guidance and Early Warning Applications.[1154]

*International*

- In September 2024, this lab co-organized the "3rd International Conference on Earth and Space: From Infrared to Terahertz" (ESIT 2024) [第三届地球与太空：从红外到太赫兹国际会议]. The conference is focused on infrared millimeter wave and terahertz

technologies for space exploration, digital earth, and intelligent sensing and cognition.[lxxvii] Other organizers/sponsors included the CAS Shanghai Institute of Technical Physics, the University of the Chinese Academy of Sciences, Fudan University School of Optoelectronics, North China Institute of Optoelectronics [华北光电技术研究所], Kunming Institute of Physics [昆明物理研究所], the Key Lab of Infrared Science and Technology [红外科学与技术重点实验室], Ningbo University School of Information Science and Engineering, and others. Foreign participants came from Northwestern University and University of Rochester in the U.S., the Military University of Technology in Poland, Pisa University in Italy, Hanyang University in Korea, Institute of Semiconductor Physics in Ukraine, Russian Academy of Sciences, Nanyang Technical University in Singapore, and the Finnish Geospatial Research Institute and Center for Machine Vision and Signal Analysis at University of Oulu in Finland.[1155]

**Lab Equipment:**

None found

**Address**:

Shanghai 200083[1156]

**Known Aliases:**

- 红外探测全国重点实验室
- 军用红外探测全国重点实验室

[lxxvii] A list of more specific topics is available.

## 49. Defense S&T Key Laboratory of Integrated Avionics Technology

**Official English Name:** Unknown

**Chinese Name:** 航空电子系统综合技术国防科技重点实验室

**Post-2024 Name**: likely National Key Laboratory of Integrated Avionics and Systems Integration[lxxviii] [航空电子综合与体系集成全国重点实验室][1157]

**Research Focus:**

Domain:

- Air

Equipment:

- Aircraft
- *Secondary: Unmanned Systems*

Functional Field:

- Avionics
- *Secondary: GNC, Intelligent Technologies*

**Affiliations:**

- Aviation Industry Corporation of China (AVIC) [中国航空工业集团]
  - Aeronautical Radio Electronics Research Institute [中国航空无线电电子研究所]
    - *a.k.a. AVIC 615th Research Institute*

**Key Data:**

- Established: 2009[1158]
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab was established in 2009 to develop integrated avionics systems for PRC military and civilian aircraft.[1159] Particular areas of interest include advanced avionics architecture, cockpit display and layout (including intelligent cockpit technologies),[1160] guidance, navigation, and control (GNC) systems,[1161] and UAV control and cooperation technology.[1162]

[lxxviii] Literal translation, no official name given

The lab's parent company, AVIC's Chinese Aeronautical Radio Electronics Research Institute (a.k.a. the AVIC 615th RI), conducts research on military and civil avionics technology, communications, and navigation systems.[1163]

Under the ongoing reorganization of the PRC's national key lab system, this lab is likely now known as the National Key Lab of Integrated Avionics and Systems Integration [航空电子综合与体系集成全国重点实验室].

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- Avionics architecture[1164]
- Intelligent cockpit technologies[1165]
- Navigation systems[1166]
- Aircraft combat system architecture[1167]
- Manned/unmanned aircraft combat cooperation[1168]

The lab funds research into the following areas:

- UAV cooperation and tracking[1169]
- Display interface layout for new fighter aircraft[1170]

**Notable Applications:**

None found

**Leadership and Key Personnel:**

- Director: Wang Jinyan [王金岩]
    - Also director of 615th RI[1171]
    - Specializes in avionic system architecture, including cockpit display control systems, core processing systems, flight management systems, radio communications, navigation, and surveillance systems, and integrated information systems[1172]
- Executive Committee Deputy Director: Wu Jianmin [吴建民][1173]
    - Former Director (2017)[1174]

**Notable Collaborations:**

*Domestic*

- In 2023, this lab co-organized the National Academic Conference on Datalink Technology [全国数据链技术学术会议] with the Chinese Institute of Command and Control [中国指挥与控制学会] and its Datalink Technology Professional Committee [数据链技术专业委员会] and the CASC 804th RI. Participants included the Academy of Military Sciences, AVIC, CETC, and Shanghai Jiao Tong University.[1175]
- In 2021, this lab co-organized the 1st National Air Intelligent Gaming Competition [首届全国空中智能博弈大赛], along with the Chinese Institute of Command and Control [中国指挥与控制学会] and its Air Multi-intelligent Body Cooperative Control Professional Committee [空中多智能体协同控制专业委员会], AVIC Shenyang Aircraft Design Institute and other AVIC subsidiaries, Beijing Huaru Co. [北京华如科技股份有限公司], and multiple key labs. The PLA Air Force also sent experts. The conference was focused on artificial intelligence and human-machine hybrid intelligence for aviation.[1176]
- In 2017, this lab co-organized the 5th China Aviation Weapons Conference [第五届中国航空兵器大会], along with the Chinese Society of Aeronautics and Astronautics [中国航空学会], Northwestern Polytechnical University, and several key labs, including the Aviation S&T Key Lab of Aviation Guided Weaponry [航空制导武器航空科技重点实验室]. Topics included intelligent weapons systems, manned/unmanned aircraft cooperation and UAV cluster combat, C2, EW and countermeasures, stealth and anti-stealth, fire control, target detection and identification, and multiple other topics.[1177]

*International*

- In 2024, this lab co-organized the 13th Avionics International Forum [2024（第十三届）飞机航空电子国际论坛] in Shanghai, intended to promote the development of the PRC's avionics industry. The forum was organized by the Chinese Society of Aeronautics and Astronautics [中国航空学会] along with multiple AVIC and COMAC institutes. Topics included airworthiness standards, intelligent avionics and autonomous control, supply chains, and simulation technology. It appears to be primarily focused on civil aviation, but included multiple entities affiliated with military aerospace. International participants came from U.S. company Wind River Systems and Aviage Systems, as well as the Federal Aviation Administration.[1178] The U.S. FAA and U.S. companies Honeywell and Collins Aerospace, French company Dassault, and Finnish company Qt Group also participated in the 2023 conference.[1179]

**Lab Equipment:**

None found

**Address**:

Shanghai 200233[1180] and 200241[1181]

**Known Aliases:**

- 航空电子系统综合技术国防重点实验室
- 航空电子系统综合技术重点实验室
- 航空电子系统综合技术国家重点实验室

## 50. Defense S&T Key Laboratory of Lightweight, High-strength Structural Materials

**Official English Name:** State Key Laboratory for Light Weight and High Strength Structural Materials[1182]

**Chinese Name:** 轻质高强结构材料国防科技重点实验室

**Post-2024 Name**: No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Multi-Domain (Air, Space, Nuclear)

Equipment:

- Multiple (Aircraft, Munitions, Space Vehicles, Nuclear Weaponry & Power)

Functional Field:

- Materials

**Affiliations:**

- Central South University (CSU) [中南大学]
    - Powder Metallurgy Research Institute [粉末冶金研究院]

**Key Data:**

- Established: 2005
- Total Funding: Unknown
- Personnel: Unknown[1183]
- Official start of operations: 2016
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research into lightweight structural materials for aviation and aerospace uses.[1184]

The lab is subordinate to CSU's Powder Metallurgy Institute, which conducts research on (among other things) lightweight alloy materials which are widely used in aviation, aerospace, weapons, shipbuilding, electronics, the nuclear industry, and other industrial sectors.[1185]

**Further Information:**

- There is another provincial-level key lab with a very similar name—the Jiangxi Province Key Laboratory of Lightweight and High Strength Structural Materials [(江西省)轻质高强结构材料重点实验室] at Nanchang University. The two labs do not appear to be connected.

**Research Direction:**

No formal research direction available.

*Other Notable Research Areas:*

- Broad descriptions include work in materials science, material processing, material shaping and control (micro)structures, and performance control, processing, and forming of aluminum or titanium alloys.[1186]

**Notable Applications:**

None found

**Leadership and Key Personnel:**

- Director: Liu Wensheng [刘文胜][1187]
- Deputy Directors: Zhang Fuqin [张福勤]; Gan Xueping [甘雪萍][1188]

**Notable Collaborations:**

*Domestic*

- The lab collaborates with the National Engineering Research Center of Powder Metallurgy [粉末冶金国家工程研究中心], China Nonferrous Metal Industry Powder Metallurgy Product Quality Supervision and Testing Center [中国有色金属工业粉末冶金产品质量监督检测中心] and State Key Laboratory of Powder Metallurgy [粉末冶金国家重点实验室] to manage the Hunan Shixin New Material Co. [湖南世鑫新材料有限公司] (a.k.a. CSUN), a Central South University company which develops new carbon ceramic composite materials. The company has a 2,000 sqm research base and total value of over 40m RMB. Its facilities include a material research and development test line, mechanics testing laboratory, and friction and wear laboratory. Its equipment includes a high-speed train 1:1 braking stand from German company RENK, shrinkage inertia test stand for rail train, friction and wear performance testing machine, single-side vertical dynamic

balancing machine, and coordinate meter. Its products have gone into the PRC's high-speed trains, subways, automobile parts, carbon ceramic brakes, and unnamed military-civil fusion (MCF) projects.[1189]

- The lab has co-hosted (at least through the 2nd-6th iterations, from 2013-2019) the High-end Forum on Aerospace Engineering and High-Performance Materials Demand and Application [航天工程和高性能材料需求与应用高端论坛]. The main hosts have been the Chinese Materials Research Society [中国材料研究学会] and the Chinese Society of Astronautics [中国宇航学会]. CASC's China Academy of Space Technology (CAST) [中国空间技术研究院], which is responsible for designing and manufacturing China's satellites, has been a frequent co-host. CASC's 1st Academy 703rd RI has also co-hosted multiple times. This forum focuses on conducting academic exchanges on major aerospace engineering fields such as China's manned spaceflight, deep space exploration, Beidou satellite navigation, the Chang'e moon exploration program, satellites, and future aerospace development directions, as well as the application of high-performance new materials, new structures, integration of structural functions, and meeting demand for advanced manufacturing technologies and industrialization of aerospace materials.[1190]

**Lab Equipment:**

No Information

**Address**:

No. 932 Lushan S. Road, Changsha City, Hunan Province [湖南省长沙市岳麓山(南路 932 号)][1191]

**Known Aliases:**

- (Central South University) National Key Laboratory for High-strength Structural Materials [(中南大学)轻质高强结构材料国家(级)重点实验室]
- National Key Laboratory of Science and Technology for National Defence on High-strength Structural Materials [轻质高强结构材料(国家)重点实验室]
- National Key Laboratory of Science and Technology for National Defence on High-strength Lightweight Structural Materials
- Key Laboratory on High-strength Lightweight Structural Materials [轻质高强国防科技重点实验室]

## 51. Defense S&T Key Laboratory of Liquid Rocket Engine Technology

**Official English Name:** (likely) Science and Technology on Liquid Rocket Engine Key Laboratory[1192]

**Chinese Name:** 液体火箭发动机技术国防科技重点实验室

**Post-2024 Name**: National Key Laboratory of Aerospace Liquid Propulsion[lxxix] [航天液体动力全国重点实验室][1193]

**Research Focus:**

Domain:

- Space
- *Secondary: Air*

Equipment:

- Space Vehicles
- *Secondary: likely Ballistic Missiles*

Functional Field:

- Propulsion

**Affiliations:**

- China Aerospace Science and Technology Corporation (CASC) [中国航天科技集团]
  - Xi'an Institute of Space Power [航天科技集团六院西安航天动力研究所]
    - *a.k.a. CASC 6th Academy 11th Research Institute [6 院 11 所]*

**Key Data:**

- Established: 2015[1194]
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: 2017[1195]
- Floor Space: Unknown

**Lab Overview:**

This lab was established in 2015 to aid the CASC 6th Academy in the development of liquid rocket engine technology for both weaponry and aerospace transport,[1196] and it passed SASTIND and PLA EDD approval in 2017.[1197] Research areas include rocket spray and

[lxxix] Literal translation, no official name given

combustion, heat transfer and cooling, thermal processes, coupling simulations, kinetic and static mechanics, rotor dynamics, and rotary turbine pumps.[1198] 3-D printing of rocket engine parts also appears to be an area of interest.[1199]

In 2023, sources began to suggest this lab is facing a significant reorganization, although no further details were given.[1200] As of 2023-2024, it is still referred to in authoritative sources as a Defense S&T Key Lab,[1201] although it has also begun using the characters "全国" (national) in place of "国防科技" (Defense S&T), in line with multiple other labs at this time.[1202] As of 2024, this lab is now known as the National Key Lab of Aerospace Liquid Propulsion [航天液体动力全国重点实验室].

The lab's parent institution, the CASC Xi'an Institute of Space Power (a.k.a. the CASC 11th Research Institute) is the main R&D and design unit of CASC's 6th Academy. It had a hand in design of the Long March series of rockets, among other rocket engines.[1203]

**Further Information:**

- The lab has a subordinate Engine Design and Simulation Center [发动机设计仿真中心] and a civil-military shared technological innovation platform.[1204]
- Sponsors a CASC academic journal, *Journal of Rocket Propulsion* [火箭推进].[1205]

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- Technologies related to liquid rocket propulsion, including rocket spray and combustion, heat transfer and cooling, thermal processes, coupling simulation, kinetic and static mechanics, rotor dynamics, and rotary turbine pumps[1206]

For 2022, the lab's Key Laboratory Fund provided funding for the following projects:[1207] [lxxx]

1. New vibration isolation structure design based on low-dimensional metamaterials [基于低维超材料的新型隔振结构设计]
2. High-temperature wall regeneration/sweat cooling technology research [高温壁面再生／发汗冷却技术研究]
3. New Rocket Engine Combustion Diagnostic Technology Based on Ion Current Method [基于离子电流法的新型火箭发动机燃烧诊断技术]

[lxxx] Further details about funding priorities, targets, and funding are available. Information about 2021 funding priorities is also available.

**Notable Applications:**

- This lab was involved in development of Long March 5 rocket[1208]

**Leadership and Key Personnel:**

- Director: Tan Yonghua [谭永华][1209]
- Academic Committee Director: Wang Zhenguo [王振国][1210]
- Office Director [办公室主任]: Du Feiping [杜飞平]
    - Also serves as the 11th RI's S&T Division Deputy Director [西安航天动力研究所科技处副处长][1211]
- Standing Committee [常务] Deputy Director: Hong Liu [洪流]
    - Engaged in the development of Long March rocket engines[1212]
- A list of 2023 Academic Committee members is also available.

**Notable Collaborations:**

*Domestic*

- In 2023, this lab discussed deepening cooperation with the School of Astronautics at Northwestern Polytechnical University.[1213]
- In 2023, this lab co-organized the 18th Annual China Electric Propulsion Symposium [第十八届中国电推进学术年会], along with Chinese Society of Astronautics Electric Propulsion Committee [中国宇航学会电推进专业委员会], CASC 11th RI, Shaanxi Key Laboratory of Plasma Physics and Application Technology [陕西省等离子体物理与应用技术重点], and the China-Belarus Aerospace Hi-Tech Industrial Research and Development Center Co. [中白航天高新技术产业研发中心有限公司]. The conference theme is space electric propulsion technology innovation, development, and in-orbit applications.[1214]
- In 2023, this lab co-organized the Liquid Power 3D Printing Design Competition [3D打印设计大赛决赛], along with the CASC 11th RI, SASTIND Technology Innovation Center for Additive Manufacturing of Aerospace Special Components [国防科技工业航天特种构件增材制造技术创新中心], Xi'an Platinum Power Additive Technology Co. [西安铂力特增材技术股份有限公司], and the Additive Manufacturing Innovation Center [国家增材制造创新中心]. This was part of a larger forum on aerospace manufacturing which featured talks from two members of the Australian Academy of Technological Sciences and Engineering [澳大利亚技术科学与工程院] on both aerospace design and manufacturing and metal 3D printing.[1215]

*International*

- In 2018, this lab established the China-Italy Joint Laboratory of Liquid Rocket Engine Simulation Technology [中意液体火箭发动机仿真技术联合实验室] with the Sapienza University of Rome.[1216]
- In 2019, this lab co-organized the 2019 International Workshop on Space Propulsion Technology [2019年空间推进技术国际研讨会], along with Northwestern Polytechnical University's Defense S&T Key Laboratory of Solid Rocket Engine Combustion, Thermal Structure, and Inner Flow Field [燃烧、热结构与内流场重点实验室], the Xi'an National Civil Aerospace Industrial Base [西安国家民用航天产业基地], and Germany's Technical University of Munich Institute of Space Propulsion. The workshop featured participation from the U.S., Germany, France, Sweden, and Russia. Research topics included combustion, flow and numerical calculations in power devices, and liquid engine technology.[1217]

**Lab Equipment:**

None found

**Address**:

Co-located with the 11th RI at No. 289 Feitian Road, Aerospace Base, Xi'an, Shaanxi Province [陕西省西安市航天基地飞天路289号][1218]

**Known Aliases:**

- 液体火箭发动机技术国防重点实验室
- 液体火箭发动机技术国家级重点实验室
- 液体火箭发动机技术国家重点实验室
- 液体火箭发动机技术重点实验室

## 52. Defense S&T Key Laboratory of Low Interception Probability Signal Detection

**Official English Name:** Unknown

**Chinese Name:** 低截获概率信号侦测国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Likely Multi-Domain

Equipment:

- Possibly Electronic Warfare

Functional Field:

- Communications Technologies
- *Secondary: Cyber Technologies*

**Affiliations:**

- PLA Strategic Support Force[lxxxi]
  - PLASSF 57th Research Institute [战略支援部第五十七研究所]
    - *Former General Staff Department 57th Research Institute [总参谋部第五十七研究所]*

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

Based on the few public snippets of information, this Lab probably conducts research into communications and information systems, and possibly electronic warfare.

[lxxxi] As of April 2024, the PLA Strategic Support Force has been replaced by three new arms. This lab may thus be subordinate to the new Information Support Force.

The PLA 57th Research Institute was formerly subordinate to the General Staff Department before being transferred to the Strategic Support Force following the 2016 reforms.[1219] Also known as the "Electronics Institute" [电子所], it is allegedly the PLA's largest electronics research institute.[1220] It conducts research into communications, information systems, and electromagnetic and microwave technology.[1221]

**Further Information:**

- Academician Yang Xiaoniu is on the Lab's Academic Committee. Yang is an expert on communications signal processing, broadband digital receivers, and integrated electronic information control systems. He is also affiliated with the Defense S&T Key Lab of Communications Countermeasures Technology.[1222]
- Chen Jing, a CAE Academician, was also previously an Academic Committee Member. Chen is an expert in communications and information systems and space target monitoring. He once participated in a project involving a foreign satellite-borne synthetic aperture radar data signal reception and processing system.[1223]

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- "Ultra-wideband weak signal communication with time-hopping spread spectrum signal design" [超宽带弱信号通信与跳时扩频信号设计][1224]

**Notable Applications:**

None found

**Leadership and Key Personnel:**

No leadership found

*Key Personnel*

- Yang Xiaoniu [杨小牛]
  - Academic Committee Member[1225]
- Chen Jing [陈鲸]
  - Former Academic Committee Member[1226]
- Wang Xiaoning [汪晓宁]
  - Possible researcher, or possibly just a frequent collaborator[1227]

**Notable Collaborations:**

*Domestic*

- The Lab may also have a close relationship with Southwest Jiaotong University, although there is no evidence they are officially affiliated.[1228]

**Lab Equipment:**

None found

**Address**:

- Chengdu, Sichuan Province [四川省成都市][1229]

**Known Aliases:**

None found

## 53. Defense S&T Key Laboratory of Marine Corrosion and Protection

**Official English Name:** Key Laboratory of Marine Corrosion and Protection of Defense Science and Technology

**Chinese Name:** 海洋腐蚀与防护国防科技重点实验室

**Post-2024 Name**: National Key Laboratory of Marine Corrosion and Protection[lxxxii] [海洋腐蚀与防护全国重点实验室][1230]

**Research Focus:**

Domain:

- Maritime

Equipment:

- Surface Vessels

Functional Field:

- Materials
- *Secondary: Ship Design*

**Affiliations:**

- China State Shipbuilding Corporation (CSSC) [中国船舶集团]
    - Luoyang Ship Material Research Institute (LSMRI) [洛阳船舶材料研究所]
        - *a.k.a. CSSC 725th Research Institute (Qingdao Branch) [725 研究所]*
        - *a.k.a. (Qingdao) Sunrui Company [(青岛)双瑞公司]*

**Key Data:**

- Established: 1997
- Total Funding: Unknown
- Personnel: Unknown[1231]
- Official start of operations: 2004
- Floor Space: approx. 3,400 sqm

**Lab Overview:**

This lab researches corrosion and corrosion defense for maritime-environment materials. It is CSSC's primary institution for corrosion and protection testing.[1232]

[lxxxii] Literal translation, no official name given

This lab's parent institution, the CSSC Luoyang Ship Material Research Institute (LSMRI) specializes in ship materials and technology [舰船材料与工艺及] and has made important contributions to the development of naval weapons and equipment.[1233] It is on the U.S. Commerce Department Entity List for export control.[1234]

Under the ongoing reorganization of the PRC's national key lab system, this lab may now be known as the National Key Lab of Marine Corrosion and Protection [海洋腐蚀与防护全国重点实验室].

**Further Information:**

- The lab has several subordinate labs:[1235]
  - *Marine Environment Simulation and Accelerated Corrosion Lab* [海洋环境模拟与加速腐蚀实验室]
  - *Coating Layer Performance Testing Lab* [涂覆层性能检测实验室]
  - *Biomaterials Technology Lab* [生物材料技术实验室]
  - *Public Basic Lab* [公共基础实验室]
  - *Corrosion Electrochemical Performance Testing Office* [腐蚀电化学性能测试室]
- The lab's original location (co-located with the 725th RI) was 3,200 square meters, but by 2015 it had moved into a new harbor laboratory [海港实验室] with a total area of 3,400 square meters. There is a Xijiang Science and Technology Exchange Center [西姜科技交流中心] at this location, which may be a possible alternate name for the lab.[1236]
- The lab is also a China Shipbuilding Industry Corrosion and Protection Testing Station [中国船舶工业腐蚀与防护检测站] and China Classification Society Marine Material Verification Test Center Corrosion and Protection Inspection Station.[1237]
- The lab has an East Sea Experimental Unit [东海试验单元] located at the CSSC 725th RI Inspection and Calibration Center [检验与校准中心] in Xiamen, also known as the CSSC Xiamen Inspection Station for Ship Coatings [涂料厦门检测站] or the Coatings Inspection Station of Ship Material Validation and Testing Center [船舶材料验证试验中心涂料检验站]. It also has a network of test stations in Qingdao, Sanya, and the "deep sea" [深海].[1238]

**Research Direction:**

1. Corrosion of materials in marine environments and modern corrosion test methods [材料在海洋环境中的腐蚀和现代腐蚀试验方法研究]
2. New electrochemical anti-corrosion and anti-fouling technologies [电化学防腐防污新技术研究]
3. Coating layer protection mechanisms and technology [涂覆层防护机理及技术研究]

4. Biological anti-corrosion and anti-fouling technology [生物防腐防污技术以及腐蚀控制工程基础研究]
5. Fundamentals of corrosion control engineering [腐蚀控制工程基础][1239]

**Notable Applications:**

- This lab has developed marine anti-corrosive technologies for both surface vessels as well as various other materials in a marine environment, including shipboard ballast water treatment equipment, shipboard sewage treatment equipment, shipboard exhaust gas treatment equipment, marine concrete structures, and seawater desalinization plants.[1240]
- The lab conducts research on ship, port, marine platform, nuclear power plant, and bridge and tunnel facilities, including on cathodic protection technology, electrolytic antifouling technology, anticorrosion and antifouling coating technology, comprehensive and integrated anticorrosion technology, corrosion protection state monitoring and detection technology, special functional coating technology, and corrosion-resistant material technology.[1241]

**Leadership and Key Personnel:**

- Director: Xu Likun [许立坤][1242]
- Deputy Director: Sun Mingxian [孙明先][1243]

**Notable Collaborations:**

*Domestic*

- This lab has taken part in research collaboration with various PLA units and institutions on corrosion and anti-fouling, including PLASSF Unit 63796, PLAN Unit 91922, PLAN Luoyang 407 Factory Military Representative Office, and the PLAN Equipment Department.[1244]
- The lab claims to have established a wide range of domestic and international academic exchanges and cooperation platforms, including with Tsinghua University, Tianjin University, Harbin Engineering University, Ocean University of China, the Chinese Academy of Sciences Institute of Oceanography, and other more than 20 domestic universities and research institutes, to carry out joint training of master and doctoral degree students as well as scientific research projects.[1245]
- In 2023, this lab co-hosted, along with the CSSC 725th RI, a meeting of the International Organization for Ship Standardization and Offshore Technical Committee (ISO/TC8) Working Group on Intelligent Shipping (WG10) and Workshop on International Standards for Intelligent Shipping. It was attended by delegates from the U.S., Italy, Norway, Japan, South Korea, and others. Topics included an international standardization roadmap for

intelligent shipping, the implementation process and results of the MEGURI 2040 Autonomous Ship Program of the Japanese industry, the implementation process of the KASS Autonomous Ship Program of the South Korean industry, greenhouse gas emissions reduction in shipping, air pollution prevention and emergency response, and autonomous ships. Likewise, this lab played a leading role in international standard-setting for corrosion of metals and alloys in simulated deep-sea environments.[1246]

- In 2024, this lab co-organized the 22nd International Corrosion Congress [第 22 届世界腐蚀大会]. Other organizers included the Harbin Institute of Technology, Harbin Engineering University, Beihang University, and multiple other universities, companies, and CAS institutes. Topics of interest included corrosion and protection of oil and gas, atmospheric corrosion, intelligenct corrosion control, various coatings, nuclear corrosion, marine corrosion, high-temperature materials and coatings, and numerous other topics. Foreign institutions came from the U.S. (Ohio University, Association for Materials Protection and Performance), U.K. (British Corrosion Society), Australia (RMIT University, University of New South Wales, Corrosion Society of Aurstalia), Germany (BASF Coatings GmbH, Helmholtz-Zentrum Hereon, Geesthacht, German Society of Corrosion Protection), Netherlands (Delft University of Technology), Italy (Polytechnic University of Turin, Ricerca sul Sistema Energetico), Belgium (Vrije Universiteit Brussel), Denmark (Technical University of Denmark), Czechia (Prague University of Chemical Technology), Portugal (University of Coimbra), Slovenia (Jožef Stefan Institute), Korea (Korea University, Corrosion Science Society of Korea), and India (IIT Bombay), among others. The announcement also lists a high number of individual names.[1247]
- The lab claims to have academic exchanges with unnamed corrosion research institutions in the United Kingdom, the United States, Australia, Russia, and other countries.[1248]

**Lab Equipment:**

- The lab has China's only actual-sea/seawater environmental testing web system [实海环境试验网站体系], with stations in Qingdao, Xiamen (Fujian Province), Sanya (Hainan Province), the "deep sea" (possibly the South China Sea), and possibly elsewhere.[1249]

The lab has internationally-advanced corrosion test equipment and (large-scale) analysis and testing instruments, including:

- Salt spray test chamber
- Dynamic water simulation test device
- Stress corrosion testing machine
- Environmental scanning electron microscope (ESEM)
- Scanning probe microscope (SPU)
- X-ray diffractometer
- Laser Raman spectrometer
- Scanning Kelvin probe and corrosion electrochemical measurement systems[1250]

**Address**:

No. 8-5, Laoshan Road, Laoshan District, Qingdao, Shandong Province [山东省青岛市崂山区崂山路 8-5 号][1251]

**Known Aliases:**

- Corrosion and Protection Testing Institution [腐蚀与防护检测机构]
- Marine Material Testing and Verification Center [船舶材料检测与验证中心]
- Navy Ship Material Testing Center [海军舰船材料检测中心]
- Xijiang Science and Technology Exchange Center [西姜科技交流中心]
- Key Laboratory of Marine Corrosion and Protection [海洋腐蚀与防护重点实验室]
- State Key Laboratory for Marine Corrosion and Protection [海洋腐蚀与防护国家重点实验室]
- Defense Key Laboratory of Marine Corrosion and Protection Technology [海洋腐蚀与防护技术国防重点实验室]
- Key Laboratory of Marine Corrosion and Protection [海洋腐蚀与防护国防重点实验室]
- State S&T Key Laboratory of Marine Corrosion and Protection [海洋腐蚀与防护国家科技重点实验室]
- National Key Laboratory of Marine Corrosion and Protection [海洋腐蚀与防护国家级重点实验室]

## 54. Defense S&T Key Laboratory of Materials Technology in Impact Environments

**Official English Name:** National Key Laboratory of Science and Technology on Materials under Shock and Impact[1252]

**Chinese Name:** 冲击环境材料技术国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Multi-Domain (Air, Ground, Maritime)

Equipment:

- Munitions
- *Secondary: Armor, Non-ballistic Missiles*

Functional Field:

- Materials
- *Secondary: Blast, Impact & Damage, Laster Technologies, Simulation & Modeling*

**Affiliations:**

- Beijing Institute of Technology (BIT) [北京理工大学]
- (possibly) China Ordnance Industries Group Corporation (Norinco) [中国兵器工业集团]
    - Inner Mongolia Institute of Metal Materials [内蒙古金属材料研究所]
        - *a.k.a. Norinco 52nd Research Institute [第五二研究所])*

**Key Data:**

- Established: Unknown
- Total Funding: over 80m RMB
- Personnel: over 40[1253]
- Official start of operations: 2011
- Floor Space: over 5,000 sqm

**Lab Overview:**

This lab conducts research into new materials, with a focus on material damage and protection. Much of its work is on high-density, ultra high-strength and ductile high-entropy alloys, including nanostructures. Among its primary tasks are developing key structures and materials for

warheads and protective materials for military use, as well as materials for armor-piercing ammunition, high-explosive anti-tank munitions, missiles, armor, and laser weapons.[1254]

The lab is overseen by the Beijing Institute of Technology, and possibly Norinco's Inner Mongolia Institute of Metal Materials (a.k.a. the Norinco 52nd Research Institute) as well. The 52nd RI is engaged in research of metal materials and process technology, including metal matrix composites and ceramic composites.[1255] While Norinco has a national key lab of the same name that is probably the same lab, no direct evidence connecting the two was found. BIT's other two Defense S&T Key Labs both have partnerships with Norinco entities.

**Further Information:**

- This lab has five subordinate research labs:
  - *Protective Materials and Composite Structures Lab* [防护材料与复合结构研究室]
  - *Destructive Materials and Munitions Mating Lab*[lxxxiii] [毁伤材料及弹药匹配研究室]
  - *Simulation and Material Design Lab* [模拟仿真与材料设计研究室]
  - *Materials Testing and Characterization Lab* [材料测试与表征研究室]
  - *Operational Effectiveness Evaluation and Special Protection Lab* [使用效能评估与特种防护研究室][1256]
- The lab has a subordinate "National Defense S&T Innovation Team of Material Damage and Protection" [毁伤与防护材料国防科技创新团队]. This appears to be a major source of the lab's research output. This team is designing new materials for warheads.[1257]
- The lab hosts a National Materials Corrosion and Protection Data Center [国家材料腐蚀与防护科学数据中心].[1258]

**Research Direction:**

No formal research direction was found, but the lab's five subordinate research labs give a good idea of the likely research direction:

1. Protective Materials and Composite Structures [防护材料与复合结构]
2. Destructive Materials and Munitions Mating/Compatibility [毁伤材料及弹药匹配]
3. Simulation and Material Design [模拟仿真与材料设计]
4. Materials Testing and Characterization [材料测试与表征]
5. Operational Effectiveness Evaluation and Special Protection [使用效能评估与特种防护][1259]

[lxxxiii] Alternative translation: Destructive Materials and Munitions Compatibility Lab

A list of lab topics of research for 2020 included four categories:

1. Genomic and Big Data Technologies in the Field of Destructive and Protective Materials [毁伤与防护材料领域基因组与大数据相关技术]
2. New Multifunctional Destructive or Protective Materials Technology [新型多功能毁伤或防护材料技术]
3. Integrated Design Technology of Materials and Structures in the Field of High-Performance Destruction or Protection [高性能毁伤或防护领域的材料与结构一体化设计技术]
4. Material High Strain Rate Response Testing and Characterization or Simulation Technology [材料高应变率响应测试表征或模拟仿真技术][1260]

**Notable Applications:**

- The National Defense S&T Innovation Team of Material Damage and Protection [毁伤与防护材料国防科技创新团队] under this lab develops armor-piercing materials, new multi-functional special destructive metamaterials [新型多功能特种毁伤元材料] and lightweight protective armor materials (a possible reference to the Type-15 light tank, which BIT was involved in designing).[1261]
- This lab conducts research into new alloys and high entropy alloys for advanced weapons systems. A research team under this lab has utilized this research for new aerospace, weaponry, and shipbuilding mandated by national strategic requirements.[1262]
- The lab has designed a nanostructure with a new strengthening mechanism that increases the strength of the alloy while maintaining ductility. The multi-alloy has stronger corrosion and oxidation resistance, making it an ideal material for protective coatings.[1263]
- This lab developed a new titanium alloy material and its shaped parts, which is "urgently needed" to develop an unidentified new piece of equipment.[1264]

**Leadership and Key Personnel:**

- Director: Li Shukui [李树奎][1265]
- Academic Committee Director: Cai Hongnian [才鸿年][1266]
    - CAE Academician
- Deputy Director: Cheng Xingwang [程兴旺][1267]

*Key Personnel:*

- Xue Yunfei [薛云飞][1268]
    - Was a visiting scholar at University of Michigan in the U.S.
    - Xue's team has been involved in creating new alloys for aerospace, weaponry, and shipbuilding

- Wang Fuchi [王富耻][1269]
    - Former Director
    - Serves as head of the National Defense S&T Innovation Team of Material Damage and Protection

**Notable Collaborations:**

*Domestic*

- This lab is affiliated with the Norinco Yantai Research Institute (Norinco 52nd RI Yantai Branch), which is itself affiliated with the Shandong Province Metal Powder Materials and Application Engineering Technology Center [山东省金属粉体材料及应用工程技术中心] and the China and Russia New Materials Cooperation Research Center [山东省中俄新材料合作研究中心]. It specializes in vehicle armor protection, special ceramic materials, refractory metal materials, powder materials, and functional materials.[1270]
- BIT and CASC signed a joint cooperation agreement in 2020 to deepen cooperation in a variety of areas, including AI, big data, software engineering, sensing, and communications networks. CASC representatives visited this lab prior to the signing, implying it may be involved in this cooperation.[1271]
- This lab signed an agreement with Xiamen Tungsten Industry Co. [厦门钨业股份有限公司] in 2018 to produce a new titanium alloy for military use.[1272]

*International*

- In 2012, a professor from the University of Michigan Additive Manufacturing Process Laboratory visited this lab and conducted discussions on furthering cooperation between the two labs.[1273]
- This lab was a key organizer of the 2014 International Fall Conference on Experimental Mechanics and International Symposium on Strong Dynamic Loads and Their Effects [2014 年国际实验力学秋季会议暨国际强动载及其效应研讨会] in Beijing. The conference featured participants from 15 countries, including the U.S., Japan, Australia, Germany, France, Korea, etc. American speakers came from Purdue University, University of Rhode Island, NC State University, and Case Western Reserve University.[1274]
- This lab also co-organized the 2018 International Symposium on Advanced Materials Research [2018 年先进材料研究国际研讨会], which featured scholars from multiple countries. U.S. scholars came from Princeton, Purdue, Northeastern, Utah University, and Akron University. Interestingly, a list of topics of interest for this conference listed "military-use materials," but a similar list of topics on the more prominent front page of the announcement does not include this.[1275]
- In 2018, this lab and others at BIT invited a professor from the University of California-San Diego to come speak.[1276]

- At an unidentified date, a Professor from the German Ludwig Maximilians-Munchen University who was a member of the research team behind the world's first attosecond laser visited this lab. He also discussed long-term cooperation, including establishing a joint surface engineering lab between BIT and his university.[1277]
- The lab was visited by a Professor of the French National Glass and Ceramics Lab, who lectured on the topic of infrared and thermal (night vision) imaging technologies and new materials.[1278]
- The lab frequently encourages its researchers to go abroad for further study.[1279]

**Lab Equipment:**

The lab has over 100 major pieces of equipment worth over 100m RMB, including:

- Complete range of metal material preparation equipment
- Testing equipment:
    - Thermal expansion meter
    - Gleeble thermal simulation tester
    - Hopkinson compression bar
    - Elastic modulus tester
    - Universal tester
    - Micro hardness tester, etc.
- Characterization instruments
    - Advanced simulation platforms such as OM, SEM, EBSD, TEM, XRD, Thermo-Calc, DICTRA, Micress, Ansys, LS-DYNA, etc.[1280]

**Address**:

No. 5 Zhongguancun S. Street, Haidian District, Beijing [北京市海淀区中关村南大街 5 号][1281]

**Known Aliases:**

- Key Laboratory of Armor Protection [装甲防护重点实验室]
- National Key Laboratory of Science and Technology on Materials in Impact Environment [冲击环境材料技术国家级重点实验室]
- Science and Technology on Materials in Impact Environment Laboratory
- 冲击环境材料技术重点实验室
- 冲击环境材料技术国防重点实验室
- 毁伤与防护国防科技重点实验室
    - Listed as such in the "official" list of Defense S&T Key Labs, but actually a subordinate team of this name

## 55. Defense S&T Key Laboratory of Metrology and Calibration Technology

**Official English Name:** Unknown

**Chinese Name:** 计量与校准技术国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Multi-domain (Air, Space, Nuclear, likely others)

Equipment:

- Multiple (Aviation, Space Vehicles, Nuclear Weaponry & Power)

Functional Field:

- Measurement Technologies
- *Secondary: GNC, Nuclear Technologies*

**Affiliations:**

- China Aerospace Science and Industry Corporation (CASIC) [中国航天科工集团]
  - Beijing Institute of Radio Metrology and Measurement (BIRM [北京无线电计量测试技术研究所]
    - *a.k.a. CASIC 2nd Academy 203rd Research Institute) [二院 203 研究所]*
- Aviation Industry Corporation of China (AVIC) [中国航空工业集团]
  - Changcheng Institute of Metrology & Measurement (CIMM) [北京长城计量测试技术研究所]
    - *a.k.a. AVIC 304th RI [304 研究所]*
    - *a.k.a. AVIC Metrology Institute [航空工业计量所]*
    - *a.k.a. National Defense Science and Technology Industry 1st Metrology and Testing Research Center [国防科技工业第一计量测试研究中心]*
- China National Nuclear Corporation (CNNC) [中国核工业集团有限公司]
  - China Institute of Atomic Energy (CIAE) [中国原子能科学研究院]

**Key Data:**

- Established: 2003
- Total Funding: Unknown
- Personnel: Unknown[1282]
- Official start of operations: 2011
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research into precision measurement technology, including atomic frequency standards, calibration, and time synchronization, for both aerospace and nuclear research applications.

CASIC's Beijing Institute of Radio Metrology and Measurement (BIRM) (a.k.a. the CASIC 203rd Research Institute) is responsible for the lab's day-to-day work. However, the lab is composed of three research offices under three different organizations: a Radio Time (and) Frequency Office [无线电时间频率分室] under BIRM, a Long Thermal Office [长热力分室] under the Changcheng Institute of Metrology & Measurement (CIMM) (a.k.a. the AVIC 304th Research Institute), and an Ionizing Radiation Office [电离辐射分室] under the China Institute of Atomic Energy (CIAE), a research institution under the China National Nuclear Corporation.[1283]

The Beijing Institute of Radio Metrology and Measurement conducts research into measurement and test technology, traceability, measurement calibration technology, frequency control technology, automatic testing technology, and comprehensive support technology.[1284] It is on the U.S. Commerce Department Entity List for export control.[1285] The Changcheng Institute of Metrology & Measurement is an aviation research institute that integrates measurement technology research and industry management.[1286] The China Institute of Atomic Energy focuses on nuclear research.[1287]

**Further Information:**

- The lab's CIAE Ionizing Radiation Office is referred to as the Metrology and Testing Department [计量测试部], the Ionizing Radiation Level One Metering Station for National Defense Science & Technology Industry [国防科技工业电离辐射一级计量站], and the Nuclear Industry Radioactivity Measurement and Testing Center [核工业放射性计量测试中心]. It has around 48 personnel and multiple defense/military certifications. It is responsible for researching and establishing the highest-standard ionizing radiation measurement instruments and calibration devices [电离辐射最高计量标准器具和校准装置] required by the defense industry, and undertaking value transfer and value traceability work for the ionizing radiation field.[1288]

**Research Direction:**

1. Atomic frequency standards [原子频标]
2. Remote calibration and time synchronization technology [远程校准和时间同步技术]
3. Continuous wave medium- and high-power and pulsed high-power measurement and calibration technology [连续波中大功率和脉冲大功率测量与校准技术][1289]

*Other notable research areas:*

The lab's Ionizing Radiation Office's research includes:

- Ionizing radiation measurement and measurement methods
- Establishment of measurement standards devices and improvement and enhancement of technical capabilities
- Expansion of the types of reference materials
- Improvement of measurement value transmission methods
- Improvement of value traceability systems
- Improvement of ionizing radiation measurement technology
- Radioactivity, radiation dosage and neutron metrology[1290]

**Notable Applications:**

- The lab's research on satellite-based high-precision and high-reliability atomic frequency standards technology and nanosecond-level time synchronization have been applied to the Beidou satellite navigation system, the development of China's atomic frequency standards, remote calibration and time synchronization technology, and continuous wave medium and high power/pulsed high power measurement and calibration technology.[1291]
- The lab's Ionizing Radiation Office has established 19 highest-standard measurement devices, of which five are for national defense. These devices meet the needs for development and testing of strategic weapons, nuclear materials and radioisotope production, power reactor and nuclear power plant operation, nuclear fuel cycle and spent fuel reprocessing, nuclear facility decommissioning and radioactive waste management, nuclear technology applications, nuclear accident response and anti-nuclear terrorism, and other areas.[1292]

**Leadership and Key Personnel:**

- Deputy Directors: Yang Renfu [杨仁福]; Zhang Shengkang [张升康]; Zhang Li [张力][1293]
    - Yang Renfu has been a visiting scholar at UC Berkeley in the U.S. and Dresden Institute of Technology in Germany
- Ionizing Radiation Office Director: Liu Yuntao [刘蕴韬][1294]
- Ionizing Radiation Office Deputy Director: Cai Yueli [蔡跃鹂][1295]

**Notable Collaborations:**

*Domestic*

- This lab has co-hosted the National Defense Metrology and Testing Academic Exchange Conference [国防计量与测试学术交流会] series, at least for the 2010, 2015, 2016, 2018,

and 2020 iterations. The conference is guided by the SASTIND Science & Technology and Quality Department [科技与质量司], with the National Defense Science and Technology Industry Second Metrology and Testing Research Center [国防科技工业第二计量测试研究中心], International Union of Radio Science (URSI) China National Committee on Electromagnetic Metrology Specialized Committee [URSI 中国国家委员会电磁计量专业委员会], and Chinese Society of Astronautics Metrology and Testing Specialized Committee [中国宇航学会计量与测试专业委员会] also co-hosting. Participants came from defense industries such as nuclear, aviation, aerospace, shipbuilding, weapons, electronics, etc., and the PLA.[1296]

*International*

- German company Rohde & Schwarz participated in at least one iteration of the above-mentioned National Defense Metrology and Testing Academic Exchange Conference, in 2016.[1297]
- The lab's Ionizing Radiation Office is an observer party of the International Committee for Weights and Measures' (ICWM) Consultative Committee for Ionizing Radiation (CCRI) (Neutron Branch) [国际电离辐射咨询委员会（中子分会）观察员单位] and an International Atomic Energy Agency (IAEA) Secondary Standard Dosimetry Laboratory (SSDL).[1298]

**Lab Equipment:**

No Information

**Address**:

None found, possibly co-located with BIRM at No. 50 Yongding Road, Haidian District, Beijing [北京海淀区永定路 50 号][1299]

**Website**:

The Ionizing Radiation Office has websites at http://www.ciae.ac.cn/subpage/danwei_7.htm and http://www.ciae.ac.cn/subpage/shiyanshi_6.htm

**Known Aliases:**

- National Key Laboratory of Metrology and Calibration Technology [计量与校准技术国家级重点实验室]

- National Metrology and Calibration Technology Key Laboratory [国家级计量校准技术重点实验室]
- Stake Key Laboratory of Metrology and Calibration Technology [计量与校准技术国家重点实验室]
- Science and Technology on Metrology and Calibration Laboratory [计量与校准技术重点实验室]
- Key Laboratory of Science and Technology on Metrology ＆ Calibration
- 计量校准技术国防科技重点实验室
    - Missing the character 与

## 56. Defense S&T Key Laboratory of Microsystem Technology

**Official English Name:** Key Laboratory of Science and Technology on Micro-System[1300]

**Chinese Name:** 微系统技术国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Multi-Domain (Air, Ground, Likely Others)

Equipment:

- Multiple (Command & Control Systems, Communications Equipment)

Functional Field:

- Microelectronics
- *Secondary: Communications Technologies, Intelligent Technologies, Optoelectronics, Sensing, Target Detection/Recognition*

**Affiliations:**

- Chinese Academy of Sciences [中国科学院]
  - Shanghai Institute of Microsystem and Information Technology (SIMIT) [上海微系统研究所]

**Key Data:**

- Established: 2004[1301]
- Total Funding: Unknown
- Personnel: 108, 54 grad students (2016)[1302]
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab was first proposed around 1999, following a belief among prominent PRC researchers that microelectromechanical systems (MEMS) were increasingly trending toward integrated systems, including integration of sensors, processing units, and actuators, and the PRC needed a lab to encourage development in this direction.[1303] Accordingly, this lab was established in 2004 as the first key lab dedicated to microsystems.[1304] It is focused on research of microelectronics and solid state electronics for a wide range of applications, including

communications and information systems, AI/ML, neural networks, target detection, identification, and tracking, and wireless sensor networks.[1305]

The lab's parent institution, the Shanghai Institute of Microsystem and Information Technology (SIMIT) of the Chinese Academy of Sciences, was established in 1928 and was historically involved in developing key uranium enrichment components needed for the PRC's nuclear program. Today, it researches high-end microelectronics, including for wireless sensor networks, mobile communications technology, integrated circuits, and quantum computing.[1306]

While it is a national-level lab,[1307] the lab's exact status as a Defense S&T Key Lab is not entirely clear. It is not commonly referred to as such, but has been occasionally referred to as a DSTKL, most notably by SIMIT itself when it was being established.[1308] More recently, its research fund used its DSTKL moniker in 2023.[1309] Other sources referring to it as a DSTKL include a 2015 research paper[1310] and a 2022 article about one of its early founders.[1311] Nevertheless, these instances are rare, making this lab a prime example of an "ambiguous" lab whose public status is obfuscated and unclear. If it is a DSTKL, this would make it unusual, as most national-level CAS labs fall under the civilian National Key Lab system.

**Further Information:**

- The lab has branches in Jiading [嘉定] and Caohejing [漕河泾].[1312]
- The lab has a Fuzhou Sub-center [微系统技术重点实验室福州分中心], established around 2018 and also known as the Fuzhou Internet of Things Open Laboratory [福州物联网开放实验室]. It may also be known as the Fujian Province Key Laboratory of Intelligent Networked Commercial Vehicles (Information Science) [福建省智能网联商用车（信息科学）重点实验室]. It has an EMC darkroom, OTA darkroom, reliability laboratory, safety laboratory, and other major test systems.[1313]

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- Microelectromechanical systems (MEMS)[1314]
    - Research and applications include miniaturized wireless sensor networks, collaborative detection, identification and lightweighting algorithm system of mixed targets, miniaturization, low-power technology, large-scale random deployment networking and heterogeneous system fusion, wearable information terminals, next-generation wireless sensor networks.[1315]
- Based on recent publications, other research areas are varied and include: communications network algorithms, AI/ML, neural networks, target detecting, identification, tracking, UAV communications, and surveillance sensors.[1316]

In 2021, the lab is funding the following projects:[1317] [lxxxiv]

1. Unattended Nodal Integration Microenergy Technology
2. Technical specifications of AI-based multi-spectral intelligent micro-optoelectronic system
3. Research on UHF Micromechanical Antenna and Its Application in Wireless Sensor Networks

**Notable Applications:**

- This lab developed a wireless mobile C3 system which utilizes video, image, voice, positioning, messaging and other real-time information processing capabilities, providing horizontal connectivity with existing digital shortwave, satellite communications, and voice intercom systems. While the source describes it as being used by the PAP for firefighting, it is a military system used to enable joint operations.[1318]
- A lab team led by Liu Zhengxin [刘正新] worked with a team from the University of Electronic Science and Technology of China to create a solar cell with an efficiency of almost 29%.[1319] [lxxxv]
- Equipment developed by the lab has been used for security at the G20 Hangzhou Summit, Belt and Road Summit Forum, and BRICS Summit.[1320]

**Leadership and Key Personnel:**

- Director: Li Baoqing [李宝清][1321]
- Deputy Director: Yuan Xiaobing [袁晓兵][1322]
- Deputy Director: Li Tie [李铁]
    - Researches micro- and nano-sensors, including silicon nanowire fabrication and devices, infrared thermopile, infrared gas modules[1323]
- Academic Committee Deputy Director: Luo Le [罗乐]
    - Studied and worked in Germany in 1990s
    - Has been affiliated with both this lab and the National Key Lab of Transducer Technology [传感技术国家重点联合实验室] since 2001[1324]

*Key Personnel:*

- Liu Zhenxin [刘正新]
    - Led a team that has reportedly made major advances in solar power (see "Notable Applications")[1325]

[lxxxiv] Further details on research targets and funding is available.
[lxxxv] Further information on technical details is available.

**Notable Collaborations:**

*Domestic*

- This lab appears to be closely affiliated with another national key lab under SIMIT, the State Key Laboratory of Transducer Technology [传感技术联合国家重点实验室]. Older (pre-2014) sources even list the two side by side, seemingly as a single entity.[1326] There is also strong overlap in personnel affiliated with both institutions.[1327] However, SIMIT currently lists them as separate institutions.[1328]
- The lab's parent company, CAS-SIMIT, launched a joint venture with Norinco in 2016 called Scifine [上海事凡物联网科技有限公司], focused on IoT applications. The company relies on research from this lab. Applications include composite integrated sensors, self-grouping network communications, and broadband self-grouping network communications for the military, public security, and emergency response.[1329]
- This lab has an ongoing relationship involving cooperation and exchange with the University of Science and Technology of China.[1330]
- This lab has carried out exchanges and cooperation with AVIC's Key Laboratory of Avionics Integrated Technology [航电综合技术重点实验室] on the topics of airborne multi-platform and multi-sensor data fusion technology, terahertz technology, and other areas.[1331]
- A lab team led by Liu Zhengxin [刘正新] worked with a team from the University of Electronic Science and Technology of China to create a solar cell with an efficiency of almost 29% (see "Notable Applications").[1332]
- This lab is a core member unit of the Shanghai Internet of Things Center [上海物联网中心].[1333]

*International*

- According to its collaboration page, Scifine (see above) collaborates with German company Nemak and TRW Automotive, a formerly U.S. company that is now owned by a German company.[1334]

**Lab Equipment:**

The lab is equipped with the following environmental adaptability test platforms:[1335]

- Temperature shock test chamber
  - Used for High temperature tests, low temperature tests, temperature cycling tests, environmental stress screening, temperature shock
  - Capacity: 125 liters
  - Temperature range: +50°C to +220°C (high temperature zone)
  - Temperature range: - 80°C to +70°C (low temperature zone)
- High and low temperature alternating humidity and heat box

    - Used for High-temperature tests, low-temperature tests, temperature cycle tests, high and low temperature heat and humidity tests
    - Space size：800mm×950mm×800mm
    - Temperature range: -72℃ to 180℃.
    - Humidity range：10-98%RH
- Package Drop Test Bench
    - Used for drop tests
    - Maximum test load: 200 kg
    - Height of drop test bench: 0-1200mm
    - Falling mode: free falling
    - Maximum size of package: 1200mm×1200mm×1200 mm
- Rain test box
    - Used for rainfall, drip, blowing rain tests
    - Space size: 1000mm×1000mm×1000mm
    - Wind source: Yes
    - Raindrop diameter: 0.5~4.5mm
    - Rainfall intensity: 100mm-150mm/h
- Electrodynamic vibration test system
    - Used for vibration, shock tests
    - Sine peak thrust: 9.8kN
    - Random RMS thrust: 9.81kN
    - Maximum acceleration: 75gn
    - Maximum velocity: 2m/s
    - Maximum displacement: 50.8mm
    - Moving coil mass: 12.05kg
    - Frequency range: DC-3,500Hz

**Address**:

Block A, Xinwei Building, No.1455, Pingcheng Road, Jiading District, Shanghai, 201899 [上海市嘉定区平城路 1455 号新微大厦][1336]

**Website**:

http://www.sim.cas.cn/kybm2016/wxcgwsyb2016/

**Known Aliases:**

- Key Laboratory of National Defense for Science and Technology on Microsystem

## 57. Defense S&T Key Laboratory of Military Solid-State Laser Technology

**Official English Name:** Key Laboratory of Solid-State Laser Technology[1337]

**Chinese Name:** 军用固体激光技术国防科技重点实验室

**Post-2024 Name**: No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Multi-Domain (Space, likely others*)*

Equipment:

- Multiple (Semiconductors, Space Vehicles, likely others)

Functional Field:

- Laser Technologies
- *Secondary: Optoelectronics*

**Affiliations:**

- China Electronics Technology Group Corporation (CETC) [中国电子科技集团]
  - North China Institute of Optoelectronics [华北光电技术研究所]
    - *a.k.a. CETC 11th Research Institute*

**Key Data:**

- Established: 1994
- Total Funding: Unknown
- Personnel: Unknown[1338]
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab, established in 1994, was the first national-level lab in the PRC dedicated to research of solid-state lasers. Officially, it is focused on solid-state laser materials, laser devices, and their applications. It supports CETC's laser technology development[1339] and has made undisclosed significant contributions to CETC's development of optoelectronic technology and equipment.[1340] Among other things, its research appears to be applied to development of semiconductors.[1341]

The lab's parent institution, the CETC North China Institute of Optoelectronics[lxxxvi] (a.k.a. the CETC 11th Research Institute), was founded in 1956 and is focused on R&D of electronic components and materials, particularly in laser and infrared materials, devices, and systems.[1342]

**Further Information:**

- As of 2019, the CETC 11th RI was building a large new base, called the CETC Electro-Optical Headquarters Base [中电科光电总部基地], in the Lingkong International Zone of Beijing's Zhongguancun Shunyi Park [中关村顺义园临空国际板块] to host this lab and the Defense S&T Key Lab of Infrared and Ultraviolet Technology [红外紫外技术国防科技重点实验室]. Per the initial report, it is set to cover 104 mu (approximately 17 acres) and cost 1.56 billion RMB. When completed, the base is expected to employ 500 people and have an annual output of over 3 billion RMB.[1343] A second article from less than a year later ups the size of the base to 200 mu (approximately 33 acres) costing 5.2 billion RMB, and annual production value of 6 billion RMB.[1344] As of 2023, this base appears to have been built and integrated into the area's 3rd-gen semiconductor industrial chain.[1345]
- The lab's 3rd academic committee was seated from 2006-2010; this indicates the first committee would have been established around 1996.[1346]

**Research Direction:**

1. Solid state laser materials [固体激光材料]
2. Laser devices [激光器件]
3. Laser application technology [激光应用技术][1347]

*Other Notable Research Areas:*

- Fiber lasers, hot-capacity lasers, slat lasers and thin-film lasers[1348]
- The lab also funds research on laser satellite communications[1349]

**Notable Applications:**

- The lab's research appears to be utilized in semiconductor development.[1350]

**Leadership and Key Personnel:**

- Director: Zhao Hong [赵鸿]
    - Previously served as Standing Committee Deputy Director (2019)[1351]

[lxxxvi] Translation of name is author's own.

**Notable Collaborations:**

*Domestic*

- In 2022, this lab signed an agreement with Haucore (a.k.a. Shandong Huaguang Electro-Optical Co. [山东华光光电子股份有限公司] to establish a branch in Jinan, called the National Key Laboratory of Solid-State Laser Technology Jinan Research Center [固体激光技术国家重点实验室济南研究中心]. The center will be based with Haucore. The center is tasked with solving "urgent" technical problems in laser development, including but not limited to lidar sensing, laser radar sensing, solid-state pumping sources, and high-energy laser chips. In the face of increasing foreign embargo, it will also focus on industrial manufacturing of chips, including faster and more efficient manufacturing. The two sides are set to spent at least 60 million RMB over three years and included at least 20 high-level technical personnel.[1352]

**Lab Equipment:**

None found

**Address**:

Beijing 100015 [北京市][1353]

**Known Aliases:**

- 军用固体激光技术国防重点实验室
- 国防固体激光技术重点实验室
- 固体激光技术国防科技重点实验室
    - The lab oftentimes removes the “Military” [军用] part of its name in public sources.
- 固体激光技术国家重点实验室
- 固体激光技术重点实验室

## 58. Defense S&T Key Laboratory of Military Underwater Intelligent Robotic Technology

**Official English Name:** Unknown

**Chinese Name:** 军用水下智能机器人技术国防科技重点实验室

**Post-2024 Name:** National Key Laboratory of Intelligent Marine Vehicle Technology[lxxxvii] [智能海洋航行器技术全国重点实验室][1354]

**Research Focus:**

Domain:

- Maritime

Equipment:

- Underwater Vehicles

Functional Field:

- Multiple (Acoustics, GNC, Intelligent Technologies, Robotics, Sensing, Target Detection/Recognition)

**Affiliations:**

- Harbin Engineering University (HEU) [哈尔滨工程大学]
    - College of Shipbuilding Engineering [船舶工程学院]

**Key Data:**

- Established: 2002
- Total Funding: 16.757m RMB
- Personnel: 50[1355]
- Official start of operations: 2009
- Floor Space: Unknown

**Lab Overview:**

The Defense S&T Key Laboratory of Military Underwater Intelligent Robotic Technology has its roots in the 103 Teaching and Research Office of the Harbin Engineering University Department of Naval Engineering Shipbuilding Section [海军工程系造船科 103 教研室].[1356] It was established by joint approval of COSTIND and the PLA General Armaments Department in November 2002 and officially began operations in 2009.[1357] Prior to this, HEU had been working

[lxxxvii] Literal translation, no official name given

on intelligent underwater robotics as early as 1989 following the 8th Five Year Plan, which elevated this field to a key project.[1358] Today, it conducts research into intelligent underwater robotics in line with the PRC's oceanic development strategy and naval equipment needs. It is heavily involved in research into unmanned and autonomous underwater robotic systems, swarm intelligence, and green technologies for both civilian and military use.

Notably, this Lab usually removes the "Military" part from its name in Chinese literature, and always in English literature, possibly to conceal military involvement. In English it is typically referred to as the National Key Laboratory of Science and Technology on Autonomous Underwater Vehicle.[1359] While the Lab heavily emphasizes the civilian uses for AUVs, it is heavily involved in military AUV development, and an article from 2006 written by researchers from this Lab describes the potential military uses for AUVs, including for intel acquisition, precision attack, and "asymetric intelligence acupunctural warfare" [非对称情报战].[1360] Further, HEU's AUV efforts have been linked to industrial espionage. In one case, a Chinese national purchased and re-exported items related to AUVs to HEU, including underwater acoustic locator devices, underwater cables and connectors, PC104 computer processing units, 907 multiplexers, underwater pressure sensors, and control sticks and button strips.[1361] In another case from 2018, two individuals were charged in the United States for attempting to steal trade secrets related to syntactic foam. Their company was closely tied to HEU and cooperating in construction of AUVs.[1362]

Under the ongoing reorganization of the PRC's national key lab system, this lab is now known as the National Key Lab of Intelligent Marine Vehicle Technology [智能海洋航行器技术全国重点实验室]. Its current research foci are advanced unmanned platforms, intelligent control, marine environment sensing, and intelligent swarm technology. In 2018 it established the first program in marine robotics, providing undergraduate and graduate degrees.[1363]

**Further Information:**

- A team from HEU won the 2018 and 2019 RoboSub AUV competitions in San Diego. The team is not officially connected to the lab in promotional material, but can be seen utilizing this lab's facilities to train their AUV in a promotional video.[1364]
- Lab Administrative Divisions include an S&T Division [科技处], Development Planning Division [发展计划处], Finance Division [财务处], Infrastructure Division [基建处], and a Lab and Property Management Division [实验室与资产管理处].[1365]
- The lab has office space, deep-water integrated experimental pools, horizontal circulation tanks and other fixed assets of nearly 200 million yuan.[1366]

**Research Direction:**

1. Systems Architecture and Intelligent Control Technology [体系结构与智能控制技术]

2. Acoustic and Non-acoustic Environmental and Target Sensing Technology [声与非声环境与目标感知技术]
3. Oceanic Environment Adaptation Technology [海洋环境适配技术][1367]

*Other Notable Research Areas:*

- Autonomous AUV and underwater robotics technology
- Intelligent Control of Underwater Robotics
- Environmental and Target Sensing
- Oceanic Environment Adaptation Technology
- Underwater Micro-robotics[1368]

The lab is interested in supporting research in the following areas in 2025:[1369]

1. Key basic technology research on non-uniform groove drag reduction film for underwater vehicles [水下航行器非均匀沟槽减阻薄膜关键基础技术研究]
   Key Project, up to 2 million RMB in funding, 2 years
   Aiming for range increase, acceleration and energy saving for underwater vehicles, drawing on the characteristics of non-uniform groove structure of marine organisms, which has better drag reduction ability, and considering the mechanisms of non-uniform groove surface on the boundary layer flow of underwater vehicles, this will research key basic technologies such as the design and optimization of non-uniform grooves of underwater vehicles, the preparation of large-area spectralized groove drag-reducing films, and the high-efficiency and replaceable adhesion of films with the surfaces of the vehicles, achieving advances in non-uniform grooves with drag reduction for underwater vehicles. It aims to realize the resistance prediction of underwater vehicles with non-uniform grooves, lay a theoretical foundation for the application of drag-reducing grooves on underwater vehicles, and explore methods of preparing and applying non-uniform groove films, so as to provide an effective means for the improvement of the overall function and optimization of the design of underwater vehicles.
   Assessment indicators:

   (1) At 4 knots, the total resistance of the underwater vehicle model (6 meters in length, 0.8 meters in diameter, and 4 meters in length of the parallel center body) will be reduced by not less than 20% after the non-uniform groove film is mounted on the model;

   (2) The formed non-uniform film design scheme has drag reduction effect in the speed of 1-6 knots, and the average drag reduction rate of the experimental model in index value 1 is not less than 8% in several speeds of 1, 2, 3, 5 and 6 knots.

   (3) The thickness of the non-uniform groove drag reduction film is not more than 2mm, with self-adhesion function.

   (4) For the attachment area of not less than 3 square meters of the hanging plate, durability test in seawater, seawater environment within 7 days without corrosion, swelling, degumming.

2. Intelligent underwater unmanned vehicle double mechanical arm precise cooperative control technology research [智能水下无人航行器双机械臂精确协同控制技术研究]
General project, up to 500,000 RMB in funding, 2 years
Aiming at the current problems of long arrival time and unstable control operations faced by intelligent underwater unmanned aerial vehicles, this will construct a model of autonomous operation unmanned underwater vehicles, and master the characteristics of high maneuverability and highly robust hydrodynamic performance. It will master scattering and absorption correction methods, construct a theoretical model of underwater image enhancement in multi-scale gradient domains, and realize accurate identification and calibration of underwater targets. It will carry out research on attitude robust control systems for dual mechanical arms of autonomous operational underwater vehicles, and complete the design of dual mechanical arm trajectory planning method under the weak disturbance conditions of hovering of autonomous operational underwater vehicles.
Assessment indicators:

(1) Underwater binocular vision localization accuracy ≤40mm, underwater binocular vision recognition rate ≥80%;

(2) The range of underwater operating space of dual robotic arms is not less than 350mm×250mm×250mm;

(3) Image enhancement algorithm can be applied to real-time video stream enhancement, and after enhancement underwater color image quality evaluation index (UCIQE) ≥ 0.5, underwater image quality evaluation index (UIQM) ≥ 1.0;

(4) The accuracy of tracking is ≤10cm when dual robotic arms operate the same object for trajectory tracking cooperatively;

(5) When the ratio of perturbation (water environment perturbation or robotic arm perturbation) to the weight of the navigator body is less than 0.1, the precision of the navigator's position control reaches 10cm and the precision of attitude control reaches 5° after 1s adjustment time.

3. Lightweight modularized ocean temperature difference energy power supply technology for deep-sea unmanned equipment [面向深海无人装备的轻质模块化海洋温差能供电技术]
General project, up to 500,000 RMB in funding, 2 years

Aiming at the current miniaturization technology of ocean temperature difference energy power supply devices for deep-sea equipment, this project will carry out the development of miniaturized, modularized and integrated temperature difference energy drive devices, establish physical models of the capture and conversion of ocean temperature difference energy drive devices, make breakthroughs in the design of the ocean temperature difference

energy drive device system, optimize the structure of heat exchanger devices and strengthen the matching technology of heat exchanger and power supply, improve temperature difference energy drive device modeling and hydrodynamic calculation, achieve breakthroughs in motion control technology of temperature difference energy drive devices, carry out research on power supply technology for lightweight and efficient temperature difference energy underwater equipment, and realize independent research and development, long endurance, and high self-sustainability of ocean temperature difference energy drive underwater unmanned equipment, to meet the requirements for the modularized design of the deep-sea equipment and long endurance power supply capability.

Assessment indicators:

(1) Propose a new type of temperature difference energy heat exchanger design scheme to realize phase change rate increase of more than 50%;

(2) Put forth a principle prototype of the proposed modularized lightweight temperature difference energy device, with a mass power density of no more than 500kg/kW;

(3) The proposed temperature difference energy device should dive to a pressure-resistant depth of not less than 500m.

4. Research on automatic control method of unmanned aerial vehicle berthing process [无人航行器靠泊母船过程自动控制方法研究]
General project, up to 500,000 RMB in funding, 2 years

Carry out research on automatic control methods for surface UAV berthing to mother ships, break through key technologies such as hydrodynamic interaction analysis between surface the UAV and its mother ship, time-optimized path planning and trajectory tracking of surface UAV berthing process, and complete graphical interface visualization and experimental verification of berthing maneuvering and control process, so as to improve the operation efficiency and safety of surface UAV berthing to mother ship, reduce the necessity of human intervention, and enhance the efficiency of surface UAV berthing to mother ship, as well as improve the safety of surface UAV berthing. Reduce the necessity of manual intervention, and enhance the reliability and autonomy of surface UAVs in performing complex tasks.

Assessment indicators:

(1) The longitudinal error of automatic berthing maneuvering control of surface UAVs is <0.05 ship length;

(2) The lateral error of automatic berthing maneuvering control of surface UAV is <0.04 ship length;

(3) Realize real-time control and graphical interface visualization of the berthing-mooring method.

5. Research on anti-jamming motion control of intelligent underwater unmanned aerial vehicles based on deep reinforcement learning [基于深度强化学习的智能水下无人航行器抗干扰运动控制研究]

   Aiming at the demand for intelligent underwater unmanned aerial vehicle (UAV) platform and high anti-jamming ability motion control, establish a simple and efficient intelligent control algorithm for underwater UAV motion control, explore different solutions of deep reinforcement learning for underwater UAV motion control, research and propose anti-jamming motion control algorithms based on deep reinforcement learning, carry out relevant experiments to fully validate the performance of the algorithms, and improve the performance of underwater UAV motion control. Conduct relevant experiments to verify the performance of the algorithm, and improve the degree of intelligence of the underwater UAV platform and its anti-interference ability in complex environments.

   Assessment indexes:

   (1) Depth control error of the algorithm under different working conditions ≤ 10cm, heading control error ≤ 5°;

   (2) Completion of training and successful motion control time ≤ 5h;

   (3) Ability to be generalized to different underwater UUVs with the same control mode and within 20% difference in weight and volume;

   (4) The computing power occupied by the algorithm on the main control system after the deployment of underwater unmanned aerial vehicles is less than 30%.

**Notable Applications:**

- In 2022, this lab developed a UUV-UAV hybrid which can both fly and go underwater, called Longbow 1 and Longbow 2 [长弓 1 号/长弓 2 号]. It can hold a 1 kg payload, dive to 100 meter, and carries high-definition cameras and digital radio. It is able to emerge from the water, unfold its wings, and take off in under six seconds. The project was led by Deputy Director Li Ye [李晔].[1370]
- A 2006 article written by researchers from this lab describes the potential military uses for AUVs, including for intelligence acquisition, precision attack, and "asymmetric intelligence acupunctural warfare."[1371]
- There are unconfirmed reports that this lab may have been involved in development of the PLAN's first military AUV, the HSU001, first revealed at the 2019 National Day parade.[1372]
- A team from this lab, including Deputy Director Li Ye, built the Wukong [悟空] AUV. This AUV is designed to operate autonomously at extreme depths. It is capable of autonomous navigation, obstacle avoidance, hydrolocation with a precision of 1.5 meters,

and acoustic communications to a range of 10.8km. In November 2019, the team tested Wukong in the Paracel Islands as part of a National Key R&D Plan Project, referred to as the "All-depths AUV Key Technical Research" [全海深无人潜水器 AUV 关键技术研究] project. There are plans to test Wukong at depths of 11,000m in the Mariana Trench. HEU already holds the PRC record for AUV depth at 6,000 meters.[1373]

- This lab has been involved in the Zhishui [智水] series of intelligent AUVs. These AUVs are designed for underwater target sensing and differentiation [水下探测与识别], oceanic resource exploration and sampling [海底资源探查采样], seafloor geography mapping [海底地形勘测], and oceanic engineering and repair [海洋工程维护]. Zhishui-III was the first AUV to achieve autonomous recognition of underwater targets and drawing of target maps. As early as 2003 this lab, only recently established, was developing the Zhishui-IV with advanced sensors for depth, elevation, GPS, compasses, velocity, collision avoidance sonar, 3D imaging sonar, and TV. Zhishui-IV completed a 110-km autonomous journey and conducted autonomous sensing of targets, autonomous placement of targets, and autonomous gathering and testing of oceanic environmental information. The lab developed the Zhishui-V around 2011 with improved capabilities, including underwater autonomous mapping of geography and landforms, autonomous target tracking, and automatic patrol and inspection of seafloor pipes and power lines.[1374]

**Leadership and Key Personnel:**

- Director: Qin Hongde [秦洪德][1375]
- Deputy Directors: Li Ye [李晔][1376]; Han Duanfeng [韩端锋][1377]
    - Li led the Longbow 1/Longbow 2 [长弓 1 号/长弓 2 号] UAV-UUV hybrid project.[1378]

*Key Personnel:*

- Xu Yuru [徐玉如][1379]
    - Lab founder
    - CAE Academician and one of China's leading scholars in the field of intelligent AUV technology
    - Died in 2012
- Su Yumin [苏玉民][1380]
    - Expert on marine propulsion
    - Did PhD at Yokohama National University in Japan and has studied abroad in U.S., U.K., and France
    - Served as lab Director in 2015

**Notable Collaborations:**

*Domestic*

- In 2024, this lab established the "Deep-sea Unmanned Equipment Industry Alliance [深远海无人装备产业联盟] with the Defense S&T Key Lab of Hydroacoustic Technology and Harbin Engineering University. It also included a first bath of nine enterprises, including Hainan Sound Deep Blue Marine Technology Co. [海南声科深蓝海洋技术有限公司], Hainan Water Sound Marine Technology Co. [海南水之声海洋科技有限公司], and Hainan Ai Rui Ao Technology Co. [海南艾锐奥科技有限公司].The alliance will bring together industry and research resources and talent to focus on unmanned equipment technology R&D in service of the PRC's national ocean power strategy [国家海洋强国战略].[1381]
- In 2022, this lab collaborated with Hohai University on deep-sea terrain-assisted navigation, improving high-precision initial localization of the system and estimation of the confidence interval, and high-precision initialization of the system's nonlinear filter.[1382]

*International*

- Personnel from this lab have allegedly completed their PhDs at unidentified institutions in Japan and the U.S.[1383]

**Lab Equipment:**

- This lab controls 1,072 pieces of surface and underwater intelligent equipment worth over 1.6 million RMB.[1384]

**Address**:

HEU Ship and Sea Building [船海楼] at 145 Nantong Rd., Nangang District, Harbin, Heilongjiang [哈尔滨市南岗区南通大街 145 号][1385]

**Website**:

http://sec.hrbeu.edu.cn/2015/1204/c469a1096/page.htm

**Known Aliases:**

- Defense S&T Key Laboratory of Underwater Intelligent Robotic Technology [水下智能机器人技术国防科技重点实验室]
    - Omits reference to military

- Defense S&T Key Laboratory of Underwater Robotic Technology [水下机器人技术国防科技重点实验室]
- National Key Laboratory of Underwater Robotic Technology [水下机器人技术国家级重点实验室]
- National Key Laboratory of Science and Technology on Autonomous Underwater Vehicle

## 59. Defense S&T Key Laboratory of Millimeter-Wave Remote Sensing Technology

**Official English Name:** Science and Technology on Millimeter-Wave Laboratory[1386]

**Chinese Name:** 毫米波遥感技术国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Air
- *Secondary: Space*

Equipment:

- Radar
- *Secondary: Non-Ballistic Missiles, Space Vehicles*

Functional Field:

- Sensing
- *Secondary: Intelligent Technologies, Millimeter-Wave Technologies, Target Detection/Recognition*

**Affiliations:**

- China Aerospace Science and Industry Corporation (CASIC) [中国航天科工集团]
    - Beijing Institute of Remote Sensing Equipment [北京遥感设备研究所]
        - *a.k.a. CASIC 2nd Academy 25th Research Institute [航天科工二院 25 所]*

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab appears to be primarily focused on use of millimeter-wave sensing technology for radar detection, identification, and imaging. It has only rarely been publicly described as a Defense S&T Key Lab, and not recently—sources describing it as such include a 2013 state media article posted on the PRC's space agency website,[1387] and a 2014 inclusion in a list of CASIC 2nd

Academy's DSTKLs.[1388] However, it has been described as a national-level lab in authoritative sources,[1389] and has a clear military mission, suggesting it is a DSTKL. If so, it is one of five DSTKLs under CASIC's 2nd Academy.[1390]

The CASIC 2nd Academy, also known as the Changfeng Mechanics and Electronics Technology Academy [中国长峰机电技术研究设计院], is the primary designer of the PRC's air, missile, and space defense systems, including SAMs, ASAT technologies, and associated radars.[1391] The CASIC Institute of Remote Sensing Equipment (a.k.a. the CASIC 25th Research Institute) was established in 1965 and is focused on precision guidance and measurement technology. It has contributed to the PRC space program, including the manned spaceflight, moon probe, and deep space exploration programs, and is also involved in development of AI, 5G, and laser communications.[1392]

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- Precision guidance imaging and detection technologies, including terahertz, quantum, and metamaterials[1393]
- Millimeter-wave radar[1394]
- Radar design, millimeter-wave radar imaging[1395]
- May be interested in 5G and space-based 5G networks, or at least is part of the conversation in formulating national policy on 5G[1396]
- May be interested in aerospace defense communications and collaborative detection technology[1397]

**Notable Applications:**

None found

**Leadership and Key Personnel:**

- Director: Director: Dong Shengbo [董胜波]
    - CPPCC member[1398]
- Deputy Director: Zha Yue [赵越][1399]
- Party Branch Secretary: Yi Chong [易翀][1400]

*Key Personnel*

- Zhao Chonghui [赵崇辉]
    - Focused on radar design, millimeter-wave radar imaging[1401]

**Notable Collaborations:**

*Domestic*

- In 2023, the 25th RI, this lab's parent institution, established a Joint Laboratory of Advanced Detection and Guidance [先进探测与导引联合实验室] with the University of Science and Technology of China's School of Integrated Circuit Science and Engineering. This joint lab will be focused on R&D of components and chips, key integration technologies, and intelligent technologies in the field of advanced detection and guidance. It is not explicitly stated what role this lab will play, if any.[1402]
- In 2023, this lab co-organized the Aerospace Defense Communications and Collaborative Detection Technology Forum [航天防务通信与协同探测技术论坛] along with the CASIC 25th RI, Weihai Institute of Advanced Laser Communication Technology [威海激光通信先进技术研究院], Guidance and Fuzing Information Network [制导与引信信息网], and the city of Weihai. The forum focused on detection and guidance technology and advanced communications for national defense.[1403]
- In 2019, this lab co-organized the 2nd Air and Space Cup [空天杯] competition for air and space defense. Other involved parties included SASTIND, PLA National University of Defense Technology, the Chinese Academy of Astronautics [中国宇航学会], the DSTKL of Automatic Target Recognition (ATR), various CASIC Academies, and seemingly all of the CASIC 2nd Academy's DSTKLs. Research topics included new aircraft designs, detection and identification algorithms, and new defense system concepts, including radar detection and tracking of small targets and infrared detection and tracking.[1404]
- In 2019, the lab co-organized the Forum on Advanced Air and Space Defense Technology [先进空天防御技术高端论坛], along with the CASIC Defense Technology Institute [中国航天科工防御技术研究院], Chinese Optical Engineering Society [中国光学工程学会], he Defense S&T Industry Space Defense Innovation Center [国防科技工业空天防御创新中心], the CAS Shanghai Institute of Technical Physics [上海技术物理研究所], CETC 53rd RI, National University of Defense Technology, Xidian University, the DSTKL of Complex Aviation Systems Simulation, DSTKL of Opto-Electronic Countermeasures Technology, DSTKL of Aerospace Systems Simulation, the Institute of Aerospace Intelligence and Information [北京航天情报与信息研究所], the Chinese Society of Astronautics Unmanned Flight Vehicle Branch [中国宇航学会无人飞行器分会], and others. The forum focused on incorporating AI, big data, and early warning sensing and identification technologies into air and space defense systems. Topics of interest included space-based early warning, passive sensing of air and space targets, air and missile defense systems, microwave weaponry, intelligent sensing of space-based targets, intelligent technology for missiles, satellites, and air defense systems, intelligent command & control, and a wide range of other topics.[1405]

*International*

- In 2023, this lab co-organized the 16th IEEE International Conference on Electronic Measurement and Instrumentation [第 16 届 IEEE 国际电子测量与仪器学术会议], along with the China Instrument Society [中国仪器仪表学会], IEEE Beijing Section, Beijing Institute of Remote Sensing Devices [北京遥感设备研究所], Harbin Engineering University, Harbin Institute of Technology, CETC 49th RI, Pinying Instruments (Beijing) Co. [品英仪器（北京）有限公司], and Shanghai Jianyi S&T Co. [上海简仪科技有限公司]. Participants came from Xi'an Jiaotong University, CASC 514th RI, Hong Kong Polytechnic University, Shanghai Jiao Tong University, Chinese University of Hong Kong (Shenzhen), and Tianjin University. Foreign participants included a professor from University of Bologna in Italy, who presented on physical model-based deep learning in scientific intelligent maintenance.[1406]

**Lab Equipment:**

None found

**Address**:

None found, but possibly co-located with CASIC 25th RI at No. 52 Yongding Rd., Beijing [北京市永定路 52 号][1407]

**Known Aliases:**

- Defense S&T Key Laboratory of Millimeter and Sub-Millimeter-Wave Guidance [毫米波亚毫米波制导国防科技重点实验室]
- 毫米波遥感技术重点实验室
- 毫米波遥感技术国家重点实验室
- 毫米波遥感技术国家级重点实验室

## 60. Defense S&T Key Laboratory of Multi-Spectral Information Processing Technology

**Official English Name:** Unknown

**Chinese Name:** 多谱图像信息处理技术国防科技重点实验室

**Post-2024 Name**: National Key Laboratory of Multispectral Information Intelligent Processing Technology[lxxxviii] [多谱信息智能处理技术全国重点实验室][1408]

**Research Focus:**

Domain:

- Air
- *Secondary: Maritime*

Equipment:

- Multiple (Aircraft, Non-Ballistic Missiles, Underwater Vehicles, Unmanned Systems)

Functional Field:

- Multiple (GNC, Imaging, Information Processing, Imaging, Intelligent Technologies, Laser Technologies, Sensing, Target Detection/Recognition

**Affiliations:**

- Huazhong University of Science and Technology (HUST) [华中科技大学]
    - School of Artificial Intelligence and Automation [人工智能与自动化学院]

**Key Data:**

- Established: 2005
- Total Funding: Unknown
- Personnel: Unknown[1409]
- Official start of operations: 2012
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research into multispectral imagery processing for guidance, navigation, target recognition, and route planning for aerospace, and, to a lesser extent, underwater vehicles.

[lxxxviii] Literal translation, no official name given

As of December 2022, this lab was reconstituted as part of the ongoing reorganization of the national key lab system, and is now known as the National Key Lab of Multispectral Information Intelligent Processing Technology [多谱信息智能处理技术全国重点实验室].[1410]

**Further Information:**

- The construction cost of this lab was 46.4 million RMB.[1411]
- The lab has research offices/platforms for each of its four research directions.[1412]
- The lab has a subordinate "Image Recognition and Intelligent System Team" [图像识别与智能系统团队].[1413]
- There is a similarly-named lab under the same School, the Key Laboratory of Ministry of Education for Image Processing and Intelligent Control [图像信息处理与智能控制(教育部)重点实验室] which was founded in the 1990s and may have some level of overlap with this lab in terms of the fields they work in. There is some information online suggesting that this was a previous incarnation of the lab, and while that may be possible, at this point in time they are separate entities.[1414]
- The lab's parent institution has gone through multiple iterations and mergers. It was formerly known as the Institute for Pattern Recognition & Artificial Intelligence (IPRAI) [图像识别与人工智能研究所 (图像所)], then the School of Automation [华中科技大学自动化学院] and now the School of Artificial Intelligence and Automation. IPRAI was jointly established in 1978 by the Ministry of Education and Ministry of Space. IPRAI may have been under HUST's National Defense Institute [华中科技大学国防院], and may have carried out multispectral image guidance work involving visual scene matching positioning for Chinese key "assassin's mace" and other missiles and weapons systems.[1415]

**Research Direction:**

1. (Ground object fine) spectral property mechanisms [(地物精细)波谱特性机理]
2. (Multispectral) image guidance information processing (theory and methods) [(多谱)图（像）制导信息处理(理论与方法)]
3. (Multispectral) target detection (theory and methods) [(多谱)目标探测(的理论和方法)]
4. (Multispectral) new sensor design and real-time information processing (technology) [(多谱)新型传感器设计与实时信息处理(技术)].[1416]

*Other Notable Research Areas:*

- The lab is focused on multispectral imaging target detection and identification under complex conditions, and conducts applied basic research, frontier technology exploration, and key technology research on ultra-broad and fine spectral properties, multispectral intelligent detection theory and methods, multispectral intelligent

guidance theory and methods, heterogeneous intelligent synergy theory and methods, and multispectral sensing and intelligent computation technology.[1417]

- As of 2024, the lab is recruiting for positions in computer vision, intelligent perception and cognition, millimeter-wave/infrared radiometry, micro-nano optoelectronic devices, imaging detection, sensing and computing microsystem design, and multi-intelligent body navigation and control. [1418]

**Notable Applications:**

None found

**Leadership and Key Personnel:**

- Deputy Director: Hu Fei [胡飞][1419]
  - Research interests in millimeter-wave and terahertz technologies, as well as signal processing in target detection
  - Previously a visiting scholar at the University of Tennessee in the U.S.

**Notable Collaborations:**

*Domestic*

- This lab worked on several projects involving lasers/Lidar with the Tianjin Jinhang Technical Physics Institute [天津津航技术物理研究所]) (a.k.a. CASIC Third Academy's 8358th RI [航天三院 8358 所])[1420]

**Lab Equipment:**

None found

**Address**:

Possibly co-located with parent institution at No. 1037 Luoyu Road, Hongshan District, Wuhan, Hubei Province [湖北省武汉市洪山区珞瑜路 1037 号][1421]

**Website**:

http://aia.hust.edu.cn/yxgk/xkjd/dpxxcljsgjjz.htm

https://web.archive.org/web/20190215015421/http://auto.hust.edu.cn/yxgk/xkjd/dpxxcljsgjjz.htm

**Known Aliases:**

- National Key Laboratory of Science and Technology on Multi-spectral Information Processing
- National Key Laboratory of Multi-Spectral Information Processing Technology [多谱信息处理技术国家级重点实验室]
- State Key Laboratory for Multispectral Information Processing Technologies
- 多谱信息处理技术国防科技重点实验室
- 多谱图像信息处理技术重点实验室

## 61. Defense S&T Key Laboratory of Nano- and Microfabrication Technology

**Official English Name:** National Key Laboratory of Advanced Micro and Nano Manufacture Technology[1422]

**Chinese Name:** 微米纳米加工技术国防科技重点实验室

**Post-2024 Name:** National Key Laboratory of Advanced Micro and Nano Manufacture Technology [微米纳米加工技术全国重点实验室][1423]

**Research Focus:**

Domain:

- Multi-Domain (Space, likely others)

Equipment:

- Multiple
- *Secondary: Computers, Semiconductors, Space Vehicles*

Functional Field:

- Microelectronics
- *Secondary: Materials, Robotics, Sensors*

**Affiliations:**

- Peking University [北京大学]
  - School of Integrated Circuits [集成电路学院]
- Shanghai Jiao Tong University [上海交通大学]
  - School of Electronic Information and Electrical Engineering [电子信息与电气工程学院]

**Key Data:**

- Established: 1996[1424]
- Total Funding: Unknown, 100m RMB research fund[1425]
- Official start of operations: 2000[1426]
- Personnel: 20-43 full time[1427]
- Floor Space: Unknown

**Lab Overview:**

This lab was established, apparently as a Defense S&T Key Lab due to the involvement of COSTIND, in April 1996, and officially passed acceptance and began operations in October 2000

(although one source says 1998[1428]).[1429] Its establishment was intended to meet the micro- and nano-processing needs of the PRC's defense establishment,[1430] and its research is broadly centered around microelectronic mechanical systems (MEMS) for a wide variety of uses, both civilian and military. This has included civilian and military semiconductors,[1431] micro- and nano-processing technology,[1432] non-silicon MEMS, high depth-to-width ratio LIGA and quasi-LIGA technology, multi-layer complex micro-machining technology, flexible substrate micro-machining technology, micro-nano composite micro-machining, and non-silicon and silicon integration technology, among many other things. Applications have included electromagnetic micro motors, MEMS brain-computer interface devices, MEMS sensors for extreme environments, MEMS optical switches, MEMS combination locks, GMR microsensors, microfluidic chips, flexible MEMS sensors, and other components.[1433]

The lab has a research fund of nearly 100 million RMB and has trained more than four hundred master and doctoral students.[1434] As of 2012, it had a permanent staff of 20 people, including nine professors and four associate professors.[1435] A likely more recent source states that it has 43 researchers.[1436]

The lab is jointly managed by Peking University and Shanghai Jiao Tong University, with PKU being the senior branch.[1437] Per one source, the PKU branch is more focused on MEMS/NEMS and IC integrated design and manufacturing technology while the SJTU branch is more focused on non-silicon reference LIGA micro- and nano-processing technology.[1438]

Like many other DSTKLs in recent years, the lab has adjusted its official status. Today, it is officially known as the National Key Laboratory of Advanced Micro and Nano Manufacture Technology [微米/纳米加工技术国家全国重点实验室]. Much of its research does appear to be primarily civilian in nature, although much is likely dual-use.

**Further Information:**

- The lab has a subordinate "Joint Lab of Micro- and Nanoelectronic Engineering" [微纳电子工程联合实验室] focused on numerical micro- and nanotechnology and micro-/nano-device development and applications.[1439]
- According to an undated source, the laboratory has 8 professors, 2 professor-level senior engineers, 3 associate professors, and 1 researcher.[1440]
- During the 13th Five-Year Plan period, the lab's SJTU branch undertook more than 200 scientific research projects, with a contract funding of more than 500 million RMB.[1441]

**Research Direction:**

1. Micro- and nano-fluidics
2. Bio-microelectromechanical systems[1442]

*Research direction c.2008*:[1443]

1. Microelectronic and microelectromechanical process technology, microelectromechanical devices and microelectronic devices, including:
   - MEMS design and processing technology
   - Applied research on MEMS technology
   - Processing technology services for major MEMS research projects at home and abroad
   - Industrialization of MEMS technology

*Other Notable Research Areas:*

- Non-silicon three-dimensional micromachining technology[1444]
- Micro/nano processing technology of non-silicon materials[1445]
- System-on-a-chip research[1446]
- Internet-of-things sensor technology for manufacturing[1447]
- Radiation monitoring microsystems[1448]
- Integrated circuits[1449]
- Advanced energy generation[1450]
- New materials[1451]
- Professor Lu Yipeng's [卢奕鹏] research group does research for this lab, as well as the PKU High Precision Innovation Center for Integrated Circuits [集成电路高精尖创新中心] and the PKU Yizhuang IC Industry and Education Integration Base [北京大学亦庄集成电路产教融合基地]. Research incudes MEMS design, micromachining, and micro-nano system integration, Piezoelectric MEMS, ultrasonic MEMS, sensors and actuators, and their intelligent micro-nano systems in consumer electronics, smart home, autonomous driving, healthcare, and other fields, piezo MEMS and CMOS integration, piezo MEMS printheads, and portable miniature optical, ultrasonic, and photoacoustic imaging sensing systems.[1452]

**Notable Applications:**

- Per PKU, the PKU branch's research and applications have included micro-nano processing technology, micro-nano devices and integrated micro-nano systems, silicon-based micro-nano-electromechanical systems (M/NEMS) key processing technology and complete sets of processes, advanced materials processing technology, design methodology, process modeling and simulation, M/NEMS /IC monolithic integration technology, micro-nano cross-scale processing technology, inertial devices and systems, radio frequency devices and systems, and optical devices and systems and biological devices and systems.[1453]
- In 2021, this lab was part of an evaluation committee for a National Key R&D Project [国家重点研发计划], "Dynamic Characterization Tester for Micro-Nano Structures" [微纳结构动态特性测试仪项目]. According to the press release, the purpose of the project is "Aimed at the problems of fine structure and complex system of MEMS micro-nano

devices, which makes it difficult to carry out comprehensive quality inspection, based on further improving the performance of laser Doppler vibration measurement, combining the stroboscopic micro-vision and micro-interference technology with the integration of the development of micro-nano structural dynamic characteristics tester, to realize the accurate measurement of the three-dimensional vibration and surface morphology of a MEMS device."[1454] [lxxxix]

- This lab supported the construction of the first non-silicon MEMS pilot production line in China.[1455]

Other lab inventions have included:

- A high-precision radiation detector that broke an international embargo and was used in multiple satellites, including Beidou
- High-temperature sensors that can withstand 5000 degrees Celsius
- The first international standard from China's MEMS industry submitted to the International Electrotechnical Commission (IEC)
- As part of the 973 Plan, this lab led a major breakthrough in developing China's first ten-layer stacked electrical interconnect structure for national defense.
- A soft robot with jellyfish-like features, published in a CSSC journal dedicated to underwater warfare[1456]
- In 2023, a team from this lab developed a wearable device, namely an ultrafine flexible wearable system for accurate monitoring of sleep and nasal cycle, developed by team led by Yang Zhuoqing [杨卓青][1457]
- Implantable brain-computer interface devices, which were presented at a conference hosted by military company Norinco[1458]

**Leadership and Key Personnel:**

- Director, PKU Branch: Wang Wei [王玮]
  - Conducts research on MEMS (microelectromechanical systems), polymer micro-nano-processing methods, and clinical micro-nano-systems[1459]
  - Board member of Beijing Saiwei Electronics Co. [北京赛微电子股份有限公司][1460]
- Director, SJTU Branch: Liu Jingquan [刘景全][1461]
- Academic Committee Deputy Director: Li Zhihong [李志宏]
  - Conducts research on MEMS/NEMS theory, design and processing, and biological MEMS
  - Visiting scholar to UC Davis and Cornell University in USA, 2000-2004[1462]

[lxxxix] More information on project and participants available.

*Key Personnel*

- Hu Zhiyu [胡志宇]
  - Former Director (c.2012-c.2020) after returning to PRC in 2008 as part of Thousand Talents Plan
  - Worked at U.S. DOE Oak Ridge Laboratory for "many years", and as professor at Georgia Institute of Technology, University of Tennessee, and other unis; led multiple projects for DOE and U.S. Department of Defense, as well as the National Science Foundation
  - Member of United Front Work Department Western Returned Scholars Association[1463]
  - When Hu returned from the U.S. to the PRC in 2008, he took with him his research into advanced power generation, including thermoelectric energy. His work on nano room temperature combustion technology led to a breakthrough in PRC in power generation with minor temperature difference [小温差发电], which is expected to add trillions of kilowatts of power to the grid via a MEMS thermoelectric chip based on silicon oxide substrate.[1464]
- Wang Luda [王路达]
  - Conducts research on micro and nano carbon materials in nanofluidics and separation membranes
  - Postdoc research at MIT, PhD at University of Colorado in U.S.
  - Has given lectures at multiple U.S. universities, including MIT, Penn State, and Michigan State[1465]
- Zou Xudong [邹旭东]
  - Another recipient of Thousand Talents Plan, returned from PhD at Cambridge University in UK in 2013
  - Engaged in research on micromechanical resonators, resonant microinertial sensors, vibrating microgenerators, RF MEMS filters, oscillators, and micromachining process development[1466]

**Notable Collaborations:**

*Domestic*

- This lab has a relationship with the Beijing Graphene Institute [北京石墨烯研究院] to help convert its basic research into practical applications.[1467]
- The lab is affiliated with the Beijing Qingdao Yuanxin Microsystems Technology Co. [北京青岛元芯微系统科技有限责任], which utilizes the lab's research. The company is a joint venture between Peking University Qingdao Group [北大青鸟集团] and Peking University Yuhuan Co. [北大宇环公司], and focuses on microelectronics technology and sensor design, especially miniature sensors.[1468]
- This lab is also affiliated with the PKU Center for Nanoscience and Technology [北京大学纳米科学与技术研究中心], PKU Department of Medicine and its affiliated hospital

[京大学医学部及附属医院], and the Beijing Institute of Graphene [北京石墨烯研究院].[1469]

*International*

- According to its recruitment pitch for 2019, grad students at the lab can be recommended to work or study at Harvard, MIT, Standford, or Caltech in the U.S.[1470]
- The lab is collaborating with an unnamed institution in Gothenburg, Sweden, on advanced energy storage and generation.[1471]
- The lab's PKU branch hosts the 111 Program "Post-Moore Era Micronanoelectronics Innovation Base" [后摩尔时代微纳电子学科创新引智基地], along with the Key Laboratory of Microelectronic Devices and Circuits of the Ministry of Education [微电子器件与电路教育部重点实验室] and the National Natural Science Foundation of China's "Research on New Devices and Processes for Nanoscale Integrated Circuits" Innovation Research Team [国家自然科学基金"纳米尺度集成电路新器件与新工艺研究"创新研究团队]. This base conducts international cooperative research on micro-nano-electronics in the post-Moore era for devices, chips, and applications, and particularly for portable and intelligent carriers for micro-nano-electronics. The base will focus on green and intelligent Internet of Things (IoT) nodes, intelligent (node-side information processing), and portable (wearable multi-functional integration), as well as key chips and typical applications. The Base's status as part of the 111 Program is notable, as this program is intended to facilitate knowledge transfer to the PRC via collaboration with foreign talent.[1472]

**Lab Equipment:**

- The lab has nearly 100m RMB of equipment, while the PKU Center for Nanoscience and Technology [北京大学纳米科学与技术研究中心] has over 150m in equipment.[1473]
- According to a source from 2012, the lab has 20 sets of key equipment valued at more than 10 million RMB, including sputtering machines, lithography machines, RIE, and other key MEMS equipment.[1474]
- According to one source, the lab has purchased the most advanced key equipment for MEMS processing, which constitutes an internationally advanced MEMS processing line. This equipment, combined with its microelectronic process lines and microfabrication equipment dispersed in various research institutes, form the basis of the current MEMS processing technology in China. The equipment includes:[1475]
    - STS deep groove etching machine
    - Karlsuss double-sided photolithography/bonding alignment machine
    - Karlsuss bonding machine for silicon/glass electrostatic bonding and silicon/silicon pre-bonding
    - LPCVD
    - Compression molding machine
    - Sputtering table

    - Diffusion furnace
    - RIE etching machine
    - PECVD
    - Photolithography and other equipment,
- According to older sources that may be from around 2004-2008, the lab has more than 150 sets of equipment for process experiments, testing, and analyzing, valued at about 80 million RMB, as well as more than 130 sets of various advanced processing and testing equipment which can process CMOS integrated circuits, ultra-high-speed silicon bipolar integrated circuits, microelectromechanical systems, CMOS/SOI integrated circuits, and compound semiconductor devices. It has the ability to meet experimental research demands for silicon MEMS devices, CMOS/SOI circuits, high-speed bipolar circuits, and other devices. At time of writing, the laboratory has more than 15 sets of equipment valued at more than 2 million RMB, making it the largest experimental research environment for microelectronics and microelectromechanical processes in China. Eighty percent of the equipment is imported. The lab's facilities include:[1476]
    - Microelectronics purification process ultra-clean laboratory with an area of 900 sqm
    - System-on-chip (SOC) software and hardware co-design laboratory
    - Multi-target chip design laboratory and computer aided engineering (CAE) laboratory with an area of 1,000 sqm, with the latest software for conducting research in logic synthesis, circuit simulation, circuit design, layout design, and device and process simulation
    - Precision plasma etching machine
    - Ellipsometer
    - Low stress PECVD, LPCVD and a number of international first-class large-scale process or testing equipment.
- According to a likely more up to date source, the lab has more than 150 sets of silicon-based micro-nano processing process and testing and analysis equipment with a total asset value of more than 100 million RMB. A number of process equipment owned by the lab was the first of its kind in the PRC, including advanced CMOS/SOI circuits and silicon-based M/NEMS devices and microsystems. This equipment includes:[1477]
    - “International first-class" silicon micro-nano processing platform
    - MEMS/NEMS and IC integration design platform
    - Ultra-clean room of 1,500 sqm (including 150 sqm of Class 100)
- By 2023, the lab possessed an ultra-clean space of over 3,800 sqm, with more than one hundred million RMB of equipment retained in fixed capital.[1478]

**Address**:

- Micro-Nano Electronics Building, Peking University, No. 5 Yiheyuan Road, Haidian District, Beijing [北京市海淀区颐和园路 5 号北京大学微纳电子大厦][1479]

- Institute of Micro-Nano Science and Technology, Shanghai Jiao Tong University, No. 800 Dongchuan Road, Shanghai [上海市东川路 800 号上海交通大学微纳科学技术研究院][1480]

**Known Aliases:**

- 微米/纳米加工技术国家重点实验室
- 微米/纳米加工技术国家级重点实验室
- 微米/纳米加工技术重点实验室
- 微米/纳米加工技术国防重点实验室

## 62. Defense S&T Key Laboratory of New Ceramic Fiber and Composite Materials

**Official English Name:** National Key Laboratory of New Ceramic Fibres and Composites[1481]

**Chinese Name:** 新型陶瓷纤维及其复合材料国防科技重点实验室

**Post-2024 Name**: No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Multi-Domain (Air, Space)

Equipment:

- Multiple (Aircraft, Non-ballistic Missiles, Radar, Space Vehicles)

Functional Field:

- Materials
- *Secondary: Hypersonic Technologies, Propulsion, Stealth Technologies*

**Affiliations:**

- PLA National University of Defense Technology [国防科技大学]
    - College of Aerospace Science and Engineering [国防科技大学空天科学学院]

**Key Data:**

- Established: 1998
- Total Funding: Unknown
- Personnel: over 38[1482]
- Official start of operations: 2003
- Floor Space: 5,500 sqm (lab space)

**Lab Overview:**

This lab conducts research into new materials for advanced aerospace applications, including stealth and heat-resistant materials for aircraft, space vehicles, missiles, and aircraft and rocket engines.

**Further Information:**

- The lab has at least three subordinate research offices:
    - *Special Ceramic Fibers Research Office* [特种陶瓷纤维研究室]

- *Ceramic Thermal Structure Materials Research Office* [陶瓷热结构材料研究室]
- *Stealth Functional Materials Research Office* [隐身功能材料研究室][1483]

- During China's 10th Five Year Plan (2001-2005), the laboratory undertook over 100 research projects with annual research funds per person exceeding 500,000 RMB[1484]

**Research Direction:**

1. Materials design and preceramic polymer pyrolysis technology [材料设计与先驱体转化技术]
2. Ceramic fibers preparation technology [陶瓷纤维制备技术]
3. Preceramic polymer pyrolysis composite (material) preparation technology [先驱体转化复合材料制备技术]
4. Material performance measurement and evaluation [材料的性能测试与评估]
5. Camouflage, stealth, [伪装隐身技术] and nano-materials [纳米材料与技术][1485]

**Notable Applications:**

- The lab's research has likely been used in a range of aircraft, missile radomes, hypersonic missiles, space vehicles, aircraft and rocket engines, and aircraft stealth technology.[1486]
- PRC sources claims that the lab has achieved a series of breakthroughs and innovative achievements in the design and synthesis of preceramic polymers, continuous SiC fibers, nitride wave-transparent ceramic fibers and their composites, fiber-reinforced SiC-based composites, nanoporous thermal insulation composites, and high-temperature stealth composites, providing support for the development of a new generation of Chinese aerospace vehicles. It has also produced composite nozzle adjusting pieces and inner cones, SiC/SiC composite nozzle adjusting plates and inner cones, and aerogel insulations.[1487]

**Leadership and Key Personnel:**

- Director: Ma Qingsong [马青松][1488]
- Deputy Director: Liu Rongjun [刘荣军][1489]

**Notable Collaborations:**

*Domestic*

- The lab has significant cooperation with Central South University (CSU) [中南大学] and its Defense S&T Key Laboratory of Lightweight, High-strength Structural Materials [轻质高强结构材料国防科技重点实验室]. Both labs are located in Changsha. The two labs

have co-hosted the Special Powder Metallurgy and Composite Materials Preparation/Processing [特种粉末冶金及复合材料制备/加工] series of academic conferences, along with the CAS Institute of Metals Research [中国科学院金属研究所] and others. The conference focused on the latest developments in refractory metals, high-temperature alloys, powder metallurgy, cemented carbide, high-performance alloys, metal-matrix and ceramic composites, friction materials, structural materials, surface coating and protection technologies, and preparation and processing technologies.[1490]

*International*

- The lab claims to have established academic relationships with Tokyo University and the National Materials Institute of Japan, Sydney University in Australia, University of Bordeaux and Lyon University in France, Chungnam National University in Korea, and Nanyang Technological University in Singapore.[1491]

**Lab Equipment:**

- The lab has over 38m RMB of experimental equipment.

The lab has the following equipment and facilities:

- Continuous silicon carbide fiber production test line with 500kg annual output
- Ceramic base composite material design and molding system
- Functional composite material design and processing system
- Advanced materials analysis and testing platform[1492]

**Address**:

CFC Key Laboratory, 1st Courtyard, National University of Defense Technology, No.109 Deya Road, Kaifu District, Changsha City, Hunan Province [湖南省长沙市开福区德雅路 109 号国防科大一院 CFC 重点实验室][1493]

**Website**:

https://web.archive.org/web/20150501040729/http://www.nudt.edu.cn/ArticleShow.asp?ID=80

**Known Aliases:**

- CFC Key Lab, National University of Defense Technology [国防科技大学陶瓷纤维及其复合材料重点实验室]

- National Key Laboratory of New Ceramic Fibers and Composites [新型陶瓷纤维及其复合材料国家级重点实验]
- Defense S&T Key Laboratory of CFC [CFC 国防科技重点实验室]
- Key Laboratory of CFC [CFC 重点实验室]
- Key Laboratory of Novel Ceramic Fibers & Composites
- 新型陶瓷纤维及复合材料国防科技重点实验室

## 63. Defense S&T Key Laboratory of Nuclear Data

**Official English Name:** Unknown

**Chinese Name:** 核数据国防科技重点实验室

**Post-2024 Name**: No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Nuclear

Equipment:

- Nuclear Weaponry & Power

Functional Field:

- Measurement Technology
- *Secondary: Simulation & Modeling*

**Affiliations:**

- China National Nuclear Corporation (CNNC) [中国核工业集团公司]
    - China Institute of Atomic Energy [中国原子能科学研究院]

**Key Data:**

- Established: 2003[1494]
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: 2010[1495]
- Floor Space: Unknown

**Lab Overview:**

The roots of this lab can be traced back to the 1960s, with the creation of the China Institute of Atomic Energy's Nuclear Data Research Team [原子能院核数据研究团队].[1496] In its current form, this lab was jointly established by the Neutron Physics Laboratory [中子物理实验室] and China Nuclear Data Center [中国核数据中心] in 2003, passed its evaluation in 2008, and received final SASTIND approval in 2010.[1497] Broadly, it is tasked with both carrying out nuclear data research and making nuclear data readily available to the larger PRC research community. Its research is focused on nuclear data measurement, evaluation, and library construction [核数据测量、评价与建库], group constant production [群常数制作], and benchmarking technology [和基准检验技术].[1498] Its mission encompasses gathering and evaluating a wide range of nuclear

research data and constructing libraries to make this data accessible in order to bridge basic research with more advanced experimentation and engineering. Its data is utilized in nuclear energy and the PRC's nuclear weapons program, as well as in medical and agricultural applications.[1499] As of 2018, numerous sources state that the PRC still lags in some areas of nuclear data science, including in basic research, nuclear data measurement and evaluation, and talent training.[1500]

The China National Nuclear Corporation (CNNC) is the PRC's largest state-owned enterprise for the nuclear industry. The China Institute of Atomic Energy serves as a major nuclear research institute under CNNC, with a focus on nuclear physics, nuclear chemistry and radiochemistry, nuclear reactor engineering technology, accelerator technology, nuclear detector technology, isotope technology, nuclear security, ionizing radiation measurement, nuclear fuel cycles, and new materials.[1501] The lab is also very closely affiliated with the China Nuclear Data Center, and the two are sometimes treated as synonymous with one another, although other sources name them separately. The China Nuclear Data Center is one of the five major global nuclear data centers in the world.[1502]

**Research Direction:**

1. Nuclear Data Measurement Technology: fission yield, excitation function, decay data, secondary neutron double differential cross section, and differential cross section
2. Nuclear Data Measurement Techniques: experimental measurements of fission yields, excitation functions, decay data, secondary neutron double-differential cross sections and differential cross sections, gamma production cross sections, fission cross sections, (n,x) reaction cross sections, integral data, and atomic and molecular data, as well as building of libraries for general and specialized evaluation of nuclear data, and research and development of group constant libraries for various nuclear engineering applications[1503]

*Other Notable Research Areas:*

- Fast neutron radiography for weapons inspection (with PLA Unit 92609)[1504]
- In 2017, this lab led a major National Natural Science Foundation of China project called "Research on Key Scientific Issues of Actinide Nuclear Fission Data" [锕系核裂变数据关键科学问题研究], the first NSFC project focused on nuclear data. The project was intended to support nuclear data measurements and help establish fission theoretical models and computational systems. The data will further both nuclear energy and weaponry development.[1505] The China Scattered Neutron Source platform and the China Advanced Research Reactor of the Atomic Energy Research Institute will be utilized to carry out research on the measurement methods of the cross section and independent yield of the fission resonance region and the all-energy region, respectively.[1506] Another source points out that (as of 2018), the PRC lags in basic fission research, with gaps in experimental equipment, theoretical level, and talent, which restricts the advancement of the PRC's fission data and basic research.[1507]

- In 2020, this lab carried out a major project of the 13th Five Year Plan in "nuclide (n,2n) reaction cross-section measurements and evaluation" [核素(n,2n)反应截面测量与评价]. The project involved continuous irradiation of samples for over 20 days in a high-pressure multiplier.[1508]

**Notable Applications:**

- The lab's China Nuclear Evaluation Database [中国评价核数据库] is one of five internationally recognized mainstream nuclear databases. As of 2022, the latest version was CENDL-3.2, released in 2020.[1509]
- During the 13th Five Year Plan, this lab played a key role in supporting the PRC's basic research in nuclear physics, along with the Beijing Tandem Accelerator National Laboratory [北京串列加速器国家实验室]. This included:
    - Nuclear astrophysics and radioactive beam physics (including solar neutrinos, the new shape of the halo structure of atomic nuclei, and the nucleosynthesis of heavy elements)
    - Nuclear data development for energy and national security needs (including an unstable nuclear beam flow line and a project called "Generation and Application of Secondary Radioactive Nuclear Beams on HI-13 Tandem Accelerator" [HI-13 串列加速器上次级放射性核束的产生和应用], which won a Second Class National S&T progress award)
    - Platforms for nuclear data measurement, evaluation, library construction and application testing (including a database with data on neutron nuclear reactions, photon nuclear reactions, fission yields, nuclear structure, nuclear decay, and activation data which has been used in numerous large-scale energy and defense projects)[1510]
- The lab has completed the cross-section measurement and evaluation of nearly 100 neutrons and 20 charged particles in key reaction channels, and clarified important data differences. It has measured and evaluated a series of important fission product yields, carried out research on nuclear decay data of important fission products, and successively set up the Accompanying Particle Fast Neutron Time-of-Flight Spectrometer (APFTS), the Conventional and Unconventional Multi-Detector Fast Neutron Time-of-Flight Spectrometer (CNTTS), and the Strainer Gas Target Device (SGTD). It has made experimental measurements of multiple important nuclide differential and double differential cross sections, especially in the 8-14 MeV energy region, filling data gaps in this energy region. It has completed a large number of neutron-induced g- production cross section measurements, experimental studies on the yield of high-energy g-rays in low-energy d-D fusion.[1511]
- The lab's construction of multiple special nuclear databases has supported the development of the PRC's nuclear industry and national defense needs.[1512]

- The China Nuclear Data Center developed the UNF Program [UNF 程序], which calculates nuclear data evaluation results. The program won a National S&T Progress 3rd Class Merit.[1513]
- This lab developed a Fission Yield Retrieval Program [裂变产额数据检索应用程序] to allow researchers to more conveniently query fission yield data. It has an app which works on the Android mobile OS.[1514]
- This lab played a leading role constructing the PRC's first portable neutron generator [便携式中子发生器] with high-precision marking of the time and angle of the outgoing neutrons. This will provide new technical means for non-destructive neutron detection, a technology that has reportedly been denied to the PRC by the U.S. and others. The neutron energy of the tagged neutron source is 14 MeV.[1515]

**Leadership and Key Personnel:**

- Director: Ge Zhigang [葛智刚][1516]
    - Deputy Director of China Institute of Atomic Energy Director of China Nuclear Data Center
    - Member of China Nuclear Data Committee, International Atomic Energy Agency Nuclear Data Committee, and Committee on Data of the International Science Council
    - China representative to International Nuclear Data Evaluation Working Group
    - CPPCC Member[1517]
- Deputy Director: Ruan Xichao [阮锡超]
    - Also serves as Director of the lab's Department of Nuclear Data Measurement Technology [核数据测量技术研究部]
    - Specializes in research on experimental nuclear physics, neutron physics, reactor neutrinos, and dark matter
    - Collaborates with Taiwan in the Taiwan Neutrino Experiment Collaboration (TXENO)[1518]
- Standing Committee Deputy Director: Guo Bing [郭冰][1519]

**Notable Collaborations:**

*Domestic*

- In 2023, this lab co-organized the National Symposium on Advanced Gas Detectors [第十一届全国先进气体探测器研讨会], along with the State Key Laboratory of Nuclear Detection and Nuclear Electronics [核探测与核电子学国家重点实验室], Institute of Nuclear Physics of China Academy of Atomic Energy Sciences [中国原子能科学研究院核物理研究所], the Beijing Nuclear Society [北京核学会], and the Center for Advanced Science and Technology of China [中国高等科学技术中心].[1520]

*International*

- In 2023, this lab co-organized the National Nuclear Data Conference and the Conference on Research and Application of Macro Parameters of Nuclear Data [2023年全国核数据大会暨核数据宏观参数研究与应用会议], along with the Sino-French Institute of Nuclear Engineering and Technology of Sun Yat-sen University [中山大学中法核工程与技术学院].[1521]
- The lab's research and data are included in the International Atomic Energy Agency's (IAEA) data, and its database is one of five internationally recognized nuclear databases. The lab's parent institution has an agreement with the IAEA to cooperate in research, expertise, and conference planning.[1522]
- The affiliated China Nuclear Data Center developed an Optical Model of Homospin-Related Nucleon-Nucleus Microscopic Potentials [同位旋相关核子-核微观光学势] with Tuebingen University in Germany.[1523]
- In 2018, two personnel from this lab, Wang Jimin [王记民] and Jin Yongli [金永利], were invited to participate in the 9th Asian Nuclear Reaction Database Progress Workshop [第九届亚洲核反应数据库进展研讨会] in South Korea. The workshop discussed the development of nuclear data centers in Asia, the Experimental Nuclear Reaction Database (EXFOR), and the latest progress of the Nuclear Reaction Data Collaboration Network in Asia (NRDCAsia). It included participants from Japan, Korea, India, Mongolia, Kazakhstan, and Vietnam. The source also reveals that the Cina Nuclear Data Center is hosting an EXFOR data compilation team.[1524]

**Lab Equipment:**

- Neutron generator[1525]
- Advanced nuclear data evaluation and library building platform
- 600-kV millisecond strong-current pulse high-pressure doubler
- Fast-neutron time-of-flight spectrometer
- High purity error detector array
- Offline experimental measurement platform
- Gamma all-absorbing fluorinated collar detector array
- Online isotopic soliton separator (ISOL)
- (n,x) reaction measurement device
- He-3 spherical array detector
- Scattered Split Neutron Source (SSCS) antiangle white-light neutron beam experimental terminals
- Atomic and Molecular Experimental Research Platform (AMERP)[1526]

**Address**:

Beijing 102413 [北京市][1527]

**Known Aliases:**

- China Nuclear Data Center [中国核数据中心]
    - Although they appear to be distinct entities, the two are sometimes used interchangeably

## 64. Defense S&T Key Laboratory of Optoelectronic Countermeasures Technology

**Official English Name:** Unknown

**Chinese Name:** 光电对抗技术国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Air

Equipment:

- Multiple (Ballistic Missiles, Computers, Non-Ballistic Missiles, Semiconductors)

Functional Field:

- Optoelectronics
- *Secondary: Countermeasures, Sensing, Intelligent Technologies, Laser Technologies, Simulation & Modeling, Targeting*

**Affiliations:**

- China Electronics Technology Group Corporation (CETC) [中国电子科技集团]
  - Tianjin Institute of Opto-electronics [天津光电研究院]
    - *a.k.a. CETC Institute of Opto-electronics [CETC 光电研究院]*

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: 5,000 sqm[1528]

**Lab Overview:**

This lab conducts research into optoelectronic technology, including optoelectronic detection and simulation, information processing, computational optics, big data, artificial intelligence, and quantum information.[1529] This research is applied primarily to developing electronic countermeasures for missiles. The lab is described in some sources as the "core of technological innovation" for its parent institution, the Tianjin Institute of Optoelectronics.[1530]

The CETC Tianjin Institute of Optoelectronics, (a.k.a. the CETC 53rd Research Institute) was established in 1980 and is focused on optoelectronic engineering, electronic engineering, infrared, systems engineering, radar technology, applied mathematics and physics, computer software, materials, chemicals, munitions, rocket technology, automatic control, and information processing. It may have moved from Tianjin to Jinzhou. It also has a branch in Yanjiao.[1531]

**Further Information:**

- This lab is likely the same as the Key Lab of Optoelectronic Information Control and Security Technology, due to being a similarly-named lab under the same RI. Despite not being referred to as a Defense S&T Key Lab, profiles of the 53rd RI make clear that it does indeed have a Defense S&T Key Lab.[1532]

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- Laser research[1533]
- Mid-infrared semiconductor lasers[1534]
- Visual target tracking using AI[1535]
- Electronic Countermeasures[1536]

**Notable Applications:**

The lab has developed a range of technologies, including:

- Laser fence technology to detect stealth aircraft[1537]
- Computational imaging, including for airborne optoelectronic systems[1538]
- Using AI technology for electro-optical countermeasures[1539]
- Deep learning to detect sky, horizon, and ground in small target detection[1540]
- Countermeasures for optoelectronic precision guided weapons[1541]
- Intelligent long-range anti-ship missiles[1542]
- Electronic countermeasures for conventional missiles[1543]

**Leadership and Key Personnel:**

- Deputy Director: Li Yuhai [李宇海][1544]
- Deputy Director: Wang Kai [王锴][1545]
- Managing Deputy Director: Yan Xiusheng [闫秀生][1546]

*Key Personnel*

- Li Sensen [李森森]
    - Conducts research into mid-infrared semiconductor lasers. Worked on two laser-related 13th Five Year Plan Projects for Equipment Development Department.[1547]

**Notable Collaborations:**

*Domestic*

- This Lab co-sponsored the 5th Optoelectronic Defense Technology and Applications Symposium [第五届光电防御技术及应用研讨会] in 2020, with the State Key Laboratory of Pulsed Power Laser Technology [脉冲功率激光技术国家重点实验室] and the Anhui Provincial Laboratory of Advanced Laser Technology [先进激光技术安徽省实验室]. Topics included advanced laser technology, atmospheric optics, optical field perception and control, optoelectronic attack and defense technology, defense of weapons and equipment, key ground target protection, threat perception, countermeasures against optoelectronic threats (including precision-guided weapons), and anti-jamming of optoelectronic equipment. Participants came from NUDT School of Electronic Countermeasures.[1548]
- This lab participated in the 12th Electronic Warfare Conference, along with personnel of NUDT, PLAAF Engineering University, CETC 29th and 40th RIs, and others.[1549] Personnel from this Lab also participated in the 2019 iteration of the conference and presented on missile countermeasures.[1550]
- In 2021, this lab co-sponsored a summit on the future of space power, including space technology and science. Also participating was the PLA Strategic Support Force, CAEP, Chinese Academy of Military Sciences, and a wide range of state research institutions such as the Shanghai Academy of Spaceflight Technology under the CASC 8th Academy.[1551] [xc]

*International*

- The 53rd RI is involved in the 111 Plan, a PRC government strategic plan intended to facilitate international tech transfer, though no further details are given.[1552]

**Lab Equipment:**

- The lab has over 200 major instruments/pieces of equipment.[1553]

[xc] Complete list of participants available.

**Address**:

Jingdong Yanjiao Economic Technology Development Zone, Sanhe, Langfang, Hebei Province [河北省廊坊市三河市京东燕郊经济技术开发区][1554]

Another location may be in Tianjin 300308 [天津市][1555]

**Known Aliases:**

- Key Laboratory of Optoelectronic Information Control and Security Technology

## 65. Defense S&T Key Laboratory of Parallel and Distributed Processing

**Official English Name:** Unknown

**Chinese Name:** 并行与分布处理国防科技重点实验室

**Post-2024 Name**: No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Multi-Domain (Space, Nuclear, likely others)

Equipment:

- Computers
- *Secondary: Nuclear Weaponry & Power, Space Vehicles*

Functional Field:

- Simulation & Modeling

**Affiliations:**

- National University of Defense Technology (NUDT) [国防科技大学]
    - College of Computer Science and Technology [计算机学院]

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown[1556]
- Official start of operations: 2011
- Floor Space: 2,850 sqm

**Lab Overview:**

This lab conducts research into parallel and distributed processing algorithms, software, and architecture. It is heavily involved in the development of high-performance computer technology, particularly the development of the Yinhe and Tiane line of supercomputers and their associated technologies. It also conducts research into other cutting-edge computing fields, such as big data processing. At its founding it was lauded as an important step in the development of high-performance computing in the PRC.[1557]

**Further Information:**

- This lab has a High-Performance Computing Innovation Team [高性能计算创新团队] and a Petaflop High-Performance Computing Key Technology Innovation and Research Team [千万亿次高性能计算关键技术创新研究群体][1558]

**Research Direction:**

1. Parallel algorithms and applications [并行算法与应用]
2. Parallel and distributed processing system software [并行与分布处理系统软件]
3. Parallel and distributed processing architecture [并行与分布处理体系结构]
4. Parallel and distributed processing system performance evaluation [并行与分布处理系统性能评测][1559]

*Other Notable Research Areas:*

- S&T monitoring applications for big data[1560]

**Notable Applications:**

- NUDT's School of Computers houses the Tianhe [天河] supercomputers, which are among the fastest in the world, and this lab seems to have played a key role in the development of these supercomputers. Researcher Lu Kai, who is affiliated with this lab, was deputy lead designer for the Yinhe-Y, Yinhe-Z, Tianhe-1, and Tianhe-2 supercomputers. Researcher Yang Xuejun was the chief designer for the Tianhe-1 Supercomputer. Current Director Liao Xiangke was a leading researcher for the Tianhe-1 and Tianhe-2, as well as for the Kylin [麒麟] operating system used by these supercomputers. The Tianhe-2 Supercomputer has been cited for its use in nuclear weapons research and has been subjected to export control by the U.S. Government for that reason.[1561]
- This lab's personnel provided key research for the Yinhe-series [银河系列] of supercomputers in the 1980s and 1990s. These supercomputers led to advancements in nuclear science, space simulations, and meteorology, and were utilized by the Ministry of Space Beijing Simulation Center [航天部北京仿真中心], the 3rd Academy Simulation Center [三院仿真中心], and the 1st Academy 12th Research Institute [一院 12 所], becoming an important tool for the development of strategic weapons. The Yinhe-3 was used by the GSD, GAD, and PLAAF for military meteorology, nuclear technology, computational fluid dynamics, and other applications. Professor Lu Xicheng was involved in the development of the Yinhe-3 and Yinhe-4 supercomputers and Yinhe Yuheng 9108 Core Router [银河玉衡 9108 核心路由器].[1562]

- Recent and ongoing projects include a new generation supercomputers, key technologies toward an ultra high-performance parallel supercomputer funded by the NSFC, and a "core router" [核心路由器] program funded by the 863 Plan.[1563]

**Leadership and Key Personnel:**

- Director: Liao Xiangke [廖湘科][1564]
  - PLA Major General and CAE academician
  - Involved in Yinhe-series, Tianhe-1, and Tianhe-2 supercomputers, and Kylin OS
- Academic Committee Director: Lu Xicheng [卢锡城][1565]
  - CAE Academician.
  - Directed development of Yinhe-2 (in 1980s) and Yinhe-3 parallel supercomputers in 1990s.
  - In 2006, served as PLA GAD Deputy Director of Science and Technology Committee, and currently working with CMC Science and Technology Committee.
  - Did early career work at University of Massachusetts in the U.S. (1982-84).
- Deputy Director: Li Dongsheng [李东升][1566]
- Deputy Managing Director: Dou Yong [窦勇][1567]

*Key Personnel:*

- Zhou Xingming [周兴铭][1568]
  - Born in 1938, Corps Leader grade Major General and CAS Academician
  - Participated in early development of Chinese transistor computers, integrated circuit computers, and China's first supercomputers (Yinhe series)
- Peng Yuxing [彭宇行][1569]
  - Research interests in distributed computing technology and big data processing
- Lu Kai [卢凯][1570]
  - Expert in military uses of computers
  - Assistant lead designer for Yinhe-Y, Yinhe-Z, Tianhe-1, and Tianhe-2 supercomputers

**Notable Collaborations:**

*Domestic*

- In May 2020, this lab co-hosted a forum, "Integrating Artificial Intelligence and Computing Systems" [人工智能与计算系], featuring personnel from Coretronic Microelectronics Co. [芯创智（北京）微电子有限公司], Alibaba, Tsinghua, Shanghai Jiao Tong University, Huazhong S&T University, USTC, Peking University, National University of Defense Technology, and CAS, as well as Duke University.[1571]

- Professor Dou Yong of this lab spoke about computer systems architecture at a 2018 conference hosted by the CAEP Center for High Performance Numerical Simulation [中物院高性能数值模拟软件中心]. CAEP is responsible for research related to China's nuclear weapons. Likewise, Professor Lu Xicheng spoke at the 8th Academic Conference of CAEP in 2012.[1572]

*International*

- In 2021, this lab took part in the Radar Target Detection Challenge (ACM ICMR 2021) [雷达目标检测挑战赛], which designed new advanced radar target detection algorithms. Other participants came from the U.S. (UC Berkeley), the U.K. (Imperial College London), Switzerland (ETH Zurich), and Taiwan (National Cheng Kung University, Pingtung University of Science and Technology).[1573]
- In May 2020, this lab co-hosted a forum, Integrating AI and Computing Systems [人工智能与计算系] (see above), which featured Chinese personnel from military, academic, and private institutions, and also featured a Professor from U.S. Duke University.[1574]
- The lab allegedly has established long-term cooperative relationships with academic and research institutes in the U.K., Germany, and Singapore.[1575]

**Lab Equipment:**

- According to an unofficial source, the lab's internal Gigabit LAN is connected to the NUDT campus network.[1576]
- Facilities include:
    - High-performance parallel computing system
    - High-performance microprocessor design and testing facilities
    - Virtual computing environment test facilities
    - High-performance simulation computing platform
    - Parallel computing system evaluation environment[1577]

**Address**:

Possibly co-located with the NUDT School of Computers at No. 109 Deya Road, Kaifu District, Changsha, Hunan Province [湖南省长沙市开福区德雅路 109 号][1578]

**Known Aliases:**

- State Key Laboratory on Parallel and Distributed Processing [并行与分布处理国家重点实验室]
- National Key Laboratory of Parallel & Distributed Processing [并行与分布处理国家级重点实验室]

- State Key Laboratory for Parallel and Distributed Processing
- National Laboratory for Parallel and Distributed Processing
- Science and Technology on Parallel and Distributed Processing Laboratory
- Parallel and Distributed Laboratory

## 66. Defense S&T Key Laboratory of Particle Transport and Enrichment Technology

**Official English Name:** Unknown

**Chinese Name:** 粒子输运与富集技术国防科技重点实验室

**Post-2024 Name**: National Key Laboratory of Particle Transport and Enrichment Technology[xci] [粒子输运与富集技术全国重点实验室][1579]

**Research Focus:**

Domain:

- Nuclear

Equipment:

- Nuclear Weaponry & Power

Functional Field:

- Laser Technologies

**Affiliations:**

- China National Nuclear Corporation (CNNC) [中国核工业集团公司]
    - Research Institute of Physical and Chemical Engineering of Nuclear Industry [核工业理化工程研究院]
- Tsinghua University [清华大学]

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: Unknown

[xci] Literal translation, no official name given

**Lab Overview:**

What little information publicly exists about this lab indicates that it is engaged in research related to lasers and particle physics. Given its connection to nuclear giant CNNC, this is likely to be related to nuclear weaponry and power.

Under the ongoing reorganization of the PRC's national key lab system, this lab is now known as the National Key Lab of Particle Transport and Enrichment Technology [粒子输运与富集技术全国重点实验室]. It also appears that Tsinghua University has joined on as a managing partner.

CNNC's Research Institute of Physical and Chemical Engineering of Nuclear Industry is a major research institute for uranium isotope separation technology and equipment. Other research areas include isotope separation, ultra-clean filtration, mechanical design and manufacturing, laser physics, electromechanics and self-production, new materials, industrial chemicals, physical and chemical analysis, photoelectric technology, scientific and technological information, environmental evaluation, quality assurance, nuclear fuel cycle and materials, fluid physics, laser application and separation technology, separation of special materials, control and detection technology, and machining process research.[1580]

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- Pulsed CO2/pulsed gas lasers, magnetic pulses[1581]

**Notable Applications:**

None found

**Leadership and Key Personnel:**

None found

**Notable Collaborations:**

*Domestic*

- This lab co-organized dual 2018 conferences, "Advanced Laser Technology and Applications Seminar" [先进激光技术及应用研讨会] and "Opto-electronic Defense Technology and Applications Seminar" [光电防御技术及应用研讨会], which were held

together. Topics included gas, chemical, and fiber lasers, solid and semiconductor lasers, and opto-electronic defense. Participants included personnel from the CETC 53rd RI, CETC 46th, 38th, 36th, and 11th RIs, Army Aviation Academy, CSSC 718th RI, CAEP, NUDT (presenting on "Coherent laser detection and identification of target movement characteristics" [目标徽动特征相干激光探测识别问题]), Chinese Academy of Military Sciences (presenting on "Establishing UAV defense systems" [建设无人机防御体系], PLAAF Research Academy (presenting on "Airborne Self-Defense Laser Weapon System Requirements" [机载自卫激光武器系统需求]), China Armaments and Equipment Research Academy [中国兵器装备研究院], CASIC 2nd Academy 306th RI, and many more.[1582]

**Lab Equipment:**

None found

**Address**:

Tianjin 300180 [天津市][1583]

**Known Aliases:**

- Science and Technology on Particle Transport and Separation Laboratory
- Key Laboratory of Science and Technology on Particle Transport and Separation
- 粒子输运与富集技术重点实验室
- 粒子输运与富集技术国防重点实验室

## 67. Defense S&T Key Laboratory of Plasma Physics

**Official English Name:** Unknown

**Chinese Name:** 等离子体物理国防科技重点实验室

**Post-2024 Name:** likely National Key Laboratory of Plasma Physics[xcii] [等离子体物理全国重点实验室][1584]

**Research Focus:**

Domain:

- Nuclear

Equipment:

- Nuclear Weaponry & Power

Functional Field:

- Plasma Technologies
- *Secondary: Laser Technologies*

**Affiliations:**

- Chinese Academy of Engineering Physics [中国工程物理研究院]
    - Research Center of Laser Fusion [激光聚变研究中心]
        - *a.k.a. CAEP 8th Research Institute [第八研究所]*
- (Possibly) Wenzhou University [温州大学]

**Key Data:**

- Established: 1991[1585]
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab was founded in 1991 as one of the first Defense S&T Key Labs.[1586] It is primarily focused on research into nuclear and particle physics, including high energy density physics, laser acceleration, and ignition, utilizing laser devices such as the Shenguang II [神光 II], Shenguang

[xcii] Literal translation, no official name given

III, and Starlight III [星光 III].[1587] Its association with CAEP indicates this research is intended for both nuclear weapons as well as nuclear energy.

The lab's current parent institution, the CAEP Research Center of Laser Fusion (RCLF) (a.k.a. the CAEP 8th Institute), was established in 2000 and conducts laser fusion research, including precision diagnostics, target materials and preparation, and development of large-diameter optics and high-power laser devices.[1588]

In its early years, the lab may have been known as the "Defense S&T Key Laboratory of High-Temperature, High-Density Plasma Physics [高温高密度等离子体物理国防科技重点实验室]. In late 2023, a new lab by the name of the National Key Laboratory of Plasma Physics [等离子体物理全国重点实验室] was inaugurated. The new lab appears to be jointly run by the CAEP Laser Fusion Research Center and Wenzhou University (while this is never explicitly stated, the two sides repeatedly discuss cooperation, CAEP RCLF leaders were on hand for the opening ceremony, and the lab's Deputy Director is affiliated with RCLF).[1589] Another source seems to confirm the lab remains affiliated with CAEP in 2024.[1590] Its new name suggests it is now part of the ostensibly civilian National Key Lab system, although its continued affiliation with CAEP suggests that it will continue to conduct military and dual-use research. Confirming this, the source announcing the commencement of the new lab repeatedly acknowledges the importance of its research to national defense construction.[1591]

**Research Direction:**

No formal research direction found, but research focuses broadly on lasers and high-energy density physics.[1592]

**Notable Applications:**

- In 2024, this lab worked with Peking University School of Physics' Institute of Heavy Ion Physics [北京大学物理学院重离子物理研究所] and the CAEP Shanghai Laser Plasma Institute [上海激光等离子体研究所] to develop the first three-dimensional synchronized plasmon illumination technique to achieve a relative error in time synchronization accuracy of less than 10 picoseconds (10-11 seconds) [三维同步质子照相技术，实现时间同步精度相对误差小于 10 皮秒(10-11 秒)]. In the previous year, this lab worked with the same PKU research team to create a new laser-drive short-pulse neutron source.[1593][xciii]

**Leadership and Key Personnel:**

- Director: Zhu Shaoping [朱少平]

[xciii] Further details are available.

    - Researches laser fusion plasma physics, high-energy density physics
    - Studied in Japan in the 1990s
    - Has been awarded 5 Military S&T Progress 1st Class awards [军队科技进步奖一等奖],[1594] indicating major contributions to PRC military development, likely related to its nuclear program
    - Serves as Chief Scientist, Defense Basic Research Nuclear Science Challenge Program, Topical High Energy Density Science Area[1595]
- Deputy Directors: Li Lin [李林],[1596] Zhou Weimin [周维民],[1597] Chen Min [陈民],[1598] Gu Yuqiu [谷渝秋][1599]
    - Li Lin serves as CAEP RCLF S&T Committee Deputy Director and CAEP RCLF Target S&T Department [靶科学与技术部] Director, among many other positions
    - Li specializes in special microstructural functional materials and their applications in thermonuclear fusion targets
    - Zhou Weimin's research interests in theoretical, simulation and experimental high energy density physics, laser acceleration, fast ignition physics

**Notable Collaborations:**

*Domestic*

- In 2024, this lab worked with Peking University's School of Physics Institute of Heavy Ion Physics [北京大学物理学院重离子物理研究所] and the CAEP Shanghai Laser Plasma Institute [上海激光等离子体研究所] to develop the first three-dimensional synchronized plasmon illumination technique to achieve a relative error in time synchronization accuracy of less than 10 picoseconds (10-11 seconds) (See "Notable Applications" above).
- In 2024, this lab co-organized the 4th National Symposium on the Frontiers of Strong Laser and Particle Beam [第四届全国强激光与粒子束前沿学术研讨会], along with the Chinese Nuclear Society [中国核学会], Wenzhou University, the Jiangsu Province Laser Intelligent Equipment Technology Innovation Center [浙江省激光智能装备技术创新中心], and several other labs and research institutions. Research topics included strong laser physics, inertial confinement fusion physics, high-power microwave technology, pulsed power, particle beam and accelerator technology, nuclear science, laser detection and intelligent systems, lasers and optical field control, and other topics.[1600]

*International*

- In 2023, this lab co-organized the International Conference on Matter and Radiation at Extremes (ICMRE) [极端条件下的物质与辐射国际会议], along with Beijing Normal University and CAEP. Research topics included Fundamental Physics in Extreme Light, Physics of inertial confinement fusion, radiation and hydrodynamics, and high-pressure physics and materials science. The event featured scholars from over 10 countries, including the U.S. Department of Energy, University of Washington (U.S.), France, Germany, Canada, and Russia.[1601]

- In 2016, this lab hosted a workshop on high energy density physics which featured participation from a professor of the University of Texas at Austin in the U.S., who presented recent results on the TPW laser at the University of Texas, in which GeV electrons obtained by tail-field electron acceleration were used to bombard a high-Z tungsten target. A professor of the Institute of Laser Engineering, Osaka University, (Japan) gave a report on applications of ultra-intense laser accelerated ions for fast ignition and neutron sources, collision-less excitations driven by radiative pressure, and "Externally Strengthened Magnetic Fields on the Process of Excitation Generation." A second professor from Osaka University presented on "Optimization of Laser Illumination Configuration," which demonstrated and discussed some of the results on the inertial confinement of fusion irradiation inhomogeneity by direct-drive lasers. The participants made plans for further future cooperation.[1602]

**Lab Equipment:**

- As stated above, this lab utilizes the Starlight III laser, as well as other superintense laser devices such as Silex II and the upgraded Shenguang II. It has used these to carry out experimental research on the generation and application of intense radiation sources such as protons, X-rays and neutrons.[1603]
- This lab manages the Starlight-III laser device [星光-III激光装置], which went into operation in 2014. Starlight-III is a multifunctional laser device with "zero jitter" synchronous output of nanoseconds, picoseconds and femtoseconds, three pulse widths (527nm, 1053nm and 800nm), and three wavelengths of laser light. The device is equipped with a pinhole camera, electron spectrometer, single-photon CCD, and other advanced diagnostic equipment. It can be used for high energy density physics, strong radiation source generation, astrophysics and other experiments. It is designed to provide favorable conditions for basic experimental research of high energy density physics, strong radiation source generation, astrophysics, and other fields, as well as basic experimental research of extreme physical processes.[1604]
- This lab has an "Ultra-strong, Ultrashort Pulsed Laser Applied Basic Research Laboratory" [超强超短脉冲激光应用基础研究实验室][1605] which is equipped with a femtosecond solid-state high-power laser and the PRC's first ultra-high-power titanium gemstone laser device with 300TW (3 × 1014W) of power. This reportedly makes it among the most powerful in the world at this time. Per one source, such a strong laser can produce extreme physical conditions in the laboratory that cannot be realized by other technical means, such as electric fields of 1 trillion volts per centimeter, magnetic field of 1 billion gauss, pressure of 1 billion billion billion pascals, and the density and temperature of matter similar to the interior of the star. This make it well suited to research on fast ignition of laser fusion, superhot matter, strong radiation sources, laser particle acceleration, new light sources, astrophysics, relativistic plasma physics, nuclear physics, material science, life science, and other scientific fields.[1606]

**Address**:

Mianyang, Sichuan Province [四川省绵阳市]

**Known Aliases:**

- 高温高密度等离子体物理国防科技重点实验室
  - Former Name
- 高温高密度等离子体物理国家重点实验室
  - Possible newest name

## 68. Defense S&T Key Laboratory of Precision Guidance and Automatic Target Recognition

**Official English Name:** Unknown

**Chinese Name:** 精确制导自动目标识别国防科技重点实验室

**Post-2024 Name:** possibly National Key Laboratory of Automatic Target Recognition (ATR)[xciv] [ATR 全国重点实验室][1607]

**Research Focus:**

Domain:

- Air

Equipment:

- Non-Ballistic Missiles

*Secondary: Radar*

Functional Field:

- Target Detection/Recognition
- *Secondary: Air/Missile Defense, GNC, Information Processing, Intelligent Technologies, Microwave Technologies, Millimeter Wave Technologies, Sensing, Terahertz Technologies*

**Affiliations:**

- National University of Defense Technology (NUDT) [国防科技大学]
    - College of Electronic Engineering [电子科学学院]
- Shenzhen University
- Additional branches of unknown subordination at Xiamen University, Beihang University, and University of Electronic Science and Technology of China (UESTC)

**Key Data:**

- Established: 1992
- Total Funding: Unknown
- Personnel: 14 (Shenzhen)[1608]
- Official start of operations: Unknown
- Floor Space: 2,153 sqm (Shenzhen)

[xciv] Literal translation, no official name given

**Lab Overview:**

This lab conducts research on automatic target recognition (ATR) for radar and missile guidance. This lab has taken a leading role in the development of ATR technology for precision weapons in China.[1609]

While the lab's primary headquarters is at NUDT, it has a second, co-equal branch, called the ATR Defense S&T Key Laboratory Intelligent Information Processing Lab [ATR 国防科技重点实验室智能信息处理实验室], at Shenzhen University. It also has satellite branches at Xiamen University, known as the 6th Research Office [第六研究室], Beihang University, and the University of Electronic Science and Technology of China in Chengdu.[1610]

Under the ongoing reorganization of the PRC's national key lab system, this lab is now known as the National Key Lab of ATR.

**Further Information:**

- Far more information is available about the lab's Shenzhen branch. The ATR Defense S&T Key Laboratory of Intelligent Information Processing [ATR 国防科技重点实验室智能信息处理实验室] was established in April 2001 and formally inaugurated on 18 October 2001. It was inspected and approved on 18 September 2003 by the Shenzhen Science, Technology, and Information Bureau. It was a joint project of the PLA GAD and Shenzhen municipal government, and overseen by the GAD (now CMC Equipment Development Department) and COSTIND (now SASTIND). Its research focuses on sensor networking systems, sensor information fusion, sensor network information security, infrared, optical, and remote sensing image processing, and terahertz imaging technology. It houses nine specialist labs, including a multi-sensor networking system laboratory, embedded system laboratory, RF laboratory, infrared radar laboratory, microwave radar laboratory, terahertz laboratory, remote sensing laboratory, information security laboratory, and image and video laboratory. As of 2017, it has 14 fixed personnel, with 19 PhD students and 59 master's degree students.[1611]
- This lab oversees the subordinate ATR-3 Lab at NUDT, which conducts research into optical image automatic target recognition, embedded information processing, and intelligent image processing services for the aerospace, security, and surveillance industries.[1612]
- A recruitment notice from 2016 for this lab indicates it was interested in recruiting optical, mechanical, laser, and circuit development engineers, as well as radar target recognition technology developers.[1613]

**Research Direction:**

1. Sensor networking systems [传感器组网系统]

2. Sensor information fusion [传感器信息融合]
3. Sensor network information security [传感器网络信息安全]
4. Infrared, optical, remote sensing image processing [红外、光学、遥感图像处理]
5. Terahertz imaging technology [太赫兹成像技术][1614]

*Other Notable Research Areas:*

- Detection and tracking of small infrared targets[1615]
- Millimeter-wave automatic target recognition[1616]
- Infrared automatic target recognition[1617]

The lab has an "ATR Spring Rain Fund" [ATR 春雨基金] which allocates funding for three areas related to ATR:

- Advanced detection systems
- Data knowledge engineering
- Intelligent algorithm applications[1618]

In 2020, the lab provided funding for six research areas (providing 300k RMB in funding for each):

- Static image data dynamization technology for photoelectric sensors
- Target representation model construction for unmanned platform information assurance applications
- Underwater target detection technology in hyperspectral image data
- Intelligent separation technology of complex backgrounds and low-observable targets
- Measurement and extraction of motion features based on vortex light
- Embedded intelligent information processing systems architecture and implementation specifications[1619]

Per a 2017 Shenzhen Branch recruitment notice, the lab is recruiting in the following areas:

- Intelligent sensing network systems
- Image processing and recognition
- Information fusion[1620]

**Notable Applications:**

- This lab has played a major role in the development of the PRC's recent air and missile defense systems. This lab's Technical Innovation Team [技术创新团队] has been working on air and missile defense target information processing projects since the 8th Five Year Plan (1991-1995). This team specializes in developing the "brains" and "eyes" for these missiles (likely reference to the missile's internal computer and guidance systems), making them more accurate. Known examples of missile development include:

- In 2001, the lab worked on an unidentified "Assassin's Mace" weapon. Current Deputy Director Xie Honghong was on this team.
- The lab developed the guidance system for a major new missile system utilizing ATR around 2007. This was considered a turning point and led increased PLA interest in incorporating ATR. This could be a reference to the KT-1 [开拓者一号] anti-satellite missile, which conducted a successful launch in 2007.
- During the 11th Five Year Plan (2006-2010) the lab's Technical Innovation Team developed an unidentified piece of equipment which contributed to China's first land-based mid-course anti-missile test [陆基中段反导试验]. This is an apparent reference to the PRC's first anti-ballistic missile test in 2010. It also successfully tested equipment in the 10th, 12th, and 13th Five Year Plans.
- The Technical Innovation Team conducted a successful anti-missile defense test in the Gobi Desert in July 2017 which introduced AI into target recognition. It again tested this missile in February 2018. This is likely a reference to the DN-3 [动能三号] anti-ballistic missile system (which held launches around both these dates), implying that this lab helped develop the ATR guidance functions of the DN-3.[1621]

- In July 2020, this lab's New Systems Technical Research Office [新体制技术研究室], which specializes in precision strike weapons, researched a new weapons system (from context, a missile system). This team develops missile "brains" [大脑], and is concerned with radar and infrared guidance. It incorporates ATR in order to lift the electronic "fog" from the modern battlefield. Unofficial observers speculated that this test may be referring to the CJ-100 cruise missile.[1622]
- This lab provided technical support to improve the ATR capabilities for an unidentified new precision-guided weapons system. The lab established a new research lab fuzing millimeter wave ATR and infrared ATR to conduct research on new intelligent target recognition technologies for precision weapons.[1623]
- Former Director Guo Guirong has been involved in development of ship radar target automatic identification systems, air target electromagnetic feature extraction and identification systems, broadband radar target automatic identification systems for ships, armor, aircraft and other targets, radar anti-interference systems, and radar jamming automatic identification systems.[1624]
- This lab's Xiamen University branch developed computer chips for the Beidou satellite. It also developed technology related to "self-organizing network communications."[1625]

**Leadership and Key Personnel:**

- Director, Shenzhen Branch: Xie Weixin [谢维信][1626]
- Director, Xiamen Branch: Shi Jianghong [石江宏][1627]
- Director, Beihang Branch: Wang Jun [王俊][1628]
- Deputy Directors: Zhuang Zhaowen [庄钊文]; Xie Honghong [谢红红][1629]

    - Holds the rank of either Major General or senior uniformed civilian cadre in the PLA
    - Member of the American Society for opto-electronic Engineering, and is an expert in signal processing and ATR for radar and precision guidance.
- Deputy Managing Director: Wang Zhuang [王壮][1630]

*Key Personnel:*

- Guo Guirong [郭桂蓉][1631]
    - PLA Lieutenant General
    - CAE Academician
    - Lab director from inception in 1992 to 2017, still serving as honorary director
    - Designed a wide range of ship and aircraft radar and target recognition systems

**Notable Collaborations:**

*Domestic*

- This lab has established a joint base with the China Association for Science and Technology (CAST).[1632]
- This lab co-hosted the 2nd Aerospace Cup [空天杯] competition in 2019 with multiple other institutions, including SASTIND, CASIC, the SASTIND Aerospace Defense Innovation Center [国防科技工业空天防御创新中心], the Chinese Society of Astronautics [中国宇航学会], CASIC 2nd Academy 2nd Department [中国航天科工二院二部], the Defense S&T Innovation Base Strategic Alliance [国防科技创新基地战略联盟], CASC 8th Academy 8th Department [中国航天科技八院八部], CASIC 10th Academy 10th Department [中国航天科工十院十部], the Beijing Simulation Center [北京仿真中心], DaoCloud, and multiple key laboratories and universities.[1633]
- Personnel of this lab, including Guo Guirong and Xiamen Branch Director Shi Jianghong, are associated with an experts group in collusion with the Xiamen Yaxun Network Co. [厦门雅迅网络股份有限公司], which is itself a subsidiary of the CETC 30th RI [中国网安] and conducts research into satellite navigation, among other things.[1634]

*International*

- Lab Deputy Director Zhuang Zhaowen, a senior PLA officer and expert in automatic target recognition in radars, is also allegedly a member of the American Society for Opto-electronic Engineering.[1635]
- This lab was heavily involved in a 2009 Conference held at Shenzhen University, the 2nd Shenzhen International Conference on Advanced Science and Technology, with the lab's Shenzhen director chairing.[1636]

**Lab Equipment:**

- The lab's Shenzhen Branch website includes extensive writeups of its nine subordinate labs, including lists of specific equipment owned by the labs. This includes advanced equipment from U.S. companies Agilent, Intel, and others, possibly in violation of U.S. Government export controls.[xcv] [1637]
- Shenzhen has nearly 550 sets of instruments (another source from 2017 claims 680), and over 30m RMB (per the same 2017 source, 33.35m RMB) in fixed assets. It has over 12m RMB in "valuable" (i.e. worth over 300k RMB) equipment.[1638]

**Address**:

NUDT Courtyard 1, No. 109 Deya Road, Kaifu District, Changsha, Hunan Province [湖南省长沙市开福区德雅路 109 号国防科技大学一号院内][1639]

Shenzhen Branch: Shenzhen University S&T Building 15 [广东省深圳市南海大道深圳大学科技楼 15 楼][1640]

**Website**:

Shenzhen Branch website: https://it.szu.edu.cn/gfkjzdsys/index.htm

**Known Aliases:**

- National Key Laboratory of Automatic Target Recognition (ATR) [自动目标识别(ATR)国家级重点实验室]
    - This name is more common: the "Precision Guidance and…" [精确制导与] part is oftentimes omitted
- National Key Laboratory of Precision Guidance and Automatic Target Recognition [精确制导与自动目标识别(ATR)国防科技实验室]
- Defense S&T Key Laboratory of Automatic Target Recognition (ATR) [自动目标识别(ATR)国防科技重点实验室]
- ATR Key Laboratory [ATR 重点实验室]
- ATR Key Laboratory of Defense Science and Technology [ATR 国防科技重点实验室]
- National Lab of ATR (or ATR National Lab)
- Key Lab of ATR
- Automatic Target Recognition Laboratory of National University of Defense Technology

[xcv] Lists of lab equipment are available upon request.

## 69. Defense S&T Key Laboratory of Precision Hot Processing of Metals

**Official English Name:** National Key Laboratory for Precision Hot Processing of Metals[1641]

**Chinese Name:** 金属精密热加工国防科技重点实验室

**Post-2024 Name**: No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Multi-Domain

Equipment:

- Multiple (Semiconductors, likely others)

Functional Field:

- Materials
- *Secondary: Intelligent Technologies*

**Affiliations:**

- Harbin Institute of Technology (HIT) [哈尔滨工业大学]
    - School of Materials Science and Engineering [材料科学与工程学院]

**Key Data:**

- Established: Unknown
- Total Funding: 80m RMB (as of 2016)
- Personnel: Unknown[1642]
- Official start of operations: 1996
- Floor Space: 6,600 sqm

**Lab Overview:**

This lab conducts research into advanced hot processing, including precision casting and forming, welding, heat management, and automation and intelligentization of these processes. It is a significant source of national defense funding related to precision hot processing technology.[1643]

**Further Information:**

- This lab may have a subordinate Rapid Solidification Lab [快速凝固实验室] as well as a Fluid High-pressure Forming Technology Research Results Hall [流体高压成形技术研究成果展厅].[1644]
- In September 2020, personnel with the State Nuclear Power Technology Corporation took a tour of this lab, indicating a possible role in materials related to nuclear technology.[1645]

**Research Direction:**

1. Precision hot processing and forming of advanced materials
2. Precision casting [精密铸造]
3. Precision plastic forming [精密塑性成形]
4. Special heat management [特种热处理]
5. Automation and intelligentization for precision hot processing [精密热加工工艺过程自动化和智能化][1646]

**Notable Applications:**

None found

**Leadership and Key Personnel:**

- Director: Yuan Shijian [苑世剑][1647]
- Deputy Director: Su Yanqing [苏彦庆][1648]

**Notable Collaborations:**

*Domestic*

- This lab established the Joint Laboratory of Aerospace Metallic Materials [航空航天金属材料联合实验室] and Joint Laboratory for Welding of Metallic Materials [金属材料焊接联合实验室] with three National Key Labs in 2019. The three other labs were the State Key Laboratory of Advanced Welding and Joining [先进焊接与连接国家重点实验室], State Key Laboratory of Comprehensive Utilization of Vanadium and Titanium Resources [钒钛资源综合利用国家重点实验室], and State Key Laboratory of Metal Materials for Marine Equipment and Their Applications [海洋装备用金属材料及其应用国家重点实验室]. The SOE Ansteel Group [鞍钢集团] was also involved in this effort.[1649]

*International*

- A researcher at this lab, Shen Hongxian, was a visiting scholar at South Florida University from 2014-2015 and has since written at least four collaborative papers on microwires with researchers from this university.[1650]
- Lab researchers wrote a 2018 paper on "Advances in the research of metal-intermetallic compound laminated composites" with University of Waikato, New Zealand.[1651]

**Lab Equipment:**

This lab is equipped with numerous pieces of foreign-made equipment, including U.S. equipment (possibly in violation of U.S. Government export controls), including:

- Vacuum/atmosphere hot pressing sintering furnace (U.S.)
- Rapid mold making system (U.S.)
- Wax pressing machine (U.S.)
- Dewaxing machine (U.S.)
- PHI5700XPS/AES surface analysis system (U.S.)
- High-temperature high-pressure gas quenching furnace (France)
- Medium water-cooled copper crucible vacuum induction melting furnace (Germany)
    - 6TP, melting temp 2500C, vacuum level $5x10^{-5}$mbar)
- Double-roller thermal precision spinning machine (Spain)
- Multi-arc ion plating device (Russia)

Other lab equipment includes:

- Rapid solidifying powder and jet forming machine
- Vacuum high temperature roasting furnace
- 5000 KN Super Plastic Forming Machine
- 10000 KN high energy screw press
- 50 KJ Electromagnetic forming machine
- 20000 KN internal high pressure forming machine
- Plasma source ion injection device
- Semiconductor laser welding machine[1652]

**Address**:

There are multiple addresses associated with this lab:

Address in Baidu Map: Building A2, Office 108, Fuhua 2nd Road, Nangang District, Harbin, Heilongjiang Province [黑龙江省哈尔滨市南岗区复华二道街 A2 栋 108 室]

Harbin Institute of Technology, Building 10 [哈工大精密热加工国防科技重点实验室 10 号楼][1653]

Harbin Institute of Technology 1st School District, Hot Processing Building [哈尔滨工业大学一校区热加工楼][1654]

**Website**:

http://mse.hit.edu.cn/2015/0708/c3817a99884/page.htm

**Known Aliases:**

- National Key Laboratory for Precision Hot Forming of Metals [金属精密热加工国家级重点实验室]

## 70. Defense S&T Key Laboratory of Radar Signal Processing

**Official English Name:** National Key Laboratory of Science and Technology on Radar Signal Processing *or* National Laboratory of Radar Signal Processing *or* National Key Laboratory of Radar Signal Processing[1655]

**Chinese Name:** 雷达信号处理国防科技重点实验室

**Post-2024 Name:** National Key Laboratory of Radar Signal Processing [雷达信号处理全国重点实验室][1656]

**Research Focus:**

Domain:

- Air

Equipment:

- Radar

Functional Field:

- Information Processing
- *Secondary: Imaging, Intelligent Technologies, Simulation & Modeling, Target Detection/Recognition*

**Affiliations:**

- Xidian University [西安电子科技大学]
    - School of Electronic Engineering [电子工程学院]

**Key Data:**

- Established: 1991
- Total Funding: Unknown
- Personnel: 64[1657]
- Official start of operations: 1995
- Floor Space: 5,200 sqm

**Lab Overview:**

The Defense S&T Key Laboratory of Radar Signal Processing was part of the first batch of key labs established in 1991. It conducts research related to radar signal and data processing, detection systems, and information acquisition and processing. This lab is ranked first in China in the field of signal and information processing. As part of the larger systemic reform of the PRC

research system, in 2023 the lab was reorganized as the National Key Laboratory of Radar Signal Processing [雷达信号处理全国重点实验室].[1658]

The predecessor to this lab was the Digital Signal Processing Small Group [数字信号处理小组], established in 1974. In 1980, it became the Electronic Engineering Research Institute [电子工程研究所] (also known as the "Electronics Institute" [电子所], as it is still sometimes referred to today).[1659]

Of note, the field of target recognition was a long-term bottleneck technology for the PRC. It was considered a high difficulty area and faced many setbacks and little progress for a long period before the arrival of current Director Liu Hongwei at this lab. Liu's team eventually made a major breakthrough in target classification for which it won a 2nd Class National Technology Invention Award [国家技术发明二等奖] in 2015. This research has since become standard on PLA radars, giving them the ability to identify targets and other detailed information.[1660]

**Further Information:**

- On this lab's website, all images of the banner including the words "National Defense" [国防] are censored out. Similarly, the lab's origins are simply described as coming from generic "government investment" on the English website.[1661]
- This lab has 5 subordinate Research Offices [研究室], numbered 1 to 5:
    - *1st Office*: oversees research into New System Radars [新体制雷达] and Precision Guided Radars [精确制导雷达]
    - *2nd Office*: oversees High Speed Time-Realistic Signal Processing [高速时实信号处理] and Radar System Modeling Simulation [雷达系统建模仿真]
    - *3rd Office*: oversees Array Signal Processing [阵列信号处理] and Adaptive Signal Processing [自适应信号处理]
    - *4th Office*: oversees Radar Imaging [雷达成像] and Battlefield Reconnaissance Radar [战场侦察雷达]
    - *5th Office*: oversees Radar Target Identification [雷达目标识别], Broadband Radar Signal Processing [宽带雷达信号处理], and Network Radar Technology [网络雷达技术][1662]
- The lab has a subordinate National Model International Science and Technology Cooperation Base [国家示范型国际科技合作基地] and National Local Joint Engineering Research Center for Civil Radar [民用雷达国家地方联合工程研究中心].[1663]
- In 2019, Liu Hongwei was put in charge of the National-Local Joint Engineering Research Center [民用雷达国家地方联合工程研究中心], which aims to take radar technology developed for military use and transfer it to civilian applications.[1664]

**Research Direction:**

Updated research direction from 2022:

1. Theory and Methods of Target Detection Systems [目标探测体制理论与方法]
2. Radar Imaging Theory and Methods [雷达成像理论与方法]
3. Intelligent Information Processing Theory and Applications [智能信息处理理论及应用]
4. Multi-dimensional Signal Design and Processing [多维信号设计与处理][1665]

An older research direction (pre-2022) was as follows:

1. Radar data and signal processing [雷达数据信号处理]
2. Radar detection system technology [ 雷达探测系统技术]
3. Intelligent information acquisition and processing [智能信息获取与处理]
4. Radar imaging and target identification [雷达成像与目标识别]
5. Multi-dimensional multi-channel information acquisition and processing [多维多通道信息获取与处] [1666]

*Other Notable Research Areas:*

- STAP and array signal processing
- Radar imaging and automatic target recognition
- Radar system and emerging radar techniques
- High speed parallel processing algorithm
- Radar system modeling and simulation
- High-speed digital signal processor design
- Distributed Small Satellite SAR InSAR-GMTI Processing
- Adaptive side flap phase cancellation
- Array signal processing
- Space-time two-dimensional adaptive signal processing
- Sparse array integrated pulse aperture radar technology
- Radar imaging
- Radar automatic target identification
- Research into Rydberg atomic receivers
    - Considered a high difficulty subject with little relation to signal processing, but will have major implications for future radars[1667]

**Notable Applications:**

- This lab has played a major role in the development of the PRC's recent air and missile defense systems. This lab's Technical Innovation Team [技术创新团队] has been working on air and missile defense target information processing projects since the 8th Five Year Plan (1991-1995). This team specializes in developing the "brains" and "eyes" for these

missiles (likely reference to the missile's internal computer and guidance systems), making them more accurate. Known examples of missile development include:

  - In 2001, the lab worked on an unidentified "Assassin's Mace" weapon. Current Deputy Director Xie Honghong was on this team.
  - The lab developed the guidance system for a major new missile system utilizing ATR around 2007. This was considered a turning point and led increased PLA interest in incorporating ATR. This could be a reference to the KT-1 [开拓者一号] anti-satellite missile, which conducted a successful launch in 2007.
  - During the 11th Five Year Plan (2006-2010) the lab's Technical Innovation Team developed an unidentified piece of equipment which contributed to China's first land-based mid-course anti-missile test [陆基中段反导试验]. This is an apparent reference to the PRC's first anti-ballistic missile test in 2010. It also successfully tested equipment in the 10th, 12th, and 13th Five Year Plans.
  - The Technical Innovation Team conducted a successful anti-missile defense test in the Gobi Desert in July 2017 which introduced AI into target recognition. It again tested this missile in February 2018. This is likely a reference to the DN-3 [动能三号] anti-ballistic missile system (which held launches around both these dates), implying that this lab helped develop the ATR guidance functions of the DN-3.[1668]

- In July 2020, this lab's New Systems Technical Research Office [新体制技术研究室], which specializes in precision strike weapons, researched a new weapons system (from context, a missile system). This team develops missile "brains", and is concerned with radar and infrared guidance. It incorporates ATR in order to lift the electronic "fog" from the modern battlefield. Unofficial observers speculated that this test may be referring to the CJ-100 cruise missile.[1669]
- This lab provided technical support to improve the ATR capabilities for an unidentified new precision-guided weapons system. The lab established a new research lab fusing millimeter wave ATR and infrared ATR to conduct research on new intelligent target recognition technologies for precision weapons.[1670]
- Former Director Guo Guirong has been involved in development of ship radar target automatic identification systems, air target electromagnetic feature extraction and identification systems, broadband radar target automatic identification systems for ships, armor, aircraft and other targets, radar anti-interference systems, and radar jamming automatic identification systems.[1671]
- This lab's Xiamen University branch developed computer chips for the Beidou satellite. It also developed technology related to "self-organizing network communications."[1672]

**Leadership and Key Personnel:**

- Director, Shenzhen Branch: Xie Weixin [谢维信][1673]
- Director, Xiamen Branch: Shi Jianghong [石江宏][1674]
- Academic Comittee Director: Wu Yirong [吴一戎][1675]

- Deputy Directors: Zhuang Zhaowen [庄钊文]; Xie Honghong [谢红红][1676]
    - Holds the rank of either Major General or senior uniformed civilian cadre in the PLA
    - Member of the American Society for Opto-electronic Engineering, and is an expert in signal processing and ATR for radar and precision guidance.
- Deputy Managing Director: Wang Zhuang [王壮][1677]

*Key Personnel:*

- Guo Guirong [郭桂蓉][1678]
    - PLA Lieutenant General
    - CAE Academician
    - Lab director from inception in 1992 to 2017, still serving as honorary director
    - Designed a wide range of ship and aircraft radar and target recognition systems

**Notable Collaborations:**

*Domestic*

- This Lab has (or had) joint labs with Chinese companies SBS, ALTEA (Lab of Programmable Devices [可编程器件实验室]), and Cadence (Northwest China Technical Support and Training Center [中国西北技术支持与培训中心]).[1679]
- The lab cooperated with ZTE on the project, "W-CDMA system simulation and software radio implementation structure using intelligent antenna space-time signal processing technology" [利用智能天线空时信号处理技术的 W - CDMA 系统仿真和软件无线电实现结构].[1680]
- The lab collaborated with NORINCO 212 Research Institute [212 所] on the project, "Fuze System Modeling and Simulation" [引信系统建模与仿真].[1681]
- This Lab had a part in establishing the Radar Signal Processing Lab at Xiamen University.[1682]
- In 2012, the Lab hosted a conference on the theme of "Seminar on Advanced Radar and Countermeasures Technology" [雷达与对抗先进技术研讨]. Participants included individuals from the PLAAF Equipment Research Department, CASIC 2nd Academy 23rd RI, CETC 38th RI and 14th RI, and the National Defense University of Science and Technology. Topics included the development of air defense and early warning radar systems, countermeasures for early warning and surveillance radars, airborne early warning radars, system radar-distributed aperture phase-reference synthetic radars, target detection and identification based on polarized SAR, radar detection technology for shallow buried targets on the surface, multi-source heterogeneous information fusion algorithm based on random set theory, cooperative visual computing, and parametric radar signal processing theory and applications.[1683]

- As part of Plan 2011 [2011 计划], this Lab is part of a collaborative effort with CETC and possibly others to form a "Collaborative Innovation Center of Information Perception Technology."[1684]
- As of 2018, this Lab's academic committee includes individuals from the PLAAF Equipment Research Academy, PLAN Equipment Research Academy, Joint Staff Department Survey and Mapping Research Institute (now possibly the SSF Battlefield Research Institute), NORINCO, CALT Research and Development Center, CETC 14th and 20th RIs, CETC 2nd Academy 23rd RI, NORINCO 206th RI, and NUDT (list available, with individual names).[1685]
- The lab is involved in developing radars for autonomous vehicle navigation. Per one source, it is developing a 77 GHz 4D millimeter wave radar with a subsidiary of Suzhou Inovance Automotive Co. [苏州安智汽车].[1686]
- The lab collaborated with PLA Unit 63610 to research electromagnetic jamming.[1687]
- Images show visits from senior PLAAF personnel, including former Commander Xu Qiliang.[1688]
- This Lab hosted the 4th Electronic Information Young Scholars Forum in 2019. A professor from PLAAF Engineering University gave a talk on key problems in cognitive electronic warfare [认知电子战].[1689]

*International*

- This Lab manages a 111 Plan Innovation Base [“111 计划”创新引智基地] for "Radar cognitive detection imaging recognition" [雷达认知探测成像识别]. 111 Plan's stated aim is to establish such innovation bases to attract top foreign talent, spurring civilian and military tech transfer. This base has established joint research centers with Syracuse University and the University of Pisa in Italy.[1690] The Syracuse collaborative center is called the International Center for Information Fusion. According to a Syracuse press release, this technology can be applied to "health, the environment, and security."[1691] The Pisa collaboration is known as the Joint Center for Cognitive Signal Processing [认知信号处理联合研究中心].
- In 2019, the base held the 2nd International Workshop on Signal and Information Intelligent Learning and Processing (SIILP 2019) [信号与信息智能学习与处理国际研讨会]. Foreign speakers came to this 111 Plan Base from Columbia University, New York University, University of Maryland, MESA Lab of UC Merced, Temple University, University of Oklahoma, Akron University, San Francisco State University and Bell Labs in the US, as well as academic institutions from the UK (University of Birmingham), Italy (University of Pisa, Parthenope University of Naples), Switzerland (Swiss Federal Technology Institute of Lausanne), and Australia (University of Wollongong), (complete list of speakers and topics available). Topics discussed included cognitive learning, deep learning, compressed perception, big data processing, metamaterials, how to improve the

intelligence of modeling, the learning and processing of model parameters in different kinds of signals, and information such as radar, communication, image, hydroacoustic and language. The base is dedicated to development of radar technology in China, focusing on cognitive detection theory and methods, intelligent radar theory and methods, unmanned aircraft swarm cooperative detection theory and methods, etc. It states "introduction of foreign talents" as one of its goals.[1692] Liu Hongwei, who has played a major role in the foreign relations of this base, works on target recognition for military radars.[1693]

- In 2023, Antonio de Maio of the University of Naples Federico II in Italy, a radar signal processing expert who worked with the US Air Force Research Laboratory in 2004, gave a lecture at the lab on recent experimental results.[1694]
- This lab co-organized the 2021 CIE International Radar Conference (Radar 2021) [CIE 国际雷达会议] alongside the Chinese Institute of Electronics [中国电子学会]. PRC participants included personnel from the PLA National University of Defense Technology and CETC 38th RI. Foreign participants came from the U.S. (Syracuse University), Italy (University of Pisa, Sant'Anna School of Advanced Studies), and unnamed research institutions in France. Topics included radar imaging, target detection and tracking, target classification and identification, adaptive signal processing, cognitive radar signal processing, clutter and interference suppression, photon radar, and quantum radar.[1695]
- A graduate student from this lab received further post-doc training at an unnamed university in Italy, and then returned and worked on defense projects in China.[1696]
- In 2016, researcher Yuan Xin of Bell Labs in the U.S. was invited by this Lab to speak about his paper, "Recent Advances in Compressive Sensing", focusing on the hardware implementation of video compression-aware cameras and reconstruction algorithms.[1697]
- French expert Francois Le Chevalier from THALES, an expert on radar target identification and electronic warfare, came to the Lab in 2007 and lectured on MIMO radar, and development of the RIAS system (a French air surveillance radar project).[1698]
- This Lab has a "Model International Science and Technology Cooperation Base" about which no other information was found.[1699]
- In 2007, this Lab signed a cooperation agreement with the German high-tech electronics company Rohde & Schwarz.[1700]
- Between 2003 and 2008, the Lab's website has images documenting multiple visits and exchanges with U.S. researchers, including researchers from Boeing, RAS, University of California, University of Florida, and University of Minnesota, as well as researchers from France, UK, Germany. Another page listing exchanges with foreign scholars between 2001-2005 also includes US companies such as Motorola, MRI Devices, and Broadcom (full list available).[1701]
- Each year the Lab invites 10 foreign scholars for exchanges, and frequently brings in foreign guest lecturers.[1702]

**Lab Equipment:**

- A list of equipment possessed by this lab includes a high amount of foreign equipment, including U.S.-manufactured equipment from companies like Agilent, HP, IBM, and Tektronics.[xcvi]
- The lab has a signal generator, logic analyzer, oscilloscope, and high-performance cluster computing system. It also has advanced instruments for signal generation, test and analysis, data acquisition, and electronic system automation and design.[1703]

Photos of the following lab equipment are available:[1704]

- Rohde & Schwarz SMB 100A Signal Generator (from Germany)
- Radar Network C2 Terminal (ACT-01A from CETC 28th RI)
- S-band Radar Signal Comprehensive Test System
- Low Altitude Environmental Surveillance and Imaging Radar
- Programmable Jamming Simulator
- Advanced Radar and Information Processing System (mounted on military vehicle)
- MIMO System
- Quantum Radar Experimental Platform
- High-speed and high-resolution data recording system
- Precision two-dimensional servo turntable integrated automatic lifting and lowering hoist (mounted on military vehicle)
- Vector Network Analyzer
- External Radiation Source Detection System

**Address**:

S&T Building, Xidian University North Campus [北校区新科技楼][1705]

No. 2 Taibai South Road, Xi'an, Shaanxi Province [陕西省西安市太白南路 2 号][1706]

**Website**:

https://rsp.xidian.edu.cn

**Known Aliases:**

- Xidian Electronics Research Institute [西电电子所]
- National Key Laboratory of Radar Signal Processing [雷达信号处理国家重点实验室]
- Key Laboratory for Radar Signal Processing

[xcvi] A detailed spreadsheet of this Lab's equipment is too long to list here but is available.

- State Laboratory of Radar Signal Processing
- National Laboratory of Radar Signal Processing
- National Key Laboratory of Radar Signal Processing [雷达信号处理全国重点实验室]

## 71. Defense S&T Key Laboratory of Radio Wave Environmental Characteristics and Modeling Technology

**Official English Name:** National Key Laboratory of Electromagnetic Environment (LEME)[1707]

**Chinese Name:** 电波环境特性及模化技术国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Multi-domain (Air, Space, Maritime)

Equipment:

- Multiple (Communications Equipment, Radar, Space Vehicles)

Functional Field:

- Electromagnetics
- *Secondary: Communications Technologies, GNC, Simulation & Modeling*

**Affiliations:**

- China Electronics Technology Group Corporation (CETC) [中国电子科技集团]
  - China Research Institute of Radio Wave Propagation (CRIRP) [中国电波传播研究所]
    - *a.k.a. CETC 22nd Research Institute* [22 研究所]

**Key Data:**

- Established: 1993
- Total Funding: Unknown
- Personnel: 33 (as of 2006)[1708]
- Official start of operations: 1994
- Floor Space: Unknown

**Lab Overview:**

The Defense S&T Key Laboratory of Radio Wave Environmental Characteristics and Modeling Technology conducts research on radio waves and ionospheric characteristics and how these environments affect signals in the aerospace and maritime domains. Applications include radar, communications, and navigation, including for surface vessels and satellites.

The lab's parent institution, CETC's China Research Institute of Radio Wave Propagation (a.k.a. the CETC 22nd Research Institute), focuses on the propagation characteristics of

radio/electromagnetic waves across the electromagnetic spectrum in various media, and their applications. Its research is widely used in radar, communications, navigation, electronic warfare, measurement & control, remote sensing, space, radio interference/jamming, and other fields. It has participated in national key engineering tasks such as the "two bombs and one satellite" (the PRC's first nuclear weapons and satellite), Antarctic communications and research, and the manned space program.[1709]

**Further Information:**

- As of 2006-2007, the lab had three research offices [研究室], which focus on propagation characteristics and modeling of radio waves in the troposphere and ionosphere [电波在对流层、电离层的传播特性与建模], research and modeling of radio wave propagation characteristics in mobile or combat environments [移动或作战环境的电波传播特性研究与建模], and research of special radio wave environment propagation theory and new mechanisms [特种电波环境传播理论与新机理研究], respectively. It also has a database that provides data storage query and computing services.[1710]
- The lab allegedly has a nationwide network of radio environmental monitoring stations [电波环境监测站网] and has built four radio environment observation stations [电波环境观测站] in Singapore and the Arctic (Tromso in Norway, Sodankyla and Oulu in Finland). It has a thirteen-station radio wave observation network at home and abroad which was supported by the PLA GAD Technical Infrastructure Bureau [总装备部技术基础局]. The lab's radio wave environment database is networked with domestic observation stations [观测站] and foreign data centers.[1711]
- The lab integrates measurement, data collection, database modeling and prediction simulation [集测量、数据采集、建库建模、预测仿真于一体].[1712]

**Research Direction:**

1. Propagation characteristics and modeling of radio waves in the troposphere and ionosphere [电波在对流层、电离层的传播特性与建模] and near-Earth space environments [近地空间环境]
2. Propagation characteristics and modeling of radio waves in mobile environments [波在移动环境中的传播特性与建模] and combat environments [作战环境]
3. Propagation mechanisms of radio waves in special media or environments [特殊媒质或环境下电波传播机理]
4. Special radio wave propagation theory and special environment propagation mechanisms [特种电波传播理论研究及特殊环境传播机理][1713]

*Other Notable Research Areas:*

- Use of fundamental data of various radio wave propagation environments
- Spatial/temporal characteristics, variation (laws) and generation mechanisms of loss, reflection, refraction, diffraction, dispersion, scintillation, scattering, polarization, and other higher order effects of radio wave propagation in the space environment from the earth (sea) surface to the troposphere and ionosphere
- Development of radio wave environment and propagation prediction and forecasting methods
- Development of a model suitable for the prediction of practical radio wave environmental characteristics and the correction of radio wave propagation effects required for the operation of China's information technology and aerospace technology
- Predictive modeling, effect simulation, environmental simulation re-engineering, decision-making assistance/support, and adaptive technology
- Millimeter-wave propagation characteristics[1714]

**Notable Applications:**

- The lab has done work with radar, including over-the-horizon radar [超视距雷达], as well as GPS. [1715]
- A list of achievements includes the following technologies developed by the lab:
    - Artificial neural network technology to improve ionospheric harassment forecasting
    - Radar target environment testing technology, with ground and sea surface foreground scattering characteristics and modeling
    - Very Low Frequency (VLF) radio system electric wave field strength and phase calculation standards
    - Phase prediction corrections (PPC) model for underwater navigation
    - Shortwave frequency management forecasting system
    - Station intelligence pass-through broadcast/monitoring/frequency selection system[1716]

**Leadership and Key Personnel:**

- Director: Wu Jian [吴健][1717]
- Deputy Director: Li Qingliang [李清亮][1718]

**Notable Collaborations:**

*Domestic*

- The lab has collaborated on research with the PLAN, including the PLAN 704 Factory Communication and Electronic Warfare Workshop [海军 704 厂通信与电子对抗车间] in a 2017 study, "Application of Wideband Delphi Technique in Software Assessments" [Widebandelphi 技术在软件估算中的应用], and with PLAN Unit 92493 in the 2013 study, "Channel Analysis and Application of Troposphere Duct over Sea" [海洋大气波导信道特性分析与应用] involving over-the-horizon radar detection [超视距探测] for shore- and ship-based information systems.[1719]

*International*

- The lab allegedly has monitoring stations in Singapore, Norway, and Finland (see "Further Information" section for more).
- The lab claims to participate in international organizations and international co-operative research, such as Study Group 3 of the UN's International Telecommunication Union Radiocommunication Sector (ITU-R), Commissions F and G of the International Union of Radio Science (URSI), the European Incoherent Scatter Scientific Association (EISCAT), the Area Pacific Space Cooperation Organization (APSCO), and the International Space Environment Service (ISES). The lab also serves as ISES's Beijing Ionospheric Warning Center [北京电离层警报中心].[1720] Many of the lab's research results support the forming or revising of the recommendations of ITU-R P serials such as ITU-R.P 617, 530, 841, 676.[1721]
- The lab claims unspecified relationships with research and academic institutions in the U.S., U.K., Germany, France, Italy, Norway, Finland, Japan, Australia, Singapore, Chile and others.[1722]
- The lab has hosted and organized many international academic conferences and activities, including co-hosting the 2010 and 2018 International Symposium on Antennas, Propagation and EM Theory (ISAPE) conferences, and the 11th-16th iterations of the Chinese National Symposium on Radio Propagation (CNSRP) [全国电波传播学术讨论年会].[1723]

**Lab Equipment:**

- The lab had an original equipment value of 8.67 million RMB.[1724]
- As of 2006-2007, the lab's instruments and equipment included various types of signal sources, radio comprehensive testers, digital storage oscilloscopes, field strength comprehensive analyzers, high-precision frequency standards, test tools for various routine tests, and a computer network that integrates measurement, acquisition, library building, modeling, calculation, and simulation.[1725]

**Address**:

No. 503 Dingfu Huangzhuang, Beijing [北京市定福皇庄 503 号][1726]

**Website**:

https://web.archive.org/web/20080409182755/http://leme.ac.cn/

**Known Aliases:**

- Key Laboratory of Electromagnetic Environment [电波环境特性及模化技术重点实验室]
- State Key Laboratory of Electromagnetic Environment [电波环境特性及模化技术国家重点实验室]
- Defense Key Laboratory of Electromagnetic Environment [电波环境特性及模化技术国防重点实验室]
- 电波环境特性与模化国防科技重点实验室 [xcvii]

[xcvii] Missing the characters 技术 "technology"

## 72. Defense S&T Key Laboratory of Reliability and Environmental Engineering Technology

**Official English Name:** Unknown

**Chinese Name:** 可靠性与环境工程技术国防科技重点实验室

**Post-2024 Name:** National Key Laboratory of Reliability and Environmental Engineering Technology[xcviii] [可靠性与环境工程技术全国重点实验室][1727]

**Research Focus:**

Domain:

- Space
- *Secondary: Air, Maritime*

Equipment:

- Space Vehicles
- *Secondary: Aircraft, Surface Vessels*

Functional Field:

- Reliability/Environmental Engineering
- *Secondary: Simulation & Modeling*

**Affiliations:**

- Beihang University [北京航空航天大学]
  - School of Automation Science and Electrical Engineering [自动化科学与电气工程学院]
- China Aerospace Science and Technology Corporation (CASC) [中国航天科技集团]
  - China Academy of Space Technology (CAST) Beijing Institute of Spacecraft Environment Engineering (BISEE) [北京卫星环境工程研究所]
    - *a.k.a. CASC 5th Academy Final Assembly and Environmental Engineering Department [五院总装与环境工程部]*
    - *a.k.a. CASC 511th Research Institute [511 研究所]*
  - China Academy of Launch Vehicle Technology (CALT) Beijing Institute of Strength and Environment [北京强度环境研究所]

[xcviii] Literal translation, no official name given

**Key Data:**

- Established: 2008
- Total Funding: Unknown
- Personnel: 55[1728]
- Official start of operations: 2010
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research into reliability and environmental engineering for primarily spaced-based applications, as well as military and civilian aircraft, military and civilian maritime vessels, and other large, high-tech projects which require reliable operation in challenging environments.

This lab appears to be a major arm of the PRC's research into reliability engineering, particularly for military projects. A chart of key research platforms in this field shows this lab alongside six other entities from the PLA GAD, PLAAF, and AVIC. Further, Professor Kang Rui from this lab, in an interview, discusses the importance of reliability in manufacturing technology to the Made in China 2025 initiative.[1729]

This was the first key lab established by three parties. It is jointly run by Beihang University's School of Reliability and Systems Engineering, as well as two CASC institutions, the Beijing Institute of Spacecraft Environment Engineering (BISEE) (a.k.a. the CASC 511th Research Institute) and the Beijing Institute of Strength and Environment. BISEE is responsible for final assembly, integration, specialized testing, and environmental testing/simulation for the PRC's manned spacecraft and satellites (including navigation, communications, ground sensing, lunar, deep space, and research satellites).[1730] The Beijing Institute of Strength and Environment is tasked with testing the structural strength and environmental reliability of the PRC's space systems, including rockets, satellites, and ground equipment.[1731] It was added to the U.S. Commerce Department Entity List for export control in 1999 for "missile end-uses."[1732]

Under the ongoing reorganization of the PRC's national key lab system, this lab is now known as the National Key Lab of Reliability and Environmental Engineering Technology [可靠性与环境工程技术全国重点实验室].

**Research Direction:**

1. Reliability technology and environmental simulations, as well as accelerated experimentation and verification technology [可靠性技术与环境模拟、加速试验与验证技术的研究与开发]
2. Software reliability test and evaluation technology [软件可靠性测试与评价技术]
3. Maintenance simulation, design, and evaluation technology [维修性虚拟设计与评价技术]
4. Engineering model applications and technical support [工程型号应用与技术支持工作]

5. Teaching and talent training in this field [课程教学、人才培养工作][1733]

**Notable Applications:**

- In an advertisement meant to entice male students to come study at Beihang (titled, "*I'm at Beihang waiting for you…*"), models posing as Beihang students talk about their time volunteering at this lab. They claim to have provided technical support to the J-10 fighter, the Shenzhou-series of spacecraft, the Long March series of rockets, and PLAN aircraft carriers. Another source confirms that the School to which this lab is subordinate did indeed work on the J-10, Shenzhou, Long March, and aircraft carrier. Other likely projects include development of new materials for various space vehicles, including for the manned space program and Beidou satellites.[1734]

**Leadership and Key Personnel:**

- Director: Liu Bin [刘斌][1735]
- Academic Committee Director: Kang Rui [康锐][1736]

*Key Personnel:*

- Lu Shen [吕琛][1737]
    - Previously studied at U.S. University of Wisconsin and in France
    - Research interests in prognostics and health management [故障预测与健康管理], intelligent repair systems [智能维护系统].
- Chen Yunxia [陈云霞][1738]
    - Research interests in project failure science, complex systems reliability modeling and simulation, and high reliability and long life product design and testing techniques

**Notable Collaborations:**

*Domestic*

- In November 2020, this lab took part in the 8th Equipment Vibration and Noise Control Youth Forum and Mechanical Metamaterials/Structural Theory and Applications Workshop. Relevant participants included the Key Lab of Ship Vibration and Sound (under the Naval Engineering University and 701st and 702nd RIs of CSSC), and the National University of Defense Technology Key Lab of Integrated Equipment Support Technology.[1739]

*International*

- This lab co-organized the 2024 15th International COnference on Reliability, Maintainability and Safety [第十五届国际可靠性维修性安全性会议], along with the Chinese Society of Aeronautics and Astronautics [中国航空学会], China Armaments Society [中国兵工学会], Beihang University, and others. While extensive information was not available for the 2024 conference, the 2025 conference, the 2025 conference will be headlined by the Director of this lab and also feature presentations by researchers from the U.S. (Purdue University, Rutgers University), Japan (Hiroshima University), and Singapore (National University of Singapore). Conference committee members come from the U.S. (Western New England University), Canada (University of Alberta),Australia (University of New South Wales), New Zealand (University of Otago), France (Universite Paris-Saclay), the Netherlands (International Associaten for the Advancement of Space Safety Netherlands), Sweden (Lulea University of Technology), and Singapore (National University of Singapore), as well as from PRC military-affiliated organizations such as the China Armament Research Institute, PLA National University of Defense Technology, Beihang University, Beijing Institute of Technology, Nanjing University of Science and Technology, and Huazhong University of Science and Technology.[1740]
- In 2024, personnel of this lab took part in the 6th Chinese Conference on Simulation Technology Applications and Tianjin (Hebei) Low-Altitude Industry Development Summit [第六届中国仿真技术应用大会暨天津（宁河）低空产业发展峰会]. Event organizers included the AVIC China Helicopter Design Institute [中国直升机设计研究所], the PLA National University of Defense Technology's Tianjin Supercomputing Center, and a local PRC branch of German company Siemens.[1741]
- This lab hosted an international conference in 2011 on the topic of space vacuum hot environment simulation which included researchers from Spain and Ukraine.[1742]
- While unclear if it involves this lab in particular, BISEE has allegedly provided products and services to multiple foreign countries, including Russia for its GVU-600 large space environment simulator.[1743]

**Lab Equipment:**

None found

**Address**:

Possibly co-located with Beihang University at No. 37 Xueyuan Road, Haidian District, Beijing [北京市海淀区学院路 37 号]

**Known Aliases:**

- Key Laboratory on Reliability & Environmental Engineering [可靠性与环境工程技术重点实验室]
- Science and Technology on Reliability and Environment Engineering Laboratory
- National Defense Science & Technology Laboratory on Reliability & Environmental Engineering

## 73. Defense S&T Key Laboratory of Remanufacturing Technology

**Official English Name:** National Key Laboratory for Remanufacturing[1744]

**Chinese Name:** 装备再制造技术国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Multi-Domain (Air, Ground, Maritime)

Equipment:

- Multiple (Aircraft, Ground Vehicles)

Functional Field:

- Manufacturing
- *Secondary: Vehicle Parts & Technology*

**Affiliations:**

- PLA Army Academy of Armored Forces [陆军装甲兵学院][xcix]

**Key Data:**

- Established: 2000
- Total Funding: Unknown
- Personnel: 42 (research)[1745]
- Official start of operations: 2003
- Floor Space: over 9,000 sqm

**Lab Overview:**

This lab conducts research into remanufacturing technology for equipment life extension and battlefield emergency repairs. The lab's research is applied to tank and aircraft engines and other parts, as well as to other vehicles.[1746]

Remanufacturing is focused on the specialized repair and replacement of individual machinery parts to restore original functionality, reducing resource consumption and extending overall lifespan. The PRC is determined to catch up to the U.S. in this regard, as annual losses from friction and corrosion of machinery account for 10 percent of GDP in the PRC, vs 4-5 percent in developed countries. Remanufacturing has also begun to play an increasingly important role in

[xcix] Former Armored Forces Engineering College [装甲兵工程学院]

the national defense field. Laser additive remanufacturing is now used for aero-engine and ship blades, as well as for other load-bearing parts. Equipment remanufacturing can be used on damaged or scrap parts, utilizing failure analysis, lifespan predictions, whole lifecycle cost analysis, use of high-tech surface engineering technology, rapid forming technology, and other advanced manufacturing technologies, to quickly restore original technical performance and remanufacture new parts.[1747]

On the civilian side, this lab is part of a larger effort to create a national circular economy. It is involved in a range of remanufacturing products, including car engines and tires. Following the 12th Five Year Plan (2011-2015), it also works to remanufacture construction machinery, mining equipment, and electrochemical products. Over the first decade of its existence, this lab is said to have gone from *repair* and *surface* engineering to full *remanufacturing* engineering, developing means of remanufacturing used equipment.[1748]

**Research Direction:**

1. Remanufacturing Engineering Design Fundamentals [再制造工程设计基础]
2. Remanufacturing Quality Control [再制造质量控制]
3. Emergency Repairs [应急维修]
4. Key Remanufacturing Technologies [再制造关键技术][1749]

*Other Notable Research Areas:*

- Nanometer surface engineering
- Automatic surface engineering
- Rapid fuzing and forming
- Quality control systems
- Laser additive remanufacturing technology
- Remanufacturing life assessment
- Remanufacturing forming technology
- Remanufacturing multi-lifecycle theory
- Remanufacturing life assessment and prediction theory
- Micro- and nano-surface engineering technology
- Automated surface engineering technology
- Remanufacturing of equipment while in operation (self-healing technology)[1750]

**Notable Applications:**

- This lab is involved in the development of remanufactured tank engines. This has improved a major bottleneck in tank lifespan, as engines tended to wear out more quickly than other parts. It has effectively doubled the time between overhaul cycles for certain tank engines. Lab founder Xu Binshi has even been referred to as the "Tank Nanny" [坦克保姆].[1751]

- This lab has developed anti-wear lubricants for new, high-tech military vehicle engines. It has also worked on nano friction-reducing self-repairing additives for military jeeps and tanks. These additives self-repair engines and improve engine power, torque, and fuel consumption.[1752]
- This lab has also worked with the 5719 Factory [5719厂] on remanufacturing technology for PLAAF combat aircraft engines. The lab has worked on remanufacture of imported aircraft engine compressor blades [进口飞机发动机压气机叶片].[1753] [c]

**Leadership and Key Personnel:**

- Director: Zhu Sheng [朱胜][1754]
    - Division Deputy Grade Senior Colonel
- Deputy Directors: Wang Haidou [王海斗]; Xu Yi [许一][1755]

*Key Personnel*

- Xu Binshi [徐滨士][1756]
    - Lab founder
    - CAE Academician and PLA Major General
    - Expert in remanufacturing engineering and surface engineering
    - Called the "Father of Chinese Remanufacturing" and the "Tank Nanny"
- Dong Shiyun [董世运][1757]
    - Key researcher on tank engine remanufacturing and lifespan increase

**Notable Collaborations:**

*Domestic*

- In 2013, this lab signed a three-way agreement with Yanshan University and XCMC Group [徐工集团] to cooperate in engineering and machinery remanufacturing.[1758]
- In 2020, Director Xu Bin and his team began collaboration with Zhangjiakou Bochuang Intelligent Manufacturing Incubator Co. [张家口博创智造孵化器有限公司] to build a machinery manufacturing industry cluster and equipment manufacturing base, among other things. Research will focus on remanufacturing of key construction machinery parts, including gears, drive shafts, and engine parts, extending product lifecycles and reducing maintenance and replacement costs. It will have 500,000 RMB in research funding.[1759]
- The lab established a Recycling Economy Manufacturing Technology Innovation Industry Strategic Alliance [循环经济再制造技术创新产业战略联盟] with Huizhou Zhongrunda Remanufacturing Co. [惠州中润达再制造科技有限公司].[1760]

[c] More technical details about remanufacture of imported engine compressor blades is available upon request.

- The lab oversees the National Green Manufacturing Standardization Technology Committee [全国绿色制造标技术准化技术委员会再制造分技术委员会].[1761]
- In July 2017, the PRC established the Equipment Parts Remanufacturing Industry Alliance [设备零部件再制造产业联盟], consisting of this lab, North China University of Technology, and Beijing Aoyu Kexin Equipment Remanufacturing Research Institute [北京奥宇可鑫装备再制造技术研究院].[1762]
- This lab, along with the Machine Product Remanufacturing National Engineering Research Center [机械产品再制造国家工程研究中心], established the Beijing-Tianjin-Hebei Remanufacturing Industry Technology Research Institute [京津冀再制造产业技术研究院], which focuses on auto parts, oil mining machinery, agricultural machinery, and engineering machinery, and aims to be one of the top such centers in the world.[1763]
- In 2010, this lab signed an ongoing cooperation agreement with Furui Group [富瑞特装] and the China Automotive Engineering Research Institute [中国汽车工程研究院].[1764]

*International*

- According to an overview from 2011, this lab has allegedly established close relationships with unnamed U.S., U.K., French, Japanese, Polish, and German institutions.[1765]
- This lab hosted a delegation from the U.K. in 2016, including personnel of the U.K. government and University of Brighton. It was organized by a Professor at the University of Brighton who was serving as a visiting scholar to this lab. Cutting edge remanufacturing practices in the U.K. were discussed. The U.K. and PRC delegations agreed to more closely cooperate in research, innovation, technical development, and joint funding and investment. No mention is made of the lab's PLA affiliation, and all personnel are in civilian dress (although this is not particularly unusual). Cooperation between the two sides has continued into 2018.[1766]
- Lab Director Zhu Sheng, a Senior Colonel at the PLA Army Armor College, was a speaker at the 2024 China Materials Conference E09: Material Surface Engineering Forum [2024 中国材料大会 E09-材料表面工程论坛], which also featured participation from Beihang University and others. A French researcher from University of Technology of Belfort-Montbéliard, was also invited to speak.[1767]

**Lab Equipment:**

Lab facilities include:

- Surface analysis instruments
- Rapid forming systems
- Surface coating preparation facilities[1768]

**Address**:

Dujiakan, Fengtai District, Beijing [北京市丰台区杜家坎][1769]

**Known Aliases:**

- National Defense Key Laboratory for Remanufacturing Technology
- Key Laboratory of National Defense Science and Technology of Equipment Remanufacturing Technology
- Key Laboratory of Remanufacturing Technology [装备再制造技术重点实验室]

## 74. Defense S&T Key Laboratory of Ship Vibrational Noise

**Official English Name:** Unknown

**Chinese Name:** 船舶振动噪声国防科技重点实验室

**Post-2024 Name**: No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Maritime

Equipment:

- Underwater Vehicles
- *Secondary: Surface Vessels*

Functional Field:

- Acoustics

**Affiliations:**

- PLA Naval University of Engineering [海军工程大学]
  - (likely) Institute of Vibration and Noise [振动与噪声研究所]
- China State Shipbuilding Corporation (CSSC) [中国船舶集团]
  - CSSC Research and Design Center [中国舰船研究设计中心]
    - *a.k.a. CSSC 701st Research Institute [701 所]*
  - China Ship Scientific Research Center [中国船舶科学研究中心]
    - *a.k.a. CSSC 702nd Research Institute [702 所]*

**Key Data:**

- Established: 2011
- Total Funding: Unknown
- Personnel: Unknown[1770]
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab was established in 2011 and is sometimes referred to as the Defense S&T Key Lab of Submarine Acoustic Stealth Technology, or the Defense S&T Key Lab of Acoustic Stealth Technology.[1771] It is primarily concerned with submarine and surface vessel acoustics and noise

reduction to improve stealth. Under Deputy Director He Lin, it has reportedly made important breakthroughs in quieting that have been applied to the PLAN's newest submarines.[1772]

In addition to its subordination to the PLA Naval University of Engineering, this lab is subordinate to two CSSC research centers. The CSSC Research and Design Center (a.k.a. the 701st Research Institute and formerly known as the Wuhan Ship Development and Design Institute [武汉船舶设计研究院]) is a major institution for research and overall design of the PRC's warships, and is known as the "cradle of warships" [战舰摇篮]. The 701st RI has two Defense S&T Key Labs, this one and the DSTKL for Electromagnetic Compatibility.[1773] It is on the USG Entity List for export control.[1774] The CSSC China Ship Scientific Research Center (a.k.a. the CSSC 702nd Research Institute) conducts research into underwater engineering, hydrodynamics, structural mechanics, vibration, noise, impact resistance, and other related technologies for maritime vessels, as well as R&D of high-performance ships.[1775]

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- Submarine acoustics and stealth[1776]
- Ship noise levels and noise protection, including civilian ships[1777]

The lab's 2020 research funding priorities were as follows:[1778] [ci]

1. Design methods of low-frequency inertial actuation system based on piezoelectric stacks [基于压电叠堆的低频惯性作动系统设计方法研究]
2. Acoustic Characterization of Unsteady Flow in Ship Piping Steering and Diverter Members [船舶管路转向及分流构件非稳态流动声学特性研究]
3. Study on the acoustic characteristics of heat exchanger and manifold damping receivers and their effect on the radiated noise at the tube opening [换热器、歧管减振接管声学特性及其对管口辐射噪声的影响研究]
4. Molecular design mechanism of frequency damping properties of damping materials for vibration isolators [隔振器用阻尼材料阻频特性分子设计机理研究]
5. Real-Time Edge Computing Technology for Large Vibration Isolation Systems [大型隔振系统实时边缘计算技术研究]

**Notable Applications:**

- Senior researcher He Lin has made breakthroughs in submarine stealth technology that has been utilized in the PLAN's newest submarines. This reportedly includes reducing

[ci] Further details, including research goals, targets, and funding, are available.

submerged conventional submarine noise to 90 decibels and nuclear submarines to 110 decibels.[1779] Other alleged breakthroughs by He Lin include:

  - Prior to 2009, broke through a foreign technology blockade to develop three series of submarine vibration damping flexure receivers.
  - Invented and developed a new type of low-noise propeller bearing, solved a problem with submarine low-speed covert navigation propeller bearing high-frequency anomalies in the control of strong spectral noise, exposing the submarine in combat maneuvering due to the anomalous noise that leads to acoustic exposure.
  - Developed China's first-generation and second-generation vibration isolation device technology.
  - First internationally to put forward the concept of an intelligent vibration isolation device, including a large-scale intelligent airbag vibration isolation device, which is the world's first intelligent vibration isolation device, with automatic load balancing, self-diagnosis of faults, self-organization and repair management.
  - Made breakthrough in low-frequency vibration isolation of propulsion power unit, which is an internationally recognized technical problem, and developed the fourth-generation vibration isolation device technology with the functions of neutral attitude monitoring, control and protection management, a world first.
  - Implemented the fifth generation of vibration isolation device technology, called "magnetic levitation active-passive hybrid vibration isolation technology."
- This lab created a submarine-launched strategic missile test platform with high-precision vibration control to improve missile accuracy.[1780]

**Leadership and Key Personnel:**

- Deputy Director: He Lin [何琳][1781]
  - Corps Deputy Leader Grade Rear Admiral
  - Director of Vibration and Noise Research Institute of Naval Engineering University, member of Stealth Technology Specialized Group of General Armament Department, deputy head of Naval Submarine Acoustic Stealth Technology Expert Group.
  - CAE academician
  - Research of ship noise reduction technology for more than 30 years, and has made significant contributions to ship noise reduction tech (see Notable Applications).
- Academic Committee Deputy Director: Weng Zhenping [翁震平]
  - Former Director of this lab and the 702nd RI[1782]
  - Also serves as Director of Shanghai Jiao Tong University Institute of Marine Equipment [海洋装备研究院执行院长][1783]

**Notable Collaborations:**

*Domestic*

- This lab worked with PLA Unit 92267 [92267 部队], on a project called "Detection method for transient signal under low SNR condition based on cepstrum analysis" [基于倒谱分析的低信噪比瞬态声信号检测方法].[1784]
- In 2021, this lab co-organized the 18th National Symposium on Ship Underwater Noise [十八届全国船舶水下噪声学术讨论会] with the Vibration and Noise Group of the Academic Committee on Ship Mechanics of the Chinese Society of Shipbuilding Engineering [中国造船工程学会船舶力学学术委员会振动与噪声学组] and the academic Journal "Ship Mechanics" [船舶力学]. The conference focused on ship acoustic and stealth technology, ship noise control and quieting design, and acoustic test technology. Researchers came from Shanghai Jiao Tong University, Huazhong University of Science and Technology, Northwestern Polytechnical University, CSSC 702nd Research Institute, Tianjin University, CAS Institute of Acoustics, and Jiangsu University of Science and Technology.[1785]
- In 2019, this lab co-organized the 7th Youth Forum on Equipment Vibration and Noise Control [第七届装备振动与噪声控制青年论坛]. Other organizers included the MOE Key Laboratory of Vehicle Dynamics and Control at Beijing Institute of Technology [北京理工大学飞行器动力学与控制教育部重点实验室], MIIT Key Laboratory of Advanced Ship Power Technology at Harbin Engineering University [哈尔滨工程大学先进船舶动力技术工业和信息化部重点实验室], NUDT Key Laboratory of Comprehensive Equipment Protection Technology [国防科技大学装备综合保障技术重点实验室], Xi'an Jiaotong University State Key Laboratory of Strength and Vibration of Mechanical Structures [机械结构强度与振动国家重点实验室], Shanghai Jiao Tong University State Key Laboratory of Mechanical Systems and Vibration [机械系统与振动国家重点实验室], NUAA State Key Laboratory of Mechanics and Control of Mechanical Structures [机械结构力学及控制国家重点实验室], CAS Key Laboratory of Noise and Vibration [中国科学院噪声与振动重点实验室], 北京强度环境研究所], CASC Key Laboratory of Reliability and Environmental Engineering Technology [可靠性与环境工程技术重点实验室], the Acoustical Society of China [中国声学学会], Chinese Society of Mechanics [中国力学学会], and the Chinese Society of Vibration Engineering [中国振动工程学会]. Research topics included generation and propagation mechanisms of vibration and noise, vibration and noise testing, analysis, and evaluation techniques, equipment vibration characterization, and noise control technology.[1786]

*International*

- In 2015, this lab hosted two personnel of Swiss company Kistler, who are experts on transducer products and signal conditioning, respectively. One gave a talk on preloading, assembling, calibrating and application of piezoelectric force sensors, and gave a

demonstration based on a certain type of dynamic force plate assembly. The participants discussed measurement methods for propeller pressure micro-pulsation, measurement methods for dynamic force at the input and output of flexible receiver under the condition of flexible foundation, the design and production of multi-component dynamic force plates, and calibration of the intrinsic frequency of dynamic force plate and its influence correction methods. According to a 702nd RI press release, the discussion improved lab personnel understanding of dynamic force measurement technology and sensor use, development of dynamic force plates and applications, and how to improve lab testing facilities.[1787]

**Lab Equipment:**

None found

**Address**:

Co-located with CSSC 702nd RI:

No. 222 Shanshui East Road, Binhu District, Wuxi, Jiangsu Province 214082 [江苏省无锡市滨湖区山水东路 222 号][1788]

Possible second location: Wuhan, Hubei Province 430033 [湖北省武汉市][1789]

**Known Aliases:**

- 潜艇声隐身技术国防科技重点实验室
- 声隐身技术国防科技重点实验室
- 声隐身技术国防重点实验室
- 声隐身技术重点实验室
- 船舶振动噪声国防重点实验室
- 船舶振动噪声国家级重点实验室
- 船舶振动噪声国家重点实验室
- 船舶振动噪声重点实验室

## 75. Defense S&T Key Laboratory of Shockwave and Blast Physics

**Official English Name:** Unknown

**Chinese Name:** 冲击波物理与爆轰物理国防科技重点实验室

**Post-2024 Name:** National Key Laboratory of Shockwave and Blast Physics[cii] [冲击波物理与爆轰物理全国重点实验室][1790]

**Research Focus:**

Domain:

- Nuclear

Equipment:

- Nuclear Weaponry & Power
- *Secondary: Munitions*

Functional Field:

- Blast, Impact, and Damage
- *Secondary: Laser Technologies, Materials, Munitions Technology, Reliability/Environmental Engineering, Simulation & Modeling*

**Affiliations:**

- Chinese Academy of Engineering Physics (CAEP) [中国工程物理研究院]
    - Institute of Fluid Physics [流体物理研究所]

**Key Data:**

- Established: 1990[1791]
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: 1994[1792]
- Floor Space: Unknown

**Lab Overview:**

This lab was first set up in December 1990, although it was not fully established until 1994.[1793] According to one source, this was the first Defense S&T Key Lab to be established.[1794] It primarily researches shock and blast waves generated by high heat, pressure, and other extreme conditions of condensed matter, and their physical, chemical, and thermodynamic properties.[1795] A significant part of its mission appears to be aiding the Chinese Academy of Engineering Physics

[cii] Literal translation, no official name given

(CAEP) with research into high-temperature and high-pressure physics, explosion mechanics, and collision mechanics[1796] for development of both nuclear and conventional weaponry. One of the lab's founding members and early directors was CAS Academician Jing Fuqian [经福谦], who was a major figure in the PRC's nuclear weapons program.[1797]

The lab's parent institution, the CAEP Institute of Fluid Physics (a.k.a. the CAEP 1st Institute), conducts research into fluid dynamics and diagnostic test technology for nuclear and conventional weapons development. Research areas include blast physics, shock wave physics, pulsed power technology, accelerator physics, optics and applied electronics, laser-matter interaction, computational physics, and computational mechanics.[1798]

Under the ongoing reorganization of the PRC's national key lab system, this lab is now known as the National Key Lab of Shockwave and Blast Physics" [冲击波物理与爆轰物理全国重点实验室].

**Research Direction:**

1. Shock and blast waves generated by high heat, pressure, and other extreme conditions of condensed matter, and their physical, chemical, and thermodynamic properties[1799]

*Other Notable Research Areas:*

- Shock wave sensitivity of newly developed aluminum explosives[1800]
- Vehicle damage features after sustaining explosion, for law enforcement and counter-terrorism[1801]

The lab is recruiting post-doctoral fellows in 2024 for the following areas:

- Numerical simulation of micro-, meso- and macro-scale mechanical and physical properties of materials under dynamic or static pressure loading
- Numerical simulation of energy-containing material properties (chemical reactions) under impact loading
- Development of methods and programs for numerical simulation of molecular dynamics and other mesoscopic scales[1802]

**Notable Applications:**

- This lab began studying all-fiber laser interferometric velocimetry technology in 1997, in order to solve problems with VISAR,[ciii] such as easy to lose interference fringes and complex system structure when speed is changing rapidly, and to make laser interferometric velocimetry technology simpler and easier to use in special environments. This led to a 2007 breakthrough led by Tan Hua [谭华], in which the team successfully

[ciii] Velocity interferometer system for any reflector

developed a new type of all-fiber laser displacement interferometric velocimetry device by combining multi-mode and single-mode. This overcomes shortcomings of traditional VISAR and can be reliably used for measurement of transient velocities of high-speed moving objects under strong load.[1803]

**Leadership and Key Personnel:**

- Deputy Director: He Hongliang [贺红亮]
  - Won 1 first prize, 3 second prizes, and 3 third prizes for military S&T progress
  - Conducts research on shock wave compression, high-energy explosive blast loading, pressure gas cannon loading, magnetically-driven loading, intense laser loading, shock wave velocity measurements, shock wave profile measurements, high-pressure equation of state measurements, and high-pressure sound velocity measurements[1804]
- Standing Committee Deputy Director: Chen Junxiang [陈俊祥][1805]
  - Since 2012, has researched high pressure physical states [高压物态方程] at this lab[1806]

*Key Personnel:*

- Tan Hua [谭华][1807]
  - Led a team which made a major breakthrough in laser interferometric velocimetry technology (see "Research Direction" and "Notable Applications")

**Notable Collaborations:**

*Domestic*

- In 2018, this lab co-hosted the 12th National Conference on Explosion Dynamics [第十二届全国爆炸力学学术会议], along with the Chinese Society of Theoretical and Applied Mechanics Explosive Mechanics Specialist Committee [中国力学学会爆炸力学专业委员会], CAEP, and the Institute of Liquid Physics, the lab's parent institution.[1808] Participants included the Beijing Institute of Technology, PLA Army Engineering University, Northwestern Polytechnical University, Ningbo University, CAEP, Xi'an Jiaotong University, Nanjing University of Science and Technology, Norinco 208th RI, and a redacted PLAN Training and Test Base.[1809] [civ]
- This lab co-hosted the 2018 Bilateral Symposium on Numerical Simulation and Computational Physics at Chongqing University [重庆大学-中物院流体物理研究所数值模拟与计算物理双边学术研讨会]. This was also referred to as the 8th Sichuan High Pressure Science and Technology Symposium and Chongqing University-Institute of Fluid

[civ] Further information about the conference is available.

Physics Bilateral Symposium on Numerical Simulation and Computational Physics [四川省第八届高压科学与技术研讨会暨重庆大学-流体物理研究所数值模拟与计算物理双边学术研讨会]. The symposium discussed physical theory and numerical simulation of condensed matter under extreme conditions, computational problems in high-pressure science, and the latest scientific research results and future development direction of in-situ diagnostic techniques in the field of high-pressure science and technology. Along with this lab, hosts included Chongqing University's School of Physics and Advanced Technology Institute [重庆大学先进技术研究院], the Sichuan University Institute of Atomic and Molecular Physics [四川大学原子分子物理所], Xi'an Jiaotong University Institute of High-Temperature and High-Pressure Physics [西南交通大学高温高压物理研究所], and the Sichuan Physical Society [四川省物理学会].[1810]

- In 2014, this lab co-hosted a symposium on ultra-high-speed firing technology for three-stage guns [三级炮超高速发射技术的研究工作] with the Wuhan University of Technology's State Key Laboratory of Advanced Technology for Materials Synthesis and Processing [武汉理工大学材料复合新技术国家重点实验室]. It has hosted this event for 20 years (as of 2014). Research areas include design, materials, and experimental measurements.[1811]

**Lab Equipment:**

- The lab possesses advanced first- and second-grade light air cannons, indoor explosive towers, and other dynamic high-voltage loading equipment and precision diagnostic systems.[1812]

**Address**:

Mianyang, Sichuan Province [四川省绵阳市][1813]

**Known Aliases:**

- NKLSD
  - Likely an acronym for National Key Lab of Shockwave and Detonation
- State Key Laboratory of Shock Wave and Detonation Physics
- Laboratory for Shockwave and Detonation Physics Research
- 冲击波物理与爆轰物理重点实验室 (LSD)
  - Likely acronym for Lab of Shockwave and Detonation

## 76. Defense S&T Key Laboratory of Solid Rocket Engine Combustion, Thermal Structure, and Inner Flow Field

**Official English Name:** State Key Laboratory of Combustion, Thermal Structure and Inner Flow Field[1814]

**Chinese Name:** 固体火箭发动机燃烧、热结构与内流场国防科技重点实验室

**Post-2024 Name:** National Key Laboratory of Solid Propulsion[cv] [固体推进全国重点实验室][1815]

**Research Focus:**

Domain:

- Space
- *Secondary: Air*

Equipment:

- Space Vehicles
- *Secondary: Ballistic Missiles*

Functional Field:

- Propulsion

**Affiliations:**

- Northwestern Polytechnical University (NWPU) [西北工业大学]
  - School of Astronautics [航天学院]
- China Aerospace Science and Technology Corporation (CASC) [中国航天科技集团]
  - 4th Academy Xi'an Aerospace Propulsion Research Institute [第四研究院西安航天动力研究所]
    - *a.k.a. CASC 41st Research Institute [41 研究所]*

**Key Data:**

- Established: 1991
- Total Funding: over 200m RMB[cvi]
- Personnel: 37-48[1816]
- Official start of operations: 1995
- Floor Space: approx. 15,000 sqm

[cv] Literal translation, no official name given
[cvi] At founding

**Lab Overview:**

This lab claims to be the PRC's only national key lab dedicated to solid rocket propulsion, with a particular focus on advanced spaceflight and ballistic missile propulsion, combustion flow, heat transfer, ablation mechanisms for spaceflight propulsion, and engine insulation.[1817]

The lab is jointly managed by Northwestern Polytechnical University and the CASC Aerospace Propulsion Research Institute (a.k.a. CASC 41st Research Institute), and is a major research base for the 41st RI's rocket engine products. The 41st RI, established in 1964, has been responsible for over 80 types of solid rocket engines (as well as some liquid engines) for spaceflight and missiles, including the Long March line of rockets and the JL-series of SLBMs. It has also developed various other products for spaceflight (including the docking mechanism for the Tiangong 1 space station and escape system for the Shenzhou spacecraft) and guidance and control systems for air-to-ground missiles.[1818]

**Further Information:**

- The lab oversees three National Defense S&T Innovation Teams. It has also established a Space Propulsion Technology Cooperation and Innovation Center [航天动力技术协同创新中心] for the Ministry of Industry and Information Technology [工信部] and the Shaanxi Aerospace Power Research Institute [陕西省空天动力研究院] for the Shaanxi provincial government.[1819]
- In 2010, this lab underwent a significant expansion, providing better conditions for the lab's mission of improving the PRC's independent innovation capabilities in the field of solid rocket engines. SASTIND's Science, Technology, and Quality Division [科技与质量司] was responsible for overseeing the expansion.[1820]
- CASC's 4th Academy relied on this lab to establish its Solid Rocket Engine R&D Center [固体火箭发动机研发中心].[1821]
- The lab is affiliated with the NWPU Institute of Space Propulsion Technology [空天动力技术研究所] which is also under the School of Astronautics.[1822]

**Research Direction:**

1. Advanced spaceflight power technology [先进宇航动力技术]
2. Combustion, flow, heat transfer, and ablation mechanisms related to spaceflight power [先进宇航动力中的燃烧、流动、传热、烧蚀机理][1823]

*Other notable research areas*:

- Engine insulation, throat lining and ablation mechanisms
- Unstable combustion
- Combustion of energetic materials

- Boron-holding flame-rich propellants
- Rocket-base combined cycle engines
- Energy-managed solid engines and microwave electric propulsion
- Advanced designs and simulation platforms for propulsion systems
- Metal particle combustion
- Unsteady flow
- Two-phase flow in engines
- Numerical simulation of combustion and flow
- Gas flow regulation
- Heat transfer and thermal protection material ablation mechanisms
- Space propulsion technologies like solid micro-propulsion and electric propulsion
- Solid rocket ram engines
- Energy management solid engines
- Powder rocket engines[1824]

**Notable Applications:**

- As part of the 41st RI, this lab was likely involved in development of propulsion systems for various spaceflight and missile programs, including the Long March rockets and the JL-series SLBMs. Lab researcher Hou Xiao was lead designer for the JL-2 SLBM.[1825]
- This lab has worked with the PLARF/PLASAF on missile combustion reliability.[1826] Likewise, the lab has reportedly conducted research on the degradation of ballistic missile propellants over long periods of time. One test involved accelerated aging of a fuel with ammonium perchlorate, aluminum powder, and HTPB as the binder. It was ultimately found that this aged propellant was stable during storage, but compared to fresh fuel, it would rupture at an accelerated rate under high pressure of 6 MPa, with significant deterioration in the ductility of the fuel occurring after 27 years.[1827]
- The lab has researched improved ignition device safety and escape engine thermal structure [逃逸发动机点火装置及热结构安全性], improving the reliability of the power system of the escape tower for space launch missions.[1828]
- In 2023, the lab tested a small 65 mm solid-liquid hybrid sounding rocket utilizing a novel paraffin-containing fuel/nitrous oxide as propellant, with an average thrust of 200N. It included an improved oxidizer injecter for better gas mixing and combustion efficiency, with impulse efficiency improved by by 87 percent. It also featured a new electro-explosive valve with dual functions of ignition and sealing, which not only made for safe and reliable ignition of the engine, but also provided rapid oxidant supply, high ignition energy, and good ignition consistency. Finally, the thrust chamber was improved to prevent ablation, and through structural optimization and ablation-resistant materials, a new thrust chamber was designed which promises more reliable operation and recycling of the engine. The main body of the rocket is made of high-strength carbon fiber to meet the requirements of light weight and high strength, and the connection between the rocket engine, avionics equipment, parachute recovery equipment and the rocket body has also been improved.[1829]

**Leadership and Key Personnel:**

- Director: He Guoqiang [何国强][1830]
- Deputy Directors: Liu Peijin [刘佩进]; Wei Xianggeng [魏祥庚][1831]
    - Liu Peijin also serves as Director of the lab's NWPU Branch
- NWPU Branch Deputy Director: Lu Xiang [吕翔][1832]

*Key Personnel:*

- Hou Xiao [侯晓][1833]
    - CAE Academician
    - Lead engineer for JL-2 SLBM
- Hu Chunbo [胡春波]
    - Leads a team researching ignition device safety and escape engine thermal structure [逃逸发动机点火装置及热结构安全性], improving the reliability of the power system of the escape tower for space launch missions.[1834]

**Notable Collaborations:**

*Domestic*

- This lab participated in the CASC 3rd Specialist Information Network's 37th Technical Exchange Conference and 1st Joint Aerospace Power Conference [中国航天第三专业信息网第三十七届技术交流会暨第一届空天动力联合会议]. Other participants included multiple CASC and CASIC subsidiaries, Rocket Force Engineering University, Beijing Aerospace Long March S&T Information Research Institute [北京航天长征科技信息研究所], AVIC China Air-to-air Missile Research Institute [中国空空导弹研究院], National University of Defense Technology [国防科技大学], Navy Aviation Engineering College [海军航空工程学院], Air Force Engineering University [空军工程大学], CARDC (PLA Base 29), and dozens of other universities and research institutes.[1835]
- This lab participated in the 1st China Aerospace Propulsion Technology Forum [中国空天推进技术论坛] in 2018. Notable collaborators included CASC, multiple spaceflight-oriented labs, the National Defense S&T Key Laboratory of Hypersonic Ramjet Technology [高超声速冲压发动机技术国防科技重点实验室], the National University of Defense Technology, and Rocket Force Engineering University.[1836]
- This lab is associated in some way with the Xi'an Bell Petrochemical Technology Co [西安贝尔石油化工科技有限责任公司], a petrochemical and fracking company which may utilize solid rocket engines.[1837]

*International*

- In 2019, this lab organized that year's International Workshop on Space Propulsion in Xi'an along with the Xi'an National Civilian Aerospace Industrial Base [西安国家民用航天产业基地], the CASC Xi'an Aerospace Propulsion Research Institute (41st RI) Key Lab of Liquid Rocket Engine Technology [西安航天动力研究所液体火箭发动机技术重点实验室], and Germany's Technical University of Munich. Conference participants came from Stanford University, Bundeswehr University Munich (a major German military academy), University of Stuttgart, CERFACS (a major European research institute for high-performance computation), ONERA (the French national aerospace research center), Sweden's Lund University, and Moscow State University. The 2018 conference also featured He Guoqiang of this lab as a speaker, along with multiple international speakers, including a rocket propellant expert from Purdue University in the U.S.[1838]

**Lab Equipment:**

- The lab's total equipment value is around 40m RMB. The original value of the lab's equipment is 300,000 RMB.

Lab equipment includes:

- Flow stability numerical simulation equipment
- ECR electric thrusters
- Advanced power design platform
- X-ray real-time screen analysis system
- Rocket ramming combination engine test system
- PDPA and PLIF high-speed motion analyzers
- PLIF (Planar Laser Induced Fluorescence) experimental system[1839]

**Address**:

Likely co-located with NWPU at No. 127 Youyi West Road, Xian, Shaanxi Province [陕西省西安市友谊西路 127 号]

**Website**:

kypt.nwpu.edu.cn/index.php?c=content&a=show&id=359

**Known Aliases:**

- National Key Laboratory of Combustion, Flow and Thermo-Structure

- National Key Laboratory of Combustion, Thermostructure and Flow of SRM
- 固体火箭发动机燃烧结构与内流场国防科技重点实验室
    - Same name as official, but with no comma
- Defense S&T Key Laboratory of Solid Rocket Engines [固体火箭发动机国防科技重点实验室]
- 固体火箭发动机国防重点实验室
- 固体火箭发动机重点实验室

## 77. Defense S&T Key Laboratory of Sonar Technology

**Official English Name:** Unknown

**Chinese Name:** 声纳技术国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Maritime

Equipment:

- Underwater Vehicles
- *Secondary: Communications Equipment*

Functional Field:

- Acoustics
- *Secondary: Communications Technologies, GNC, Information Processing, Target Detection/Recognition*

**Affiliations:**

- China State Shipbuilding Corporation (CSSC) [中国船舶集团]
  - Hangzhou Institute of Applied Acoustics [杭州应用声学研究所]
    - *a.k.a. CSSC 715th Research Institute [715 研究所]*

**Key Data:**

- Established: c. 1996
- Total Funding: Unknown
- Personnel: 31[1840]
- Official start of operations: Unknown
- Floor Space: 3,114 sqm

**Lab Overview:**

The Defense S&T Key Laboratory of Sonar Technology is tasked with the development of new types of sonar, as well as research into maritime acoustics, detection, navigation, communications, and signal processing.

Prior to its founding, likely around 1996, this lab may have been known as the 715th Research Institute Submarine Sonar Research Office [715 所潜艇声纳研究室]. Its predecessor likely dates back to at least 1962, making it one of the PRC's oldest sonar R&D institutions.[1841]

The lab's parent institution, the CSSC Hangzhou Institute of Applied Acoustics (a.k.a. the CSSC 715th RI), was established in 1958. It conducts research into maritime hydroacoustics, as well as optical and magnetic sensing equipment.[1842] It is on the U.S. Commerce Department Entity List for export control.[1843]

**Further Information:**

- Much of the lab and its parent institute's field research is conducted out of Hangzhou's West Lake [西湖], specifically the west side of the lake.[1844]

**Research Direction:**

No formal research direction was found

*Other Notable Research Areas:*

- New types of underwater acoustic transducers
- Signal processing technology
- Communications networks
- Research of underwater target detection and tracking, navigation, and communications
- Sonar information processing and resolution
- Low-frequency, high-power acoustic transmitter technology
- Remote weak signal detection and resolution technology
- New types of energy transfer between electric energy and acoustic energy
- Low-frequency broadband transducer technology for new transducer materials, structures, and mechanisms[1845]

**Notable Applications:**

- This lab is primarily tasked with developing new types of sonar for PRC vessels, including waveguide sonar [波导声纳].[1846]
- This lab (via lead designer Zhou Lisheng) was involved in the development of the PRC's Haiyan [海眼] long-range towed-array anti-submarine monitoring sonar. It also incorporates a database system which records signals from adversary ships and submarines and distributes them to PLAN subs, aircraft, and intelligent mines to ID, track, and strike these targets.[1847]
- Lab Director Gong Xianyi was a driving force behind the PRC's 1st, 2nd, and 3rd-generation sonars for its nuclear and conventional submarines. Most of this was before the formal establishment of this lab (when it was still a research office under the 715th RI), but the SQG-207 sonar (utilized on Yuan and Shang class submarines), was developed under Gong in the 1990s, possibly in the early years of this lab.[1848]

- This lab also develops other related technologies, including underwater communications and alarm systems.[1849]

**Leadership and Key Personnel:**

- Director: Du Shuanping [杜拴平][1850]
- Academic Committee Director: Yang Desen [杨德森][1851]
    - Also associated with the Defense S&T Key Laboratory of Hydroacoustic Technology at Harbin Engineering University, see that entry for more

*Key Personnel:*

- Founder: Gong Xianyi [宫先仪][1852]
    - Lab founder
    - CAE Academician
    - One of the PRC's leading sonar experts
    - Studied at U.S. Case Western Reserve University 1985-87
    - Gong has helped develop the PRC's 1st, 2nd, and 3rd-generation submarine sonar systems. He has also conducted comprehensive assessments of acoustic conditions in the South China Sea. He developed the PRC's first indigenously designed submarine sonar (Type 603), a two-type comprehensive sonar used by the PRC's second generation conventional submarines, and the first sonar system with a centralized display [集中显示] and comprehensive control [综合控制] (the 265 Sonar, in the late 1980s), and a new outboard array sonar. He was involved in the development SQG-207 sonar in the 1990s.

**Notable Collaborations:**

*Domestic*

- This lab is one of the main PRC institutions for research into hydroacoustics. It has collaborated in multiple projects in this area over the years. It frequently collaborates with other such institutions, including the Key Labs of Hydroacoustic Technology, Underwater Acoustic Countermeasures, Underwater Measurement and Control Technology, Acoustic Fields and Acoustic Information, and Ship Vibration and Noise.[1853]

*International*

- In an unidentified year (prior to 2006), this lab allegedly worked with the Institute of Applied Physics at the University of Washington in the U.S. to conduct acoustic experiments on the seafloor, including acoustic scattering, seafloor reverberation, and inversion of seafloor parameters, as well as modeling of high-frequency acoustic scattering. The cooperation continued afterward for an indeterminate length of time.[1854]

- This lab participated in the 2005 7th International Conference on Theoretical and Computational Acoustics, where a Canadian researcher was said to be impressed with their results and expressed a desire to collaborate. As of 2006, this lab has ongoing cooperation agreements with several foreign institutions, and has invited multiple foreign experts to come lecture.[1855]
- This lab co-sponsored, along with five other acoustic research labs, the 2016 IEEE Oceanic Engineering Society China Marine Acoustics Symposium [IEEE/OES 中国海洋声学研讨会], which featured participation of both foreign and domestic experts. The six key labs involved in hosting this event were the Key Labs of Hydroacoustic Technology, Underwater Acoustic Countermeasures, Underwater Measurement and Control Technology, Acoustic Fields and Acoustic Information, and Ship Vibration and Noise, in addition to this lab. The event was held in Harbin and co-hosted by Harbin Engineering University and the Belgian university Université Libre de Bruxelles. The Chinese language announcement for this symposium even explicitly connects the hydroacoustic research of this symposium to the PRC's national strategy of becoming an oceanic power for economic development, national sovereignty, and military power. The event was the brainchild of Professor Yang Desen of HEU, who is also closely associated with the Defense S&T Key Lab of Hydroacoustic Technology, and a researcher from the Université Libre de Bruxelles. A similar conference was scheduled to be held in 2021.[1856]

**Lab Equipment:**

- This lab has access to the 715th RI's anechoic pool (the world's largest indoor low and medium frequency anechoic poll) and variable temperature and pressure acoustic testing equipment.[1857]

**Address**:

715th RI Building #3, Pinfeng Village, Xihu Distrist, Hangzhou, Zhejiang Province [浙江省杭州市西湖区屏峰村][1858]

An alternative address is No. 715 Pinfeng Street, Liuxia Subdistrict, Xihu District, Hangzhou, Zhejiang Province 310023 [浙江省杭州市西湖区留下街道屏峰 715 号 邮编：310023][1859]

**Known Aliases:**

- Science and Technology on Sonar Laboratory
- National Key Lab of the 715th Research Institute [七一五所国家重点实验室]
- Key Laboratory of Sonar Technology [声纳技术重点实验室]

## 78. Defense S&T Key Laboratory of Space Chemical Power Technology

**Official English Name:** Unknown

**Chinese Name:** 航天化学动力技术国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Multi-Domain (Air, Space)

Equipment:

- Multiple (Ballistic Missiles, Missiles, Space Vehicles)

Functional Field:

- Propulsion
- *Secondary: Blast, Impact, and Damage*

**Affiliations:**

- China Aerospace Science and Technology Corporation (CASC) [中国航天科技集团]
  - Hubei Institute of Space Chemical Technology [湖北航天化学技术研究所]
    - *a.k.a. CASC 4th Academy 42nd Research Institute*

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab was first approved by SASTIND and the CMC EDD in May 2018, with a focus on improving basic research in aerospace chemical power technology.[1860] It is primarily focused on solid propellant development, and is an important institution for basic and key technology research on solid propellants for both space launch and ballistic missiles.[1861] It may have been formed in 2018 as a way of developing domestic solid propellant technology in the face of tightening foreign export controls.[1862] Toward this end, this lab has a role in co-organizing at least two international conferences which bring in foreign experts to share cutting-edge research on military technology with the PRC military S&T apparatus.[1863]

The lab's parent institution, the CASC Hubei Institute of Space Chemical Technology [湖北航天化学技术研究所] (a.k.a. the CASC 42nd Research Institute), was established in 1965 and is the PRC's largest institute for solid propellant research. It is primarily focused on the development of missiles and astronautical products, including the Shenzhou manned spacecraft, Feitian extravehicular spacesuits, the Tianhe Core Module of the Tiangong space station, and the Long March V rocket.[1864]

**Further Information:**

- The lab's fund, the "Key Lab of Space Chemical Power Technology Open Fund" [航天化学动力技术重点实验室开放基金], offered 2.8m RMB in 2022.[1865]
- The lab is also noted for being the city of Xiangyang's first national-level key lab[1866] and playing a key part in the city's scientific development plans, appearing in Xianyang's 14th Five Year Plan as part of its plan to develop its S&T basic research base.[1867] Lab personnel have acted as advisors for improving Xiangyang's S&T environment.[1868]

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- Research goals include development of solid propellants with higher energy potential, wider mechanical range, wider combustion intervals, lower signature, greater robustness, and lower cost.[1869]

The lab's 2022 research priorities were as follows:[1870] [cvii]

1. Amidinouracil dinitramide (utilized in solid propellant formulations)
2. Aluminum trihydroxide (used as fire and smoke suppressant)
3. Low-temperature adhesives
4. High performance hollow continuous quartz fiber
5. Fiber-filled insulation materials
6. Low-temperature atomic layer deposition technology of new passivation materials for wet heat stabilization of aluminum trihydroxide
7. Aging process of high-energy propellants
8. High-valent chlorine compounds
9. RDX/HMX Explosives Crystal Microstructure Defect Characterization/Hot Spot Formation of High Energy and Low Vulnerability Propellants
10. Combustion performance of aluminum-based composite fuels

[cvii] Further details about each of these priorities, including areas of interest, research targets, and funding, are available.

11. Solid propellant combustion reaction dynamics modeling and combustion rate prediction[cviii]

**Notable Applications:**

None found

**Leadership and Key Personnel:**

- Director: Guo Xiang [郭翔][1871]
  - Also director of the CASC 42nd RI
  - Expert on solid propellant technology
  - Has won numerous awards, including being recognized as a "Meritorious Individual in High-Tech Weapons and Equipment Development and Construction Project" by the Hubei provincial government
- Standing Committee Deputy Director: Li Wei [李伟][1872]

*Key Personnel:*

- Wang Fang [王芳]
  - Solid propellant expert[1873]

**Notable Collaborations:**

*Domestic*

- In 2021, personnel of the Beihang University Spray Combustion Laboratory [北航喷雾燃烧实验室] visited this lab and discussed cooperation in the field of new propellant technologies.[1874]
- In 2022, this lab co-organized the 5th China Air and Space Propulsion Technology Forum [第五届中国空天推进技术]. The primary sponsors were CASC, National University of Defense Technology, Beihang, Beijing Institute of Technology, Harbin Institute of Technology, and Northwestern Polytechnical University. Other co-organizers and supporting institutions included PLARF Engineering University, PLASSF Space Engineering University, Tsinghua University, Shanghai Jiao Tong University, Xi'an Jiaotong University, CASIC, and AECC. Research topics included liquid and solid rocket propulsion, aero-engines, aspiratory power, combined cycle power, electric and special propulsion technologies, reusable space propulsion, space vehicle power and life support, micro flight vehicle and UAV propulsion, materials, processes, and manufacturing, measurement and control, and pyrotechnics.[1875]

[cviii] This received 4x more funding than any of the others, so is either the highest priority or the most expensive to study.

- In 2023, this lab co-sponsored the 2023 Annual Conference on Explosives Technology [2023年火炸药技术学术年会]. The conference was co-sponsored by the Chinese Society of Military Engineering [中国兵工学会] and Beijing Institute of Technology. Other organizers included SASTIND, the PLA EDD, various Norinco subsidiaries, CAEP Institute of Institute of Engineering Materials, and various companies.[1876] [cix]

*International*

- In 2019, this lab co-sponsored the 13th International Autumn Symposium on Propellants, Explosives and Pyrotechnics [第 13 届国际推进剂、炸药、烟火技术秋季研讨会], along with the China Society of Military Engineering, Nanjing University of Science and Technology, North Central University, Southwest University of Science and Technology, CAEP Institute of Chemical Materials, Norinco Xi'an Institute of Modern Chemistry, Xi'an Institute of Aerospace Dynamics Technology, Shaanxi Institute of Applied Physical Chemistry, Key Laboratory of Aerospace Chemistry and Dynamics Technology, Key Laboratory of Combustion and Explosive Technology, and Key Laboratory of Combustion Thermal Structure and Internal Flow Field. The conference was attended by 200 delegates (38 from abroad) from 12 countries: U.S., Russia, Canada, U.K., Italy, Poland, India, Czechia, Israel, Korea, Belarus, and Singapore. The event was co-chaired by a U.S. researcher from the University of Maryland Center for Research in Extreme Batteries. Personnel of U.S. companies Goodrich and Exodynamics Technology Inc., participated. Other speakers included a U.K. researcher from the Imperial College of Science and Technology, as well as personnel from Italy, Poland, Korea, and Russia. Several of the international participants also participated in the 1st International Conference on Defense Technology (see below) in the year prior.[1877]
- In 2018, this lab co-sponsored the 1st International Conference on Defense Technology [国际防务技术大会] in Beijing. Other hosts/sponsors include the China Association for Science and Technology, Norinco and several of its subsidiaries, Beijing Institute of Technology, Nanjing University of Technology, CAEP, and several other key labs. The PLA Army Engineering University also participated. The conference attracted a host of foreign participants, including from U.S. and U.S.-allied institutions. Over 70 foreign participants took part, including from the U.S., U.K., France, Germany, Italy, Singapore, Czechia, Australia, Poland, Russia, and other countries. Participants came from the U.S. University of Texas Institute of Advanced Technology, Italy's Polytechnic University of Milan (Italy) (who spoke on nanoenergetic ingredients for solid rocket propulsion), France's Nexter Munitions (France) (who spoke on armor-piercing fin-stabilized discarding sabot ammunition), Poland's Military Institute of Armament Technology (who spoke on passive, reactive, and hybrid armor), Czechia's University of Pardubice Institute of Energetic Materials (who spoke on explosive mixtures), and the National University of Singapore (who spoke on projectile impact). Other research topics included

[cix] These included: 四川泸州北方化学工业有限公司、辽宁庆阳特种化工有限公司、甘肃银光化学工业集团有限公司、西安北方惠安化学工业有限公司、湖北三江航 天江河化工科技有限公司、西安航天化学动力有限公司、内蒙古航天红峡化工有限公司、山西北方兴安化学工业有限公司.

electromagnetic launch, energy-containing materials, manufacturing process and management and material behavior and properties, impact dynamics, optoelectronic informatization, and other defense technologies. This lab also co-sponsored the 2022 edition of the conference.[1878]

- While less information is available about the 2024 conference, it reportedly included participants from the U.S., U.K., Australia, Italy, Turkey, Singapore, and Russia, among others.[1879] A list of lectures includes researchers from the Chinese Academy of Sciences Switzerland, Mendeleev University of Chemical Technology and the D. V. Efremov Institute of Electrophysical Apparatus of Russia, Singapore Dongguan University of Technology, and Australia's International Society of Impact Engineering, as well as institutions in Malaysia and South Africa.[1880] Curiously, a website advertising the event also lists a German researcher from Impetus Afea Co. as a speaker.[1881] Indian researchers came from Alliance University (speaking on defense applications of unmanned aerial system swarming)[1882] and RIT India.[1883] Committee members also came from UC San Diego, University of Technology Sydney, Polytechnic University of Milan, University of New South Wales Canberra, University of Essex, and National University of Singapore.[1884]

**Lab Equipment:**

None found

**Address**:

Xianyang, Hubei Province [湖北省咸阳市]

**Known Aliases:**

- 航天化学动力技术重点实验室
- 航天化学动力技术国防重点实验室

## 79. Defense S&T Key Laboratory of Space Environmental Materials Behavior and Evaluation Technology

**Official English Name:** National Key Laboratory of Space Environmental Materials Behavior and Evaluation Technology

**Chinese Name:** 空间环境材料行为及评价技术国防科技重点实验室

**Post-2024 Name:** National Key Laboratory of Space Environment and Material Effects[cx] [空间环境与物质作用全国重点实验室][1885]

**Research Focus:**

Domain:

- Space

Equipment:

- Space Vehicles

Functional Field:

- Materials
- *Secondary: Blast, Impact & Damage, Communications Technologies, Optoelectronics, Reliability/Environmental Engineering, Simulation & Modeling*

**Affiliations:**

- Harbin Institute of Technology (HIT) [哈尔滨工业大学]
    - School of Materials Science and Engineering [材料科学与工程学院]
- China Aerospace Science and Technology Corporation (CASC) [中国航天科技集团][cxi]
    - China Academy of Space Technology (CAST) Lanzhou Institute of Physics [兰州空间技术物理研究所]
        - *a.k.a. CASC 510th Research Institute [510 研究所]*

[cx] Literal translation, no official name given
[cxi] The 510th RI's involvement with this Lab is unconfirmed

**Key Data:**

- Established: 2000
- Total Funding: Unknown
- Personnel: 16[cxii] [1886]
- Official start of operations: 2012
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research into materials in space environments, primarily for the PRC's space program. This includes development of new space materials and protective technologies and evaluating the reliability and lifespans for materials and components in orbit.

Xinhua and Lanzhou University confirm that the lab is a national-level DSTKL.[1887] More recently (around 2023), this lab apparently changed its name to the "National Key Laboratory of Space Environment and Material Effects" [空间环境与物质作用全国重点实验室]. The reorganized lab's mission remains near-identical to its previous incarnation, providing research on reliability and lifespan evaluation of materials and components used in spacecraft during in-orbit service, new space materials, and protective/shielding technologies.[1888]

While not immediately obvious, this lab appears to be a joint effort of Harbin Institute of Technology and CASC's China Academy of Space Technology Lanzhou Institute of Physics (a.k.a. the CASC 5th Academy 510th Research Institute). Evidence linking the two labs is scant, but the branch in Lanzhou appears to have changed to the new name at the same time in 2023, seemingly confirming the affiliation.[1889] The CASC Lanzhou Institute of Physics was established in 1962 and conducts R&D of equipment and components for space vehicles, including vacuum technologies, electric propulsion systems, power supplies, space payloads, atomic clocks, surface engineering, electromechanical products, and pressure vessels. The PRC has launched over 200 satellites and other space vehicles using this Institute's products.[1890]

**Further Information:**

- This lab may share an affiliation with the CASC Lanzhou Institute of Physics (a.k.a. the CASC 510th Research Institute), but the nature of this relationship, and indeed whether one exists at all, remains unclear. What is known is that the 510th RI also has a subordinate National Defense Key Lab of the exact same name, located in Lanzhou. However, no evidence could be found directly linking the Lanzhou lab to its Harbin counterpart, and individual researchers are associated with one or the other, with no apparent overlap. The two labs can be found interacting, but this appears to be primarily due to their similar research aims. The exact nature of the relationship between these two institutions thus remains unclear, although it is probable the two labs are affiliated, as many such labs are joint ventures between SOEs and universities but oftentimes do not make that connection

[cxii] This may apply only to the Harbin branch.

clear. However, until a relationship can be firmly established, this entry concerns itself solely with the Harbin Lab.[1891]

- This lab is closely associated with the Space Environment Ground Simulation Device [空间环境地面模拟装置] at Harbin Institute of Technology, which is part of the PRC's National Major S&T Basic Infrastructure [国家重大科技基础设施]. In its 2024 research funding plan, it required prospective researchers who receive funding to perform at least 80 percent of their testing work with this device.[1892]

**Research Direction:**

Updated 2023 research direction for newly reconstituted lab:[1893]

1. Basic theory of interaction between space environment and materials [空间环境与材料交互作用基础理论]
2. Equivalence criterion of space environment effect simulations [空间环境效应模拟等效性判据],
3. Principles of accelerated test, damage theory, and performance evolution theory, in-orbit life prediction theory and protection theory [加速试验原理、损伤理论、性能演化理论、在轨寿命预测理论及防护理论]
4. Key technologies for space material effect evaluations [空间材料效应评价关键技术]; new materials and protection technology for spacecraft [航天器用新材料及防护技术]
5. Applications of low-temperature, vacuum and irradiation technology in the national economy [低温、真空及辐照技术在国民经济中的应用]

Old (pre-2023) research direction:

1. Reliability evaluation and lifespan assessment for materials and components in orbital service [航天器用材料及元器件在轨服役期间可靠性评价及寿命评估所需解决的基础理论及相关技术]
2. New space materials and protective technologies [新型空间材料及防护技术][1894]

*Other Notable Research Areas:*

- Material interactions in a space environment
- Simulation of space environment effects and other effectiveness criteria
- Acceleration testing principles
- Damage theory
- Performance evaluation theory
- Orbital lifespan prediction and protection theory
- Key technologies for evaluating effects of space materials
- New materials and protection technologies for spacecraft
- Low temperature, vacuum, and radiation technologies[1895]

According to the 2024 key funding plan for the newly reconstituted national key lab, it is funding research in the following areas:[cxiii] 1896

1. 1. Space environment simulation technology
   1.1 Space environment ground simulation technology
   Particle beam current irradiation control; precise design, regulation, testing and application of weak magnetic environment; artificially induced local environment simulation technology; simulation of physical process of stardust environment and regulation of multi-environmental parameters on the surface of the star; other advanced space environment ground equivalent simulation technology.
   1.2 Space environment and effect digital simulation technology
   Based on domestic and foreign satellite detection and ground simulation experiments of big data analysis methods, visualization simulation, etc.; multi-physics field of materials and devices under the space environment effect simulation; space environment under the action of the material damage to the cross-scale simulation; other advanced space environment effect simulation technology.
   1.3 Space plasma environment evolution and its mechanism
   Near-Earth space plasma environment parameter distribution characteristics, evolutionary laws and related physical mechanisms; the acceleration mechanism and transport process of energy particles in the Earth's radiation belt region; the interaction between plasma and electromagnetic waves and effects of high-speed vehicles in near-space; and new ground simulation techniques of space plasma environment.
2. Mechanisms of space environments and material effects laws
   2.1 Mechanisms of space environment and material effects
   Evolution of material damage defects and multi-scale damage mechanism; optimal design and regulation of high-performance material structure and physical properties; dynamic law of material performance evolution under the action of multiple environmental factors.
   2.2 Mechanisms of space environment and device effects
   The endowment correlation mechanism between the microscopic mechanism of space environment effect damage and macroscopic performance of electronic devices; the characterization method of space multi-physical field coupling effect of electronic devices; the key technology of experimental evaluation of space heavy ion/proton single particle effect of electronic devices.
   2.3 Mechanisms of Space Environments and Living Organisms
   The core mechanisms of space environment factors affecting the basic physiological and pathological processes of cells; the mechanism of the neural circuit of living organisms responding to changes in the space environment; effective means and interventions for brain cognitive regulation in the space environment; new technologies in space biology, etc.

3 Evaluation of space environment effects and application technology

[cxiii] The funding amount for general projects is 300,000 RMB and the research period is 2 years; the funding amount for key projects is 600,000-800,000 RMB and the research period is 3 years. At least 80 percent of funding must go tests on the Space Environment Ground Simulation Device.

3.1 Spacecraft service evaluation methods and technologies
Laws and simulation test evaluation methods of space environment complex stress on spacecraft "material-device-component-system"; design methods of space environment effect acceleration experiment; spacecraft material/device reliability evaluation methods based on numerical simulation and ground simulation experiment.
3.2 Space Environment Effect Application Technology
3.3 Research on new functional/structural materials and prototype devices adapted to the space environment; research on the regulation of material property parameters and microstructure design based on space particles and physical fields; in-situ manufacturing and self-healing repair technologies utilizing the space environment; aerospace medicine technologies; other new concepts of space environment effect application technologies.

**Notable Applications:**

- This lab's research is applied to the materials utilized by a wide range of PRC space vehicles, including its various rockets, spacecraft, and satellites.

**Leadership and Key Personnel:**

- Director: Geng Lin [耿林][1897]
- Deputy Director: Wu Yiyong [吴宜勇][1898]
    - Conducts research on environmental effects and damage mechanisms of space solar cells, irradiation damage and atomic oxygen erosion mechanisms of polymeric materials, material irradiation and conductivity effects, and material surface science and technology

*Key Personnel:*

- Li Chundong [李春东][1899]
    - Conducts research on space environment equivalent simulations and accelerated test technology, principles, and methods, space damage behavior, protection and new materials for spacecraft thermal control materials, preparation and characterization of ZnO nanostructures, nanomaterials and devices, and smart materials
    - Was a short-term visiting scholar in 2006 at the ITL Space Technology Company in Canada
    - Graduate students he has advised have studied at U.S. institutions, including the University of Washington, U.S. Department of Energy National Laboratory, and Dartmouth University, between 2011-2014
- Qin Wei [秦伟][1900]

    - Conducts research on energy conversion materials and devices, composite materials, and space environment damage effects
- Li Xingji [李兴冀][1901]
    - Conducts research on space environmental effects, radiation physics, semiconductor materials and defects, space environmental physics, and material irradiation damage
    - Has worked on projects for the European Space Agency, including Astrium, TRAD, and Space Environment and Effects Simulation
    - From 2012-2013 studied at Freiberg University of Mining and Technology in Germany

**Notable Collaborations:**

*Domestic*

- HIT signed a strategic cooperation framework agreement with CASIC's Hunan Aerospace [湖南航天] in 2017, which included this lab as an interested party. The agreement mentioned promoting the role of new materials in military-civil fusion [军民融合], developing new materials for the equipment, technology, and product fields, strengthening exchange and cooperation with Hunan Aerospace in the fields of new space materials, space material genomes, and testing materials in a space environment. Hunan Aerospace subsidiaries involved in this agreement included the New Materials Research Academy [新材料研究院], Wuhan Magnetism-electron Co. [武汉磁电公司], Sanfeng Co. [三丰公司], and Tianlu Testing Co. [天麓检测公司].[1902]

*International*

- In 2019, this lab co-hosted with several other research institutions the 3rd National Academic Conference on Hypersonic Collisions [第三届全国超高速碰撞学术会议]. This included 57 work units, including an unspecified number of military work units. A speaker from Manchester University in England also spoke.[1903]

**Lab Equipment:**

This lab utilizes multiple types of equipment for simulating the effects of a space environment, including:

- Space materials positive ion irradiation simulation system
- Vacuum thermal cycle simulation system for space
- Vacuum low-temperature friction wear system for space materials
- Space atomic oxygen effects simulation system
- Space debris high-speed impact simulation system

- Space dust high-speed impact simulation system
- Space material vacuum gas precipitation test device
- Material vacuum/low temperature hydraulic servo MTS tester
- Precision multi-functional low-temperature static load material testing machine
- Material vacuum/low-temperature tensile-compression fatigue testing machine
- Material low-temperature thermal expansion coefficient testing device[1904]
- Comprehensive irradiation simulation system for space materials
    - Final vacuum: 10-7torr; temperature range of thermal cycling: 77～400; wavelength of solar electromagnetic radiation: 200～2500nm; Wavelength of vacuum ultraviolet radiation: 1～200nm; electron-beam irradiation intensity: 1～50μa; proton-beam irradiation intensity: 1～50μa[1905]

**Address**:

Building #9, Harbin Institute of Technology, No. 92 West Dazhi Street, Nangang District, Harbin, Heilongjiang Province [哈尔滨市南岗区西大直街 92 号 哈尔滨工业大学 9 号楼][1906]

**Website**:

http://mse.hit.edu.cn/2015/0708/c3817a99883/page.htm

**Known Aliases:**

- National Key Laboratory of Materials Behavior and Evaluation Technology in Space Environment [空间环境材料行为及评价技术国家级重点实验室]
    - Most common English translation
- National Key Laboratory of Materials Behavior and Evaluation Technology in Space Environment [空间环境材料行为与评价技术国家级重点实验室]
    - Same name in English, but uses a different character for "and" (与 rather than 及)
- 空间材料行为及评价技术国防科技重点实验室
    - Missing "环境"
- 空间环境与物质作用全国重点实验室

## 80. Defense S&T Key Laboratory of Space Flight Dynamics Technology

**Official English Name:** State Key Laboratory of Space Flight Dynamics[1907]

**Chinese Name:** 航天飞行动力学技术国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Space
- *Secondary: Air*

Equipment:

- Space Vehicles
- *Secondary: Non-ballistic Missiles*

Functional Field:

- GNC
- *Secondary: Hypersonic Technologies, Manned Spaceflight*

**Affiliations:**

- Northwestern Polytechnical University (NWPU) [西北工业大学]
    - School of Astronautics [航天学院]
- PLA Strategic Support Force
    - Beijing Aerospace Control Center (BACC) [北京航天飞行控制中心]
        - *a.k.a. PLA Unit 63920 [63920 部队]*

**Key Data:**

- Established: 2010
- Total Funding: Unknown
- Personnel: approx. 45
- Official start of operations: 2010
- Floor Space: over 4,000 sqm[1908]

**Lab Overview:**

This lab is focused on various aspects of spaceflight, including orbital mechanics, manned spaceflight, deep space exploration, flight planning and control, and ground experimentation and verification.[1909]

The lab is jointly managed by Northwestern Polytechnical University and the Beijing Aerospace Control Center (BACC), itself subordinate to the PLA Strategic Support Force (prior to the PLASSF's breakup in April 2024). The BACC, established in 1996, is the primary command center for PRC space missions, as well as TT&C of satellites and spacecraft via both ground-based stations and the sea-based Yuanwang support ships.[1910]

**Research Direction:**

1. Orbital dynamics, planning and control [轨道力学、规划与控制]
    - Satellite formation flight
    - Large, flexible spacecraft
    - Deep space exploration
    - Trajectory optimization
    - Non-Keplerian orbit control
    - Attitude-orbit-multi-body coupling
    - Rigid-flexible coupling
2. Space operations and applications [空间操作与应用]
    - Orbit avoidance
    - Orbit transfer/lifting
    - Close observation and inspection
    - Rendezvous and docking
    - In-orbit payload release
    - In-orbit maintenance
    - Module replacement
    - Fuel replenishment
    - Orbit and attitude reset
    - In-orbit assembly and reconstruction
    - End-of-life and destruction maneuvers
    - Orbit transfer/lifting
    - Close observation and inspection
    - Rendezvous and docking
    - In-orbit payload release
    - In-orbit maintenance
    - Module replacement
    - Fuel replenishment
    - Orbit and attitude reset
    - In-orbit assembly and reconstruction
    - End-of-life and destruction maneuvers
3. Flight ground experimentation and verification [飞行地面试验与验证]
    - Similarity theory of space operation ground experiments
    - Liquid buoyancy/electromagnetic force hybrid levitation systems
    - Bonding diagram theory-based ground experiment similarity analysis
    - Hybrid levitation experiment test methods
    - Cyber space-assisted simulation experiment methods

*Other Notable Research Areas:*

- Rocket malfunction simulation and semi-physical simulation systems
- Space non-cooperative target grasping dynamics and control
- Ground-based microgravity environment construction and applications

- Small UAV target detection
- Hypersonic vehicle surface control[1911]

**Notable Applications:**

- This lab was involved in the launch of the Tiangong-1 space station. A team from this lab, led by then-Director Tang Geshi, was present at launch monitoring "their" flight control software to ensure the craft was in correct orbit. Tang's team also played a key role in the rendezvous and docking of the Shenzhou-8, 9, and 10 with the Tiangong-1.[1912]
- This lab was involved in development of the Tianji Small Satellite Constellation.[1913]
- In 2008, researcher Yan Jie [闫杰] was awarded a 2nd Class Military S&T Progress Award for the project,"(REDACTED) Missile Research and Development" [XXX 导弹研制]. While unconfirmed, the redacted part could be referring to air-to-air missiles and/or perhaps infrared missiles, as Yan was engaged in such research in 2008.[1914]

**Leadership and Key Personnel:**

- Director: Luo Jianjun [罗建军][1915]
- Former Director: Yuan Jianping [袁建平][1916]
- Former Director: Tang Geshi [唐歌实][1917]

**Notable Collaborations:**

*Domestic*

- This lab is associated with the Collaborative Innovation Center of Future Aerospace Vehicle (*sic*) [未来飞行区协同创新中心] at NWPU, a consortium which includes several universities, defense SOEs (CASC, CASIC), and CARDC (PLA Base 29).[1918]
- This lab has a cooperative relationship with the Shanghai Aerospace Technology Research Institute [上海航天技术研究院].[1919]
- In 2011, this lab created the Joint Research Center for Remote Operation of Deep Space Exploration [深空探测遥操作联合研究中心] with the CAS Institute of Remote Sensing Digital Earth National Engineering Laboratory of Remote Sensing Satellite Applications [中科院遥感与数字地球研究所遥感卫星应用国家工程实验室].[1920]
- In 2018, this lab hosted the 6th National Symposium on Space Flight Dynamics. Participants included SASTIND, CAST (CASC 5th Academy), SAST (CASC 8th Academy), at least three major PLASSF institutions (Xi'an Satellite Measurement and Control Center [西安卫星测控中心], Space Engineering Research Institute [航天工程研究所], and Astronaut Research and Training Center [航天员科研训练中心]), the National University of Defense Technology, and several other universities. Topics included space

robotic and robotic arm tele-operations, space tele-operation technology in the context of AI, space operation dynamics, refined lunar surface operations, intelligent image recognition, and microgravity ground simulation environments.[1921]
- Per searches of two scientific databases, this lab has collaborated with PLA Units 63921, 63999, 91206, 94647, 95854, 96271, 96363, and PLASSF Base 26.

*International*

- This lab claims to have signed cooperation agreements with the U.S. Stevens Institute of Technology, Delft University of Technology in the Netherlands, and Technical University of Munich in Germany.[1922]
- An extensive list of foreign collaborations between 2013-2017 on the lab's website claims collaborations with the Stevens Institute of Technology and Utah State University in the U.S., as well as universities from France, Germany, U.K., and Canada.[1923]
- From 2013-2017, the lab's website claims that over 95 percent of its PhD students were able to study abroad, including at MIT, Stevens Institute of Technology, Utah State University, and Texas Tech in the U.S., as well as Canadian and European Universities.[1924]
- This lab collaborated with the COSMIC Program Office of the University Corporation for Atmospheric Research in Boulder, Colorado (a nonprofit consortium of over 100 U.S. academic institutions) on ionospheric research.[1925]
- This lab collaborated with the German Research Center for Geosciences on thrust maneuvers for uncooperative space objects.[1926]
- Researcher Wang Mingming [王明明] has allegedly collaborated on projects with the German Space Center [德国宇航中心].[1927]

**Lab Equipment:**

- Virtual prototype integrated design and test system for air and space vehicles
- Multidisciplinary integrated design system for aircraft
- Hybrid buoyancy microgravity simulation experimental system
- Space proximity manipulation and remote operation experimental system
- Electromagnetic system console
- Six-degree-of-freedom rotary table
- Liquid magnetic pool circulation treatment system[1928]

**Address**:

Appears to have facilities at both of NWPU's campuses at No. 127 Youyi West Road, Xi'an, Shaanxi Province [西安市友谊西路 127 号] and No. 1 Dongxiang Road, Chang'an District, Xi'an, Shaanxi Province [陕西省西安市长安区东祥路 1 号].[1929]

**Website**:

http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=315

**Known Aliases:**

- National Key Laboratory of Aerospace Flight Dynamics [航天飞行动力学技术国家重点实验室]
- Key Laboratory of Aerospace Flight Dynamics [航天飞行动力学技术重点实验室]
- Flight Dynamics Laboratory, Beijing Aerospace Control Center
- Science and Technology on Aerospace Flight Dynamics Laboratory
- National Key Laboratory of Science and Technology on Aerospace Flight Dynamics
- Key Laboratory of Aerospace Flight Dynamics Technology

## 81. Defense S&T Key Laboratory of Space Flight Intelligent Control Technology

**Official English Name:** Unknown

**Chinese Name:** 宇航智能控制技术国防科技重点实验室

**Post-2024 Name:** National Key Laboratory of Space Flight Intelligent Control Technology[cxiv] [宇航智能控制技术全国重点实验室][1930]

**Research Focus:**

Domain:

- Multi-Domain (Air, Space)

Equipment:

- Multiple (Air/Missile Defense, Ballistic Missiles, Non-ballistic Missiles, Space Vehicles, Unmanned Systems)

Functional Field:

- GNC
- *Secondary: Hypersonic Technologies, Intelligent Technologies, Measurement Technologies*

**Affiliations:**

- China Aerospace Science and Technology Corporation (CASC) [中国航天科技集团]
    - Chinese Academy of Launch Technology (CALT) Beijing Aerospace Automatic Control Institute [中国运载火箭技术研究院北京航天自动控制研究所]
        - *a.k.a. CASC 12th Research Institute [12 研究所]*

**Key Data:**

- Established: 2003
- Official start of operations: 2006
- Personnel: Unknown
- Total Funding: Unknown [1931]
- Floor Space: Unknown

[cxiv] Literal translation, no official name given

**Lab Overview:**

This lab conducts research into guidance and control technology, with a particular focus on utilizing intelligent technologies to improve flight vehicle (including space vehicle, UAV, and missile) GNC. It is dedicated to improving the PRC's indigenous capabilities in high-tech guided weaponry.[1932]

This lab may have originally been called the "Defense S&T Key Laboratory of Missile Guidance and Control Technology" [导弹制导与控制技术国防科技重点实验室] when it was first established, but that name seems to no longer be used. More recently, as part of the ongoing reform of the national key lab system, the lab was re-approved as an ostensibly civilian National Key Lab in 2023. However, it was approved by SASTIND, which normally approves only military labs. Further, it reportedly won an award as the Number One Defense S&T Key Lab in 2023 after it had supposedly joined the National Key Lab system, indicating it may still be a DSTKL.[1933]

The lab's parent institution, the CASC Beijing Aerospace Automatic Control Institute (a.k.a. the CASC 12th Research Institute), was established in 1958 as the PRC's first institution for R&D of launch vehicle control systems. It is mainly engaged in research of launch vehicle control systems, aerospace control and information, and launch vehicle software testing/evaluation.[1934]

**Further Information:**

- This lab oversees the Aerospace Intelligent Technology Innovation Center [航天智能技术创新中心]. The Center is divided into four smaller centers focused on intelligent systems technology, intelligent sensing technology, intelligent computing technology, and intelligent systems integration. The Center is aimed at open collaboration with universities and industry to accelerate intelligent technologies for the aerospace field. It was born from the State Council's 2017 Development Plan for a New Generation of Artificial Intelligence [新一代人工智能发展规划] and the 19th Party Congress.[1935]
- This lab co-hosted the BAACI Cup for innovation and creativity in AI.[1936]
- In 2019 and 2020, this lab twice won first place in a CASC competition of 16 of its key labs. There was no mention of what this competition entailed.[1937]
- This lab designed a reusable test and validation platform for its technologies called the "Peacock Platform" [孔雀平台].[1938]
- This lab has published a large number of books on a variety of topics, including on vertical landings for reusable launch vehicles, missile simulations, and other topics related to rocketry. Notably, at least one title refers to navigation and control of both rockets *and* missiles, making clear the dual nature of this lab's work.[1939]

**Research Direction:**

1. Guidance and control technology [制导与控制技术]

2. Precision guidance technology [精确制导技术]
3. Systems integration technology [系统集成技术]
4. Rapid measurement and control technology [快速测控技术][1940]

*Other Notable Research Areas:*

- Missile guidance and control technology
- Launch vehicle and hypersonic vehicle GNC
- Simulation of anti-missile defense penetration systems
- Electrical systems for manned launch vehicles
- Thermal radiation effects on hypersonic flying vehicle
- Much of the lab's research is focused on incorporating intelligent/AI technology into rockets, missiles, UAVs, etc.[1941]

**Notable Applications:**

- This lab appears to be a key research lab for the PLA's ballistic missile program. It and its parent 12th RI were involved in the PLA's ASBM program which eventually led to the development of the DF-21D. The Director of the PLASAF Equipment Research Academy was present at the lab's official opening.[1942]
- This lab, along with the subordinate Aerospace Intelligent Technology Innovation Center [航天智能技术创新中心], created a small reusable launch vehicle that could land vertically, a major breakthrough toward the goal of an eventual full-sized reusable launch vehicle. This smaller rocket tested concepts of precision guidance necessary for reusable vertical landings.[1943]
- As part of its efforts in intelligent aerospace technologies, this lab took part in work on an intelligent space launch vehicle, developing a "non-programmed guided intelligent control technology" [非程序制导智能控制技术] for a rocket control system. This technology makes the rocket "smarter" by determining and assessing faults mid-flight, and giving the optimal solution, such as adjusting the flight attitude or re-routing the flight path. It will also allow rockets to optimize their flight control plan mid-flight, making autonomous decisions based on the external environment and mission. It enhances the rocket's attitude control, trajectory planning, center-of-mass motion, and environmental awareness, allowing it to better respond to unexpected situations in flight. Yu Chunmei of this lab has also worked on incorporating AI into launch vehicle GNC, mitigating launch failures as it makes adjustments while in flight. This tech was successfully tested using the lab's "Peacock" testing platform.[1944]
- This lab developed an "Intelligent Target Recognition and Perception Integrated System Platform based on Neuro-Electrophysiology" [基于神经电生理的智能目标识别与感知集成系统平台] which can be used to improve UAV target recognition capabilities by 20 percent. It can be used as an EEG system, connecting sensors to a human user's head. It senses the user's brain waves to recognize a target without the user having to issue any

commands. This technology is useful in situations where weather or obstacles may partially obscure a target and a human user would be better able to recognize a partial target than an AI.[1945]

- Qi Zhenqiang of this lab was involved with developing the Long March-3A launch vehicles and the GNC systems for the Chang'e-1 and Chang'e-2 lunar missions.[1946]
- This lab has researched facial recognition and maritime smart port technology.[1947]

**Leadership and Key Personnel:**

- Deputy Directors: Liu Jiarun [柳嘉润]; Yu Chunmei [禹春梅]; Ren Zhang [任章][1948]
- Management Office Director: Qi Zhenqiang [祁振强][1949]
- Senior Engineer: Zheng Zhihui [郑智辉][1950]
- Chief Software Engineer: Wang Xiaoling [王晓玲][1951]

**Notable Collaborations:**

*Domestic*

- This lab has cooperated with Peng Cheng Laboratory [鹏城实验室], a PRC government network communications lab, including in creation of an Intelligent UAV Swarm Cooperative Control Technology Exchange [智能无人机集群协同控制技术交流会] which conducts research into UAV swarms.[1952]
- The lab presumably collaborates with the PLARF (former PLASAF). The lab's official founding ceremony was attended by the Director of the PLASAF Equipment Research Academy [二炮兵装备研究院].[1953]
- This lab is a part of the Aviation Control Forum, which was formed in 2001 and holds gatherings every two years. In 2017, this lab hosted the 9th Aviation Control Forum [航控论坛]. Participants included the Ministry of Industry and Information Technology, SASTIND, and the PLA CMC Equipment Development Department. Topics included intelligent and autonomous systems technology, future control and information technology, and intelligent development of aerospace equipment.[1954]
- In 2020, this lab participated in the 2nd Intelligent Precision Strike Systems Frontier Forum [第二届智能精打体系前沿论坛], a conference focused on using intelligent systems and AI for improved precision strike and "intelligentized" operations. Topics included using intelligent systems to improve situational awareness, target identification, more rapid and timely decision-making, and intelligent weapons development. Other participants included Xidian University's Defense S&T Key Lab of Radar Signal Processing, the Space Defense Innovation Center [空天防御创新中心], the Shanghai Institute of Electromechanical Engineering, the Beijing Remote Sensing Institute [北京遥感设备研究所], CETC 12th, 29th, and 54th RIs, the Key Lab of Complex Aviation Systems Simulations, the Key Lab of Aerospace Systems Simulations, the Key Lab of Millimeter Wave Remote Sensing

Technology, the Key Lab of Satellite Navigation Systems and Equipment Technology, CAS Institute of Optoelectronics Signal Processing, the Jiangsu Engineering Research Center for Intelligent Navigation and Control Engineering for Complex Moving Bodies, the Key Lab of Complex Systems Control and Intelligent Cooperation Technology, and others.[1955] [cxv]

*International*

- Personnel of this lab are associated with a joint lab with the U.K., the Sino-British Joint Laboratory of Advanced Control System Technology [中英先进控制系统技术联合实验室]. Qi Zhenqiang of this lab is the Director of the Chinese portion of this lab.[1956]

**Lab Equipment:**

None found

**Address**:

None found, may be co-located with parent institution in the Beijing 1000854 postal code.

**Known Aliases:**

- Defense S&T Key Laboratory of Missile Guidance and Control [导弹制导与控制技术国防科技重点实验室]
    - Name used on the "official" online list of DSTKLs, but less commonly used.
- State Key Laboratory of Space Flight Intelligent Control Technology [宇航智能控制技术国家重点实验室]
- National Key Laboratory of Space Flight Intelligent Control Technology [宇航智能控制技术国家级重点实验]
- Beijing Space Automatic Control Research Key Laboratory [北京航天自动控制研究所重点实验室]
- National Key Laboratory of Science and Technology on Aerospace Intelligent Control
- State Key Laboratory of National Defense for Aerospace Intelligence Control

[cxv] Further detailed info on this conference (participants, reports, detailed topics, etc.) is available.

## 82. Defense S&T Key Laboratory of Space Intelligent Control Technology

**Official English Name:** Unknown

**Chinese Name:** 空间智能控制技术国防科技重点实验室

**Post-2024 Name**: National Key Lab of Space Intelligent Control Technology[cxvi] [空间智能控制技术全国重点实验室][1957]

**Research Focus:**

Domain:

- Space

Equipment:

- Space Vehicles

Functional Field:

- GNC
- *Secondary: Intelligent Technologies*

**Affiliations:**

- China Aerospace Science and Technology Corporation (CASC) [中国航天科技集团]
  - Beijing Institute of Control Engineering [中国航天科技集团公司第五研究院北京控制工程研究所]
    - *a.k.a. CASC 5th Academy 502nd Research Institute [502 研究所]*

**Key Data:**

- Established: 2009
- Total Funding: Unknown
- Personnel: Unknown[1958]
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab conducts applied basic and "new conceptual" research centered on intelligent and autonomous control theory and methods for aerospace, as well as space autonomous navigation and environmental perception, spacecraft autonomous operations and fault-tolerant control, and space intelligent maneuvering.[1959] Its research into space control technology ensures space

[cxvi] Literal translation, no official name given

vehicles can operate at predetermined attitudes and orbits.[1960] Autonomous tracking, measurement, and rendezvous/grappling technologies for space vehicles also appear to be areas of interest. The lab's work on intelligent space control technology has been utilized by the PRC's manned spaceflight, deep space exploration, and other major projects.[1961]

The lab's founding date is muddled. Officially, it was established, possibly in its current form, in 2009,[1962] and imagery confirms that it was classified as a Defense S&T Key Lab at this time.[1963] However, it has apparently existed in some form since at least 2004,[1964] holding its first academic committee meeting around 2006[1965] and its third academic committee meeting in 2008.[1966] Like other labs, it may have recently taken on a more civilian name, using "全国" (national) rather than "国防" (defense). However, it is still funding SASTIND projects in 2024 even under its new name,[1967] indicating a continued military role.

The lab's parent institution, the CASC Beijing Institute of Control Engineering, (a.k.a. the CASC 5th Academy 502nd Research Institute), was founded in 1956 as one of the earliest institutions working on satellite development in the PRC. It is mainly engaged in the design and development of space vehicle attitude and orbit control systems, propulsion systems, guidance, navigation and control systems, and related components for spacecraft.[1968]

Under the ongoing reorganization of the PRC's national key lab system, this lab is now known as the National Key Lab of Space Intelligent Control Technology [空间智能控制技术全国重点实验室].

**Further Information:**

- This lab is not to be confused with the Shanghai Municipal Key Lab of the same name, the "Shanghai Key Lab of Space Intelligent Control Technology" [上海市空间智能控制技术重点实验室].
- The lab's research fund conducted research on measuring the motion of non-cooperative targets in space, indicating interest in intercepting adversary satellites.[1969]
- In 2022, the lab offered 800k RMB in funding for projects from its open fund.[1970]
- A photo showing the 502nd Research Institute's space intelligent control team, apparently associated with this lab, shows approximately 35 researchers.[1971]
- This lab was involved in the formulation of the PRC's "Intelligent Control 2025" strategy ["超越计划"——智能控制 2025 纲要].[1972]

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- Intelligent and autonomous control theories and methods for spacecraft, autonomous perception of space targets, and autonomous operation for spacecraft autonomy capability in complex space perception and manipulation tasks[1973]
- In 2022, this lab funded a 2022 SASTIND project focused on cooperative robotic navigation[1974]
- The lab also funded a 2023-2025 project, partially redacted, on small spacecraft pursuit and attachment control technology[1975]
- Traction magnetic plasma power propulsion technology[1976]
- Measurement of the motion of non-cooperative targets in space[1977]

*2023 lab open fund priorities*:[1978]

(Each of these has research cycle of two years, with up to 500k RMB in funding)

1. Autonomous perception and understanding of space target behavior in complex scenes [复杂场景下空间目标行为自主感知与理解]
    - Includes orbital threat target avoidance, rapid detection and early warning of maneuvering targets and threats, intelligent recognition of target features and identity determination, heterogeneous multi-mode sensing and intent understanding of space targets, generalization and enhancement of intelligent sensing models of space targets, and autonomous collaborative sensing and understanding of multi-spacecraft
2. Multi-spacecraft intelligent gaming control [多航天器智能博弈控制]
    - Includes orbital game behavior modeling, multi-spacecraft intelligent game decision-making under multiple constraints, orbital game planning under complex space situations, and distributed multi-strategy collaborative defense of satellite swarms
3. Autonomous rendezvous and approach of non-cooperative targets at long range [远距离非合作目标的自主交会与接近]
    - Includes non-cooperative target orbit determination, target short-arc orbit fixing and motion detection, multi-target rendezvous and multi-constraint optimal guidance, and high-precision autonomous approach guidance in ring-of-fire orbits
4. Extraterrestrial detection and on-orbit service smooth maneuvering [地外探测与在轨服务柔顺操控]
    - Includes methods of precise and smooth control by visual-contact fusion, complex multi-task self-learning, multi-intelligent body interactive cooperative and communal operation, coordinated gait control of robots in complex scenes, and intelligent handling of control anomalies
5. Oher new concepts, theories and methods related to space intelligent autonomous control

*2022 Research foci*:[1979]

(Each of these has research cycle of two years, with up to 500k RMB in funding)

1. Spacecraft Complex Scene Autonomous Perception and Understanding [航天器复杂场景自主感知与理解]
    - Includes space situational awareness and threat target avoidance, mechanisms of measurement system of backlight sensitizer, multi-source fusion of target motion detection, rapid determination of identity features of known/unknown targets and associated characterization, and intention understanding based on attention mechanism or causal reasoning
2. Orbital gaming and intelligent decision-making for multi-spacecraft cooperation [面向多航天器协同的轨道博弈与智能决策]
    - Includes multi-spacecraft on-orbit cooperative work, new concepts and methods of intelligent game decision-making and optimization algorithms, focusing on solving the problems of many decision-making elements, large decision-making space, and low on-line efficiency of solving
3. Extraterrestrial body shallow surface non-structured environment detection and smooth manipulation technology [地外天体浅表层非结构化环境探测与柔顺操控技术]
    - Includes safe and efficient operation of autonomous sampling and returning in unstructured environments of shallow surface of extraterrestrial objects, intelligent and smooth manipulation technology for continuous operation of robots in complex media, intelligent fusion perception of heterogeneous data in complex media, intelligent and autonomous planning of manipulation tasks, active and reactive smooth control of contact detection in shallow extraterrestrial surface layers, and adaptability of extraterrestrial exploration robots to complex and harsh environments
4. Flexible attachment and precise impact control technology for dark and weak small bodies [暗弱小天体柔性附着与精确撞击控制技术]
    - Includes new flexible attachment sensing and manipulation mechanism program design, complex dark and weak star surface multi-observation node cooperative sensing, flexible and strong coupling constraints cooperative control, target long-range approaching observability enhancement and trajectory optimization, dark and weak target approaching observation and feature enhancement
5. Other new concepts, theories and methods related to intelligent autonomous control in space

**Notable Applications:**

- This lab developed an experimental failure simulation and fault-tolerant control system [故障模拟与容错控制实验系统].[1980]

**Leadership and Key Personnel:**

- Director: Yuan Li [袁利][1981]
  - Also CASC 502nd RI Director
  - Holds a wide variety of official positions: Vice Chairman of the 7th Council of the Chinese Society of Inertial Technology, Executive Director of the 11th Council of the Chinese Society of Automation, Director of the 7th Council of the Chinese Society of Aeronautics and Astronautics, Director of the 9th Council of the Chinese Society of Space Science, Director of the 1st Electro-propulsion Specialized Committee of the Chinese Society of Aeronautics and Astronautics, member of the Specialized Group on Overall Technology of Military Space Equipment Satellites
  - Specializes in civilian and military spacecraft attitude and orbit control technology
- Deputy Director: He Yingzi [何英姿][1982]
- Standing Committee Deputy Director: Liu Lei [刘磊][1983]

**Notable Collaborations:**

*Domestic*

- In 2009, this lab established the Joint Research Center on Dynamics and Control of Deep Space Probes [深空探测器动力学与控制联合研究中心] with Beijing Institute of Technology's School of Astronautics. This Center will carry out joint research on system modeling and simulation of spacecraft dynamics, flexure spacecraft dynamics modeling and control, spacecraft control and navigation, and control theory and technology.[1984]
- This lab has established cooperative relationships with more than ten domestic research institutions, including Shanghai Jiao Tong University, through the cooperation of joint research centers and other means, and collaborated with these institutions to carry out basic frontier research represented by the Ministry of Science and Technology's "New Generation of Artificial Intelligence Major Project" [新一代人工智能重大项目].[1985]
- In 2023, this lab co-organized the China Automation Conference "Intelligent Walking, Intelligent Control, Exploring Space" Forum [中国自动化大会“智行 智控 探索空间”专题论坛]. Other organizers and sponsors included the Chinese Association of Automation [中国自动化学会], Tsinghua University Department of Automation, Chongqing University School of Automation, and the Professional Committee of Space and Motion Control of the Chinese Society of Automation. Topics included intelligent perception, intelligent decision-making, and autonomous control with space technology and space missions.[1986]
- In 2021, this lab co-sponsored CCF Sys 2021, part of a series of conferences of the China Computer Federation. Other organizers included the CCF Architecture Special Committee [CCF 体系结构专委], the Information Storage Technology Special Committee [信息存储技术专委], the Zhijiang Laboratory [之江实验室], and Zhejiang University. The theme of the conference is "New Computer System Technology in the Age of Intelligence" [智能化

时代的计算机系统新技术], including advanced parallel processing and information storage. At least one speaker, presenting on the topic of big data storage, come from the National University of Defense Technology [国防科技大学].[1987]

**Lab Equipment:**

None found

**Address**:

Beijing 100094 [北京市][1988]

**Known Aliases:**

- 空间智能控制技术全国重点实验室
- 空间智能控制技术国家重点实验室
- 空间智能控制技术国家级重点实验室
- 空间智能控制技术重点实验室

## 83. Defense S&T Key Laboratory of Space Microwave Technology

**Official English Name:** Unknown

**Chinese Name:** 空间微波技术国防科技重点实验室

**Post-2024 Name**: National Key Lab of Microwave Communications[cxvii] [空间微波通信全国重点实验][1989]

**Research Focus:**

Domain:

- Space

Equipment:

- Space Vehicles
- *Secondary: Communications Equipment*

Functional Field:

- Electromagnetics
- *Secondary: Communications Technologies, Countermeasures, Measurement Technologies, Microwave Technologies, Sensing, Terahertz Technologies*

**Affiliations:**

- China Aerospace Science and Technology Corporation (CASC) [中国航天科技集团]
  - China Academy of Space Technology (CAST) Academy of Space Information Systems [空间电子信息技术研究院]
    - *a.k.a. CAST Xi'an Branch [中国空间技术研究院西安分院]*

**Key Data:**

- Established: 1995
- Total Funding: Unknown
- Personnel: Unknown[1990]
- Official start of operations: 1997
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research into microwave technology for satellite remote sensing, communications, and data transmission in line with the needs of the PRC's space strategy.

[cxvii] Literal translation, no official name given

Secondary areas of research may include precision measurement, space electronic countermeasures, and space debris.[1991]

The lab's parent institution, the CASC Academy of Space Information Systems (a.k.a. CASC Xi'an Branch), was formerly known as the Xi'an Institute of Space Radio Technology [西安空间无线电技术研究所/中国空间院西安空间无线所] and the 504th Research Institute. It is mainly engaged in the development and production of space vehicle payloads and electronic systems, aircraft measurement and control systems, and weapons and satellite electronics. It is involved in satellite communications, data transmission, and navigation technology, develops satellite antennas, and is a pioneer in the field of ground, sea, and space-based measurement and control technology. It has provided thousands of pieces of equipment for China's domestically produced communications, broadcasting navigation, remote sensing, meteorological, and scientific satellites, the Shenzhou spacecraft, and ground-based measurement and control equipment.[1992]

Under the ongoing reorganization of the PRC's national key lab system, this lab may now be known as the National Key Lab of Microwave Communications [空间微波通信全国重点实验].

**Further Information:**

- The lab translated the book "Principles of Terahertz Science and Technology" [太赫兹科学与技术原理] (originally published by Springer), and re-published it under the National Defense Industry Press [国防工业出版社].[1993]

**Research Direction:**

1. Space microwave communications and relays [微波通信转发]
2. Space microwave remote sensing [空间微波遥感]
3. Space microwave real-time high-speed data transmission [空间微波实时高速数传][1994]

*Other notable research areas:*

- Terahertz spectrum technologies
- Space electronic countermeasures
- Space debris situational awareness[1995]

**Notable Applications:**

- The lab is conducting research on using signal anomalies in the Beidou satellite constellation to detect stealth aircraft.[1996]
- The lab's research has been successfully applied to major space projects such as manned spaceflight, the lunar exploration project, and high-definition earth observations, including:
    - High-precision measurement technology used in the Chang'e 3 moon landing
    - Significant technical support for deep space exploration
    - Payloads for civil and military communications and remote sensing satellites such as the Zhongxing and Beidou series[1997]

**Leadership and Key Personnel:**

- Director: Shi Pingyan [史平彦][1998]
- Deputy Directors: Cui Wanzhao [崔万照]; Li Xiaojun [李小军][1999]
- Senior Engineer: Wen Yuanyuan [温媛媛][2000]
    - Researching the use of satellite signal anomalies to detect stealth aircraft.

**Notable Collaborations:**

*Domestic*

- This lab co-hosted the CAE 4th Space Information Technology and Applications Prospect Academician Forum and the 2017 Annual Conference on Satellite Payload Technology [中国工程院第四届"空间信息技术与应用展望院士论坛"暨 2017 年卫星有效载荷技术学术年会] with various universities, CASC entities and scholarly associations. It included reports and presentations on military-civil fusion [军民融合] in space, and presenters included the Chinese Academy of Military Science and the 55th RI [55 所] of the PLA Joint Staff Department.[2001]
- This lab co-hosed the 2020 Commercial Aerospace Advanced Communications Technology Forum [商业航天先进通信技术论坛] with the Key Laboratory of Millimeter Wave Remote Sensing Technology [毫米波遥感技术重点实验室], the Ministry of Education Key Laboratory of Equipment Efficiency in Extreme Environments [极端环境下装备效能教育部重点实验室], and several universities. The director of a PLASSF space organization (Beijing Institute of Tracking and Telecommunications Technology [北京跟踪与通信研究所]) spoke at the event.[2002]
- This lab co-hosed the 2020 Space Electronic Information Academic Exchange Conference [2020 空间电子信息学术交流大会] with the Defense S&T Key Laboratory of Communication Anti-Jamming Technology, the State Key Laboratory of Experimental Physics and Computational Mathematics [试验物理与计算数学国家重点实验室], and

other academic organizations. There were numerous reports/presentations by researchers from PLA and defense industry organizations, including PLA Unit 63921, the National University of Defense Technology, and CETC 22nd and 54th RIs.[2003]

*International*

- In 2023, this lab was a co-organizer of the 8th Conference on Microwave Photonic Technology and Applications [第八届微波光子学技术及应用会议/研讨会]. Major organizers included (but were not limited to) the Optical Engineering Society of China [中国光学工程学会], Nanjing University of Aeronautics and Astronautics, CETC 14th and 29th, 34th, 38th, 44th, 54th, and 55th RIs, CASC China Academy of Space Technology, and the CSSC 723rd RI, as well as multiple private companies. Individuals from the PLAAF Early Warning Academy, PLAAF Engineering University, Chinese Academy of Military Science, and AVIC were also involved in organizing. Research topics included high-speed broadband optoelectronics, microwave photonic integrated chips, microwave photon radars, imaging, sensing, and measurement, millimeter wave and terahertz communications, microwave photonics for aerospace, intelligent microwave photonics, space laster microwave communications, and communications countermeasures. The conference featured participation and reports from researchers from Canada's University of Ottowa (speaking on microwave photonics and photonic itegration) and Spain's Valenica Polytechnic University (speaking on programmable integrated photonics for signal processing and computing).[2004]

**Lab Equipment:**

None found

**Address**:

Possibly co-located with parent institution at No. 504 Chang'an E. Street, National Civil Aerospace Industrial Base, Xi'an, Shaanxi Province [陕西省西安市航天产业基地东长安街 504 号][2005]

**Known Aliases:**

- National Key Laboratory of Science and Technology on Space Microwave [空间微波技术国家级重点实验室]
- Key Laboratory of Science and Technology on Space Microwave [空间微波技术重点实验室]
- Key Laboratory on Space Microwave [空间微波重点实验室]
- Defense S&T Key Laboratory of Space Microwave [空间微波基础国防科技重点实验室]

- Fundamental Defense Key Laboratory of Space Microwave [空间微波基础国防重点实验室]
- Space Microwave Technology National Defense Key Laboratory

## 84. Defense S&T Key Laboratory of Specialized Integrated Circuits

**Official English Name:** Unknown

**Chinese Name:** 专用集成电路国防科技重点实验室

**Post-2024 Name:** this lab may have merged with the Defense S&T Key Lab of Gallium Arsenide Microwave and Millimeter Wave Monolithic and Modular Circuitry to form a new lab called the National Key Laboratory of Solid State Microwave Devices and Circuits[cxviii] [固态微波器件与电路全国重点实验室][2006]

**Research Focus:**

Domain:

- Multi-domain (likely Air, Ground, Maritime)

Equipment:

- Semiconductors
- *Secondary: likely Radar, Communications Equipment*

Functional Field:

- Multiple (Communications Technologies, Materials, Terahertz Technologies)

**Affiliations:**

- China Electronics Technology Group Corporation (CETC) [中国电子科技集团]
    - Hebei Semiconductor Institute [河北半导体研究所]
        - *a.k.a. CETC 13th Research Institute [13 研究所]*

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research into semiconductor technology, including semiconductor materials like gallium nitride, gallium arsenide, and silicon carbide. It is also one of several key labs conducting research into the terahertz spectrum, which it is applying to advanced

[cxviii] Literal translation, no official name given

communications and radar. Lab researcher Feng Zhihong has been involved in efforts to develop indigenous terahertz technology in order to break the embargo of this technology into China.[cxix] It is also researching high-speed mobile communications networks.[2007]

The lab's parent institution, the CETC Hebei Semiconductor Institute (a.k.a. the CETC 13th Research Institute), was established in 1956. It is one of the PRC's most important research institutes for semiconductors, conducting research related to semiconductors in microelectronics, photoelectronics, microelectronic mechanical systems (MEMS), high-tech sensors, and optoelectromechanical integrated microsystems.[2008]

Under the ongoing reorganization of the PRC's national key lab system, there is evidence that this lab may have merged with the Defense S&T Key Lab of Gallium Arsenide Microwave and Millimeter Wave Monolithic and Modular Circuitry of the CETC 55th RI to form a new National Key Lab, the National Key Laboratory of Solid State Microwave Devices and Circuits [固态微波器件与电路全国重点实验室]. While unconfirmed as of this writing, branches of the new lab appear to be active under both the CETC 13th RI in Shijiazhuang[2009] and 55th RI in Nanjing.[2010] Further, personnel from both former labs appear to be affiliated with this new lab.[2011] Another source lists the 55th RI as overseeing the "Nanjing branch" of the new lab, further suggesting there are other branches.[2012]

**Further Information:**

- There is a lab with a very similar name at Fudan University in Shanghai known as the "National Key Laboratory of Application Specific Integrated Circuit and System" in English. There is no evidence that these labs are affiliated with one another.

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- High Power Terahertz Frequency Multiplier and Synthetic Frequency Multiplier Sources
- Graphene, diamond, and solid-state terahertz
- Gallium nitride and silicon carbide semiconductors
- Diamond material applications in microwave power devices[2013]

[cxix] For further information on labs researching the terahertz spectrum, see Marcus Clay, "The PLA's Pursuit of Terahertz: Facts and Fallacies", *Jamestown Foundation*, 12 November 2020. https://jamestown.org/program/pla-pursuit-terahertz-facts-and-fallacies/

**Notable Applications:**

- Broadly, this lab's research has been applied to improved semiconductors and semiconductor materials, advanced communications, and radar.
- This lab teamed up with the CAS Suzhou Nano Institute's Key Lab of Nano Devices and Applications [中科院苏州纳米所纳米器件与应用重点实验室] in 2017, successfully improving the frequency of its graphene terahertz detector [石墨烯太赫兹探测器] to 650 GHz, creating the world's first graphene heterodyne mixed frequency detection [石墨烯外差混频探测]. According to PRC media, this detector, using graphene, will open a new frontier for terahertz imaging.[2014]

**Leadership and Key Personnel:**

- Director: Fang Yulong [房玉龙][2015]
    - Also heads the lab's Epitaxy Department [外延部].
    - Researches gallium nitride and silicon carbide semiconductors
- Standing Deputy Director: Feng Zhihong [冯志红][2016]
    - Expert in graphene, diamond, and solid-state terahertz

*Key Personnel:*

- Lu Yuanjie [吕元杰][2017]
    - Leads a team focused on InAlN/GaN HEMT devices for semiconductors

**Notable Collaborations:**

*Domestic*

- This lab has collaborated with the Suzhou Nano Institute's Key Lab of Nano Devices and Applications [中科院苏州纳米所纳米器件与应用重点实验室], improving the frequency of its graphene terahertz detector (see "Notable Applications").
- This lab co-hosted the 2016 2nd Annual Terahertz Science and Technology Conference [第二届全国太赫兹科学技术学术年会] along with several other institutes and key labs, including the CAS Key Laboratory of Electromagnetic Radiation and Detection Technology [中国科学院电磁辐射与探测技术重点实验室], CAS Key Laboratory of High Power Microwave Source and Technology [中国科学院高功率微波源与技术重点实验室], and CETC 12th RI State Key Laboratory of Microwave Electric Vacuum Devices [微波电真空器件国家重点实验室].[2018]
- This lab co-hosted the 2016 10th National Conference on Composite Semiconductor Materials, Microwave Devices and Photo-Electric Devices [十八届全国化合物半导体材料、微波器件和光电器件学术会议] along with the CAS Semiconductor Research

Institute [中国科学院半导体研究所], CETC 55th RI [中国电科 55 所], the CAS Microwave Electronics Institute [中国科学院微电子研究所], and Xiamen University.[2019]

*International*

- A researcher from U.S. company Plasma-Therm spoke at a semiconductor conference at which personnel of this lab also spoke.[2020]
- This Lab cooperated to organize the 14th Sino-International Forum on Semiconductor Lighting [第十四届中国国际半导体照明论坛] and 2017 International Forum for 3rd Generation Semiconductors [国际第三代半导体论坛] (IFWS 2017). These also included the scholar Martin Kuball of the UK's Bristol University. It covered Gallium Nitride microwave devices and monolithic integrated circuit material epitaxy, modeling, design, and manufacturing, reliability technology, and applications in mobile communications.[2021]
- More recently, personnel of this lab were also involved in organizing the 21st iteration of the same conference in 2024. Notable PRC participants included the Harbin Institute of Technology, University of Science and Technology of China, Huazhong University of Science and Technology, PLA General Hospital, PLA Center for Disease Control, CASC 1st Academy, CETC 13th, 46th, 48th, 55th RI, CAS Changchun Institute of Optcs, Fine Mechanics and Physics [春光学精密机械与物理研究所], CAS Suzhou Institute of Nano-tech and Nano-bionics [ 中国科学院苏州纳米技术与纳米仿生研究所], CAS Institute of Semiconductors [半导体研究所], and multiple other CAS Institutes, private companies such as Huawei and ZTE, and multiple chip manufacturing companies such as Advanced Micro-Fabrication Equipment [中微半导体]. Foreign organizers and participants came from the U.S. (UC Santa Barbara, NC State University, PowerAmerica, Virginia Tech, University of Virginia, Rensselaer Polytechnic Institute, NIST, Wolfspeed), Canada (University of Toronto), Germany (Fachhochschule Ingolstadt, Aixtron AG), Netherlands (Delft University of Technology, Ampleon), Australia (University of Sydney, RMIT University), Japan (Tokushima University, Osaka Metropolitan University, Waseda University, National Institute for Materials Science, Nippon Telegraph and Telephone), Sweden (Lund University), Taiwan (National Taiwan University, National Chiao Tung University, Chang Gung University, National Taiwan University of Science and Technology, National Yang Ming Chiao Tung University), Korea (Dong-eui University), Saudi Arabia (King Abdullah University of Science and Technology), and India (ELCOMA).[2022]

**Lab Equipment:**

None found

**Address**:

None found. Its parent institution is in Shijiazhuang, Hebei Province [河北省石家庄市].[2023]

**Known Aliases:**

- Defense S&T Key Laboratory of Gallium Arsenide Super High-speed Integrated Circuits and Power Devices [砷化镓超高速集成电路和功率器件国防科技重点实验室]
    - Name in the "official" online list of Defense S&T Key Labs, but almost never used.
- National Key Laboratory of ASIC [专用集成电路国家级重点实验室]
- National Key Laboratory of Application Specific Integrated Circuit (ASIC)
    - This name is frequently used and may be the official English name.

## 85. Defense S&T Key Laboratory of Strong Radiation

**Official English Name:** Unknown

**Chinese Name:** 强辐射国防科技重点实验室

**Post-2024 Name**: No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Nuclear

Equipment:

- Nuclear Weaponry & Power

Functional Field:

- Multiple (Laser Technologies, Microwave Technologies, Terahertz Technologies)

**Affiliations:**

- China Academy of Engineering Physics (CAEP) [中国工程物理研究院]
  - Either Institute of Applied Electronics [应用电子学研究所] or Institute of Liquid Physics [流体物理所]
- University of Electronic Science and Technology of China (UESTC) [电子科技大学]

**Key Data:**

- Established: 1996 (UESTC)[2024]
- Total Funding: Unknown
- Personnel: 21 (UESTC, 2010)[2025]
- Official start of operations: 2006 (UEST)[2026]
- Floor Space: Unknown

**Lab Overview:**

Little information is available about this lab, but it appears to conduct basic research into nuclear physics, likely for both energy and, given its connection to the Chinese Academy of Engineering Physics (CAEP), nuclear weaponry. Longtime lab Director Du Xiangwan was a leader in the theoretical design of nuclear weapons, nuclear weapons neutronics, and nuclear test diagnostic theory, and took part in the PRC's early nuclear weapons program.[2027]

A joint venture between CAEP and the University of Electronic Science and Technology of China, the latter's branch was first established in 1996 and received approval in 2006, implying the CAEP branch may have existed prior to this.[2028] While almost all sources refer to this as a "National 863 Program Key Lab,"[2029] an official CAEP source from 2012 lists it as one of CAEP's six Defense S&T Key Labs, indicating it may be a "crypto" DSTKL as well.[2030] Basically no information about this lab appears in open sources after around 2012, suggesting it may have either been reorganized, folded into another institution, or abolished (adding weight to this possibility, the 863 Program ended in 2014). The lab's current status could not be ascertained.

The lab's CAEP parent institution is unclear, with conflicting information citing either the Institution of Applied Electronics [应用电子学研究所][2031] or the Institute of Liquid Physics [流体物理所].[2032] It is possible both share (or shared) management responsibilities.

**Further Information:**

- The UESTC Branch set up a Terahertz research center[2033]

**Research Direction:**

No formal research direction found

**Notable Applications:**

- The lab developed the PRC's first relativistic backward wave oscillator, first relativistic orotron, the first relativistic magnetron, and the world's first permanent magnet packing relativistic magnetron. It completed the scheme design, processing, and testing of a 1.5GW power capacity multimode feeder, and applied it on an HPM transmitter. It designed a large aperture antenna port-face field light modulation scattering test system, solving a problem with near-field testing of high-power microwaves. It developed 2.5-dimensional particle simulation software CHIPIC2D version 1.0/2.0/3.0 and 3-dimensional particle simulation software CHIPIC3D demo version.[2034]
- Prior to 2001, this lab was the first in the PRC to obtain an ideal technical index of long-pulse high-power microwave output [较理想的长脉冲高功率微波输出技术指标].[2035]

**Leadership and Key Personnel:**

- Director: Du Xiangwan [杜祥琬][2036]
- Director of UESTC Branch: Li Jiayin [李家胤]
    - One of the earliest scholars in the PRC to carry out experimental research on high-power microwave devices and electromagnetic wave pump free-electron lasers

    - His group developed the PRC's first relativistic backward wave oscillator, the first relativistic orotron, the first relativistic magnetron, and the first relativistic magnetron in permanent magnet packaging[2037]
- Former Deputy Director: Xu Zhou [许州]
    - Awarded 4 1st Class Military S&T Progress Awards[2038]

**Notable Collaborations:**

*Domestic*

- At the lab's 2007 annual academic exchange, participants included the CETC 11th RI, CAS Dalian Institute of Chemical Physics [中科院大连化学物理研究所], and the CAS Chengdu Institute of Photoelectric Technology [成都光电技术研究所].[2039]

**Lab Equipment:**

- Complete processing line
- Three sets of high-flow electron beam gas pedals
- Microwave darkroom
- GTM chamber
- Ultra-clean room
- Optical platform
- Other complete microwave and millimeter-wave signal test platforms
- Various types of simulation and analysis software for the development of high-power microwave systems[2040]

**Address**:

Chengdu, Sichuan Province [四川省成都市][2041]

**Known Aliases:**

- 国家 863 计划强辐射重点实验室

## 86. Defense S&T Key Laboratory of Super High-Temperature Structural Composites

**Official English Name:** State Key Laboratory of Science and Technology on Thermostructural Composite Materials[2042]

**Chinese Name:** 超高温结构复合材料国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Air
- *Secondary: Space*

Equipment:

- Aircraft
- *Secondary: Non-Ballistic Missiles, Space Vehicles*

Functional Field:

- Materials
- *Secondary: Hypersonic Technologies, Nuclear Technologies, Propulsion*

**Affiliations:**

- Northwestern Polytechnical University (NWPU) [西北工业大学]
    - School of Materials Science and Engineering [材料科学与工程学院]

**Key Data:**

- Established: 2000
- Total Funding: nearly 300m RMB
- Personnel: 40[2043]
- Official start of operations: 2004
- Floor Space: approx. 10,000 sqm

**Lab Overview:**

This lab conducts research into ceramic matrix composite (CMC) materials, carbon and carbon composites, and high-temp mechanical properties for aerospace propulsion, hypersonic vehicles, aircraft and vehicle braking technology, and materials for use in space and irradiated environments.[2044]

The lab was the brainchild of CAE Academician Zhang Litong and Professor Yang Jing, and sprung from their research on CMCs and carbon/carbon composites in the early 1990s. Due to the research efforts of this lab, in 2004 China became the second country (after France) to independently master the preparation technology for CMCs.[2045]

**Further Information:**

- This lab was associated with the 2006 establishment of the Shaanxi Ceramic Matrix Composites Engineering Technology Research Center [陕西省陶瓷基复合材料工程技术研究中心] (later possibly upgraded to the National Engineering Research Center for Ceramic Matrix Composites Manufacturing Technology [陶瓷基复合材料制造技术国家工程研究中心] in 2013) and Shaanxi Carbon/Carbon Composite Engineering Technology Research Center [陕西省碳/碳复合材料工程技术研究中心].[2046]

**Research Direction:**

1. Ceramic matrix composites (CMC)
2. Carbon/carbon composites
3. High temperature mechanical properties[2047]

*Other Notable Research Areas:*

- Material design
- Efficient and precision forming and processing technology
- Material surface and interface design and preparation technology
- Simulation and characterization of material performance under high-temperature and long-time oxidation/complex stress environments
- Component preparation and application technology development[2048]

**Notable Applications:**

- This lab's award-winning study, "Development and Application of Functional Composite Materials for Carbon Ceramic Aircraft Brakes"[cxx] [碳陶飞机刹车功能复合材料的研制与应用], which included participation from Zhang Litong and Cheng Laifei, resulted in a new carbon composite material for aircraft brakes which was first tested in the J-10 combat aircraft in 2008, and is now utilized by over 10 types of combat (J-10, J-15) and transport (Y-12, Y-20) aircraft, as well as allegedly being exported for use in certain Boeing and Airbus airliners. This tech can also be used in tanks and other heavy and high-speed vehicles. It greatly increased aircraft safety and combat effectiveness. This was a joint

[cxx] "Carbon Ceramic Aircraft Brakes" was redacted in most announcements.

effort with AVIC's Xi'an Aviation Brake Technology Co. [中航工业西安航空制动科技有限公司].[2049]

- This lab produced an ultra high-temp ceramic nozzle for the ramjet engine of an unidentified missile [XX 导弹冲压发动机用超高温陶瓷喷管已定型批产].[2050]
- This lab produced a ceramic composite thermal protection system and control rudder for a hypersonic flight vehicle [高超飞行器陶瓷复材热防护系统和控制舵] which has already undergone five flight verifications.[2051]
- This lab developed a camera nozzle for the Gaofen remote sensing satellite ["高分专项" 遥感卫星相机镜筒].[2052]
- This lab developed the throat lining and thermal protection sleeves [喉衬和热防护套] used in two missile types which were paraded at both the 60th National Day and 70th Victory Day parades.[2053]
- Cheng Laifei's team has designed fiber-toughened ceramic matrix composites which have been used in aircraft engines, high-performance rockets, space vehicle thermal protection systems, aircraft brakes, nuclear and other power stations, and deep space probes.[2054]

**Leadership and Key Personnel:**

- Director: Cheng Laifei [成来飞][2055]
- Academic Committee Director: Cai Hongnian [才鸿年][2056]
- Deputy Director: Li Hejun [李贺军][2057]
- Founder: Zhang Litong [张立同][2058]
    - CAE Academician
    - Expert in aerospace materials
    - Worked as a researcher at the NASA Space Structure Materials Commercial Development Center [空间结构材料商业发展中心] from April 1989 to January 1991, where she was responsible for the fiber toughened ceramic matrix composites of a NASA space station

**Notable Collaborations:**

*Domestic*

- This lab developed military and civilian aircraft brakes with AVIC Xi'an Aviation Brake Technology Co. (see Notable Applications above)
- This lab is closely associated with Xi'an Xin Yao Ceramic Composite Material Co. [西安鑫垚陶瓷复合材料有限公司] primarily for military use, which was established with lab Director Cheng Laifei. It claims to be the PRC's only ceramic matrix composites company [陶瓷基复合材料产业化公司].[2059]

- The Lab has a long term research partnership with Shaanxi Guqin Materials Co. [固勤材料技术有限公司] to produce silicon-carbide beams.[2060]

*International*

- In 2013, this lab hosted the 8th International Ceramic Matrix Composites Conference [国际陶瓷基复合材料会议] in Xi'an.[2061]

**Lab Equipment:**

Despite NWPU being on the U.S. Commerce Department export control list since 2001, this lab advertises its use of several pieces of foreign equipment, including:

- Instron8801 hydraulic servo universal testing machine [液压伺服万能试验机] from American company Instron
- S-4700 cold field emission scanning electron microscope from Japanese company Hitachi
- STA429CD/3/7 high temperature synchronous thermal analyzer from German company NETZSCH
- EMGA-620W oxygen-nitrogen co-meter from Japanese company Horiba

Other domestically produced equipment includes:

- Material electromagnetic parameter testing system
- Chemical vapor permeation silicon carbide substrate preparation furnace
- Vacuum and atmosphere tube furnace
- Large vacuum induction hot pressing furnace[2062]

**Address**:

No. 127 Youyi West Road, Xian, Shaanxi Province [陕西省西安市友谊西路 127 号][2063]

**Website**:

http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=301

**Known Aliases:**

- National Key Laboratory of Thermostructure Composite Materials [超高温结构复合材料国家级重点实验室]
- Key Laboratory of Thermostructure Composite Materials [超高温结构复合材料重点实验室]

- Defense S&T Key Laboratory of Superhigh Temperature Composites [超高温复合材料国防科技重点实验室]
- National Key Laboratory of Superhigh Temperature Composites [超高温复合材料国家级重点实验室]
- Science and Technology on Thermostructural Composite Materials Laboratory (TSCM)
- State Key Laboratory of Superhigh Temperature Composites
- Science and Technology on Thermostructural Composite Materials Laboratory
- Key Laboratory of Ultrahigh Composites
- Ultra-High-Temperature Structural Composites Laboratory
- Science and Technology on Thermostructure Composite Materials Laboratory
- Key Laboratory of Superhigh Temperature Composites

## 87. Defense S&T Key Laboratory of Surface Physics and Chemistry

**Official English Name:** Science and Technology on Surface Physics and Chemistry Laboratory[2064]

**Chinese Name:** 表面物理与化学国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Nuclear

Equipment:

- Nuclear Weaponry & Power

Functional Field:

- Materials

**Affiliations:**

- Chinese Academy of Engineering Physics [中国工程物理研究院]
    - Institute of Materials Research (IMR) [材料研究所]

**Key Data:**

- Established: 2003[2065]
- Total Funding: Unknown
- Personnel: over 60 full-time[2066]
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab was conceived as early as 1994 to fill a need for basic and applied basic research on nuclear materials and components. It was officially established in 2003 with the purpose of researching materials needed for nuclear weaponry.[2067] It is particularly focused on actinides such as uranium and isotopes such as tritium, including their properties, compatibility, surface engineering, corrosion, aging, and storage.[2068] It is focused on all stages of research, including basic, applied basic, key technology research, and engineering applications.[2069]

The lab leveraged an early version of MCF to make use of domestic and international talent and technology to develop nuclear weapons and equipment.[2070] One unofficial source describes the materials developed by the lab as "military-civil dual-use new materials,"[2071] and evidence

suggests the lab's research is utilized by both the PRC's nuclear weapons program and civilian nuclear energy program.

**Further Information:**

- The lab is primarily made up of 5 research teams, one for each of its 5 research directions.[2072]

Per one source, the lab has three open funds: a "Stable Support Project" [定支持项目] primarily to support basic, frontier and exploratory research, a "Key Lab Fund" [重点实验室基金项目] primarily to support key technology research, and a "Lab Discipline Development Fund" [实验室学科发展基金项目] primarily to support frontier and innovative research.[2073]

**Research Direction:**

The lab's research direction [研究方向] emphasizes five fields of study (all descriptions are lightly edited translations from the website):[2074]

1. Basic physical properties of actinide materials and their compatibility with the environment [锕系材料基础物性及其与环境相容性]

   Research of basic physical properties of actinide materials, electronic structure, and the adsorption, dissociation, reaction and diffusion of various environmental gases on the surface of actinide materials from the perspective of microscopic atomic structure and electronic structure

   Obtain the microscopic mechanisms of the basic physical properties, electronic structure, and surface reaction of actinide materials, in order to promote and enhance the understanding of actinide material compatibility, and provide theoretical and experimental basis for the development of surface modification measures

   Provide theoretical and experimental basis for the development of surface modification measures, including: high-quality actinide single-crystal sample preparation, actinide single-crystal samples of the basic physical properties, electronic structure, in situ/in situ spectroscopy, actinide alloy compatibility with the environmental atmosphere, actinide alloys, the phase structure of actinide alloys, phase transition behavior and phase stability research.[2075]

2. Hydrogen isotopes and compatibility between helium and materials [氢同位素及氦与材料间的相容性]

   Research on the compatibility of hydrogen isotopes and materials in the fields of nuclear energy and hydrogen energy, which involves hydrogen corrosion and inhibition technology, hydrogen embrittlement, helium embrittlement, plasma

irradiation damage, the development of new hydrogen isotopes separation and storage materials, and testing, standardization, establishment of physical property database and new materials.[2076]

3. Compatibility between actinides and other materials [锕系材料与其他材料间的相容性]

   Research on the organizational structure and mechanical properties of materials, as well as research on the stress, deformation and evolution of interfacial structure formed by material interactions, in order to provide technical support for the assessment of material reliability.

   Macro focus on materials and mechanical properties, stress, deformation, displacement and interface corrosion, etc., and micro focus on the role of materials, phase transition, organization, and structure of the evolution of interfacial element diffusion, segregation, and solid-solid interface microscopic characteristics of the research.[2077]

4. Surface modification technology of actinides [锕系材料表面改性技术]

   Actinide materials surface modification technology, modification mechanism, anti-corrosion behavior research, in the premise of not changing the performance of the material matrix, to carry out the surface modification of the physical or chemical properties of the surface of the material

   Tracking domestic and foreign developments in the relevant technology, actinide metal development, manufacturing, corrosion-resistant design to provide technological support, and enhancing the reliability of related materials for long-term storage.[2078]

5. Numerical simulation of actinide compatibility [锕系材料相容性的数值模拟] (a.k.a. Actinide Computing [锕系计算])

   Focused on problems arising from computational simulation and theoretical studies of actinide materials, as well as challenging problems at the frontiers of condensed matter physics such as strongly correlated electron systems, in addition to opening up new research areas to strengthen the study of compatibility problems of actinide materials.[2079]

*Other Notable Research Areas:*

- Materials compatibility[2080]
- Plasma sprayed coatings on stainless steel[2081]
- Storage of tritium (used in nuclear weapons)[2082]
- Modification technology of carbon nanotubes for radioactive wastewater treatment[2083]

**Notable Applications:**

None found

**Leadership and Key Personnel:**

- Director: Luo Wenhua [罗文华][2084]
  - Also serves or has served as Director of CAEP Institute of Materials Research (2018)[2085]
- Party Secretary: Hu Yin [胡殷][2086]
- Deputy Directors: Luo Lizhu [罗丽珠][2087]; Tan Shiyong [谭世勇][2088]
- Academic Committee Director: Peng Xianjue [彭先觉]
  - Academician of CAS or CAE[2089]
- Academic Committee Deputy Director: Hao Daqiao [蒙大桥][2090]
  - CAS Academician
  - Researches material compatibility technology, materials corrosion and aging, materials joining, and tritium chemistry and processes;
  - Has won 3 First-Class S&T Progress Awards and numerous others[2091]
- Academic Committee Deputy Director: Wang Xiaolin [汪小琳][2092]
- Academic Committee Deputy Director: Liu Kezhao [刘柯钊][2093]
- List of academic committee members as of 2022 is available

**Notable Collaborations:**

*Domestic*

- Deputy Director Luo Lizhu was part of a CAEP team which received doctoral students from the Shanghai Jiao Tong University Light Alloys Program in 2023. This appears to be part of a CAEP program to recruit SJTU graduates. The students heard about the needs of PRC national defense and the nuclear industry, as well as learning about PRC's historical development of nuclear weapons.[2094]
- As of 2019, lab researchers expressed interest in the products of ScrollTec [思科涡旋科技(杭州)有限公司], particularly its floating vortex vacuum technology [浮动式涡旋技术在真空]. It is unknown if this company ended up becoming a supplier to the lab.[2095]
- In 2018, this lab co-organized the 3rd Actinide Physics and Chemistry Symposium [第三届中国锕系物理与化学学术交流会] with the Chinese Nuclear Society Actinide Physics and Chemistry Branch [中国核学会锕系物理与化学分会], CNNC North Nuclear Fuel Components Co. [中核北方核燃料元件有限公司], and the CAEP Institute of Materials Research. The article stresses research into civilian nuclear energy but also acknowledges actinides' use in military nuclear technology.[2096]
- As of 2018, this lab has regular exchange meetings with the Ministry of Education Key Laboratory of Materials Modification by Laser, Ion and Electron Beams [三束材料改性教育部重点实验室], where they discuss defense basic research, MCF, joint training, and

other cooperation in areas such as surface modification and coating technology, alloy composition design, and LIBS hydrogen isotope measurement.[2097]

- The Institute of Materials Research and this lab made a trip to Tsinghua University's Department of Physics in 2014 in which the two sides discussed their ongoing exchanges and expressed a desire to grow their cooperation in the coming years.[2098]

*International*

- In 2024, a student group from Queen Mary University of London's campus at Northwestern Polytechnical University visited this lab as part of a patriotic field trip to learn about and be inspired by China's historical and present-day nuclear weapons development.[2099]
- Li Xiaona [李晓娜], a researcher at Dalian University of Technology, is working on high-temperature Cu-based superalloys for military industrial use, an area in which the PRC lacks independent IP, as well as semiconductor-type metal silicide thin film materials and other research areas. She has working relationships with both this lab and the Institut des Mines de Nanterre and the Université de Metz in France, and the National Taiwan University of Science and Technology. It is unclear how close the research she does with these international academics is to her military and dual-use research.[2100]
- In 2016, this lab co-organized the Seventh International Conference on Surface Engineering [第七届表面工程国际会议] with the Surface Engineering Branch of the Mechanical Engineering Society [机械工程学会表面工程分会] and Southwest Jiaotong University [西南交通大学]. Participants included researchers from the Danish Academy of Sciences and New Zealand Royal Academy of Engineering.[2101]
- In 2017, this lab co-sponsored the Inorganic and Isotope Mass Spectrometry Conference of the Chinese Society of Mass Spectrometry [2017年中国质谱学会无机及同位素质谱学术会议] with the Chinese Society of Mass Spectrometry. Other organizers included the CAEP Institute of Materials Research, Sichuan Provincial Hydrogen Isotope Engineering and Technology Research Center [四川省氢同位素工程技术研究中心], Antpedia (Beijing) Technolgoy Development Co. [安特百科（北京）技术发展有限公司], and the Analytical and Testing Center of Sichuan University [四川大学分析测试中心]. The conference focused on inorganic mass spectrometry, isotope mass spectrometry, stable isotope mass spectrometry, and instrumentation development. Photos show the names of other participants who set up booths at the forum, including U.S. company Thermop Fisher Scientific and German company Analytik Jena.[2102]

**Lab Equipment:**

- The lab has facilities for preparation of advanced materials such as thin films, single crystals, etc., as well as for research on basic physical properties of materials, gas-solid reaction and corrosion behavior, material structure and mechanical properties of the research, and surface modification.[2103] This includes:
    - Double spherical aberration-corrected scanning tunneling electron microscope

- Optical electron microscope.[2104]

**Address**:

Mianyang, Sichuan Province 621907 [四川省绵阳市][2105]

**Website**:

http://www.spc-lab.cn/

**Known Aliases:**

- 表面物理与化学国家级重点实验室
- 表面物理与化学国家重点实验室
- 表面物理与化学重点实验室

## 88. Defense S&T Key Laboratory of Target and Environmental Electromagnetic Diffuse Radiation Characteristics

**Official English Name:** Unknown

**Chinese Name:** 目标与环境电磁散射辐射特性国防科技重点实验室

**Post-2024 Name**: No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Air

Equipment:

- Multiple (likely Ballistic Missiles, Non-Ballistic Missiles)

Functional Field:

- Multiple (Sensing, Communications Technologies)

**Affiliations:**

- China Aerospace Science and Industry Corporation (CASIC) [中国航天科工集团]
  - Changfeng Mechanics and Electronics Technology Academy [中国长峰机电技术研究设计院] 207th Research Institute
    - *a.k.a. CASIC 2nd Academy 207th Research Institute [航天科工二院*207所*]*

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

While little public information was found on this lab, it appears to be engaged in research and testing of target characterization toward development of battlefield sensing, offensive and defensive countermeasures [攻防对抗], and precision strike capabilities.[2106] It is one of five Defense S&T Key Labs under the CASIC 2nd Academy.[2107]

The Changfeng Mechanics and Electronics Technology Academy [中国长峰机电技术研究设计院] (a.k.a. the CASIC 2nd Academy), develops many of the PRC's air, missile, and space

defense systems, including SAMs, ASAT, and associated radars.[2108] The 207th Research Institute which oversees this lab (as well as one other, the DSTKL of Target and Environment Optical Characteristics) focuses on targets and their environmental characteristics, as well as on optoelectronic technology.[2109]

**Research Direction:**

No formal research direction was found

**Notable Applications:**

None found

**Leadership and Key Personnel:**

None found

**Notable Collaborations:**

None found

**Lab Equipment:**

None found

**Address**:

Likely Beijing [北京市]

**Known Aliases:**

None found

## 89. Defense S&T Key Laboratory of Target and Environmental Optical Characteristics

**Official English Name:** Unknown

**Chinese Name:** 目标与环境光学特征国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Multi-Domain (Air, Ground*)*

Equipment:

- Multiple (Air/Missile Defense, Artillery, Electronic Warfare, Radar)

Functional Field:

- Optoelectronics
- *Secondary: GNC, Laser Technologies, Sensing, Stealth, Target Detection/Recognition*

**Affiliations:**

- China Aerospace Science and Industry Corporation (CASIC) [中国航天科工集团]
    - CASIC 2nd Academy 207th Research Institute [航天科工二院 207 所]

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This Lab appears to be mainly concerned with research into optical technologies for both detection/sensing as well as guidance systems. It is also sometimes referred to as the Defense S&T Key Laboratory of Optical Radiation.[2110] This lab has been cited as a leading PRC institute in the field of radar cross section scale model measurement (using scale models to measure RCS rather than real targets), a key element of targeting, radar detection and target recognition, design of new radar absorbing materials, and electronic warfare.[2111]

According to an unofficial source (using material that may have originated from an official source), Zhu Zhenfu is the Lab's director and may have been involved in the infrared and TV

tracking system for the HQ-7 SAM. This system was also used in artillery TV targeting and target characteristic tracking and measurement systems.[2112]

The CASIC 2nd Academy, also known as the Changfeng Mechanics and Electronics Technology Academy [中国长峰机电技术研究设计院], produces many of the PRC's air, missile, and space defense systems, including SAMs, ASAT technology, and associated radars.[2113] The 207th Research Institute which oversees this lab (as well as one other, the DSTKL of Target and Environment Optical Characteristics) focuses on targets and their environmental characteristics, as well as on optoelectronic technology.[2114]

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- Infrared sensing/detection of small targets[2115]
- Infrared target recognition[2116]
- Radar cross section scale model measurement[2117]

**Notable Applications:**

- This lab develops optical precision guidance technology, including TVm IR, laser, optical-fiber, stellar, optoelectrical, etc.[2118]

**Leadership and Key Personnel:**

- Director: Zhu Zhenfu [朱振福][2119]
    - May be retired now

**Notable Collaborations:**

*Domestic*

- This lab has had multiple collaborations on infrared sensing and targeting with the Defense S&T Key Laboratory of Automatic Target Recognition.[2120]
- The lab participated in a 2007 conference on Optoelectronic Sensing and Guidance Technology [光电探测与制导技术的发展与应用研讨会].[2121]

**Lab Equipment:**

None found

**Address**:

Beijing 100854 [北京市][2122]

**Known Aliases:**

- Optical Signature of Targets and Environments Key Laboratory of National Defence and Technology
- Defense S&T Key Laboratory of Optical Radiation [光学辐射国防科技重点实验室]
- Laboratory of JS66 [JS66 重点实验室]
- 目标与环境光学特征国防重点实验室
- 目标与环境光学特征重点实验室
- 目标与环境光学特性国防科技重点实验室
- 目标与环境特性国防科技重点实验室

## 90. Defense S&T Key Laboratory of Transient Shock Technology

**Official English Name:** Unknown

**Chinese Name:** 瞬态冲击技术国防科技重点实验室

**Post-2024 Name:** National Key Laboratory of Transient Shock[cxxi] [瞬态冲击全国重点实验室][2123]

**Research Focus:**

Domain:

- Ground

Equipment:

- Munitions
- *Secondary: Armor*

Functional Field:

- Blast, Impact & Damage
- *Secondary: Munitions Technology*

**Affiliations:**

- Norinco [中国兵器装备集团]
    - Armament and Equipment Institute [兵器装备研究所]
        - *a.k.a. Norinco 208th Research Institute*
- Nanjing University [n 南京大学]

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research into small arms and ammunition technology, with a particular focus on munitions impact, explosive effects, and damage/injury assessment. Secondary interests

[cxxi] Literal translation, no official name given

include munition combustion and ballistics. The lab further studies this problem from the defensive perspective, researching new forms of armor and personal protection against munitions. The lab's research also has civilian applications, for instance as part of a Norinco team developing new vehicles for the civilian market.[2124]

Publicly known as the Defense S&T Key Laboratory of Transient Shock Technology, this lab is also sometimes known as the Defense S&T Key Lab of Light Weaponry Endpoint Kill Technology [轻武器终点杀伤技术国防科技重点实验室]. The former name is more common and appears to be its public-facing name, while the latter is used less often and sometimes censored in public imagery.[2125] Under the ongoing reorganization of the PRC's national key lab system, this lab is now known as the National Key Lab of Transient Shock [瞬态冲击全国重点实验室]. It now also appears to be jointly managed by Norinco's Armament and Equipment Institute and Nanjing University.[2126]

The lab's parent institution, the Norinco Armament and Equipment Institute (a.k.a. the Norinco 208th Research Institute), was established in 1960, and focuses on R&D of light weaponry and counterterrorism/"stability maintenance" equipment.[2127]

**Further Information:**

- The lab has its own fund for distributing research, the "Norinco 208th RI Defense S&T Key Lab of Light Weaponry Terminal Kill Technology Fund" [兵器 208 所轻武器终点杀伤技术国防科技重点实验室基金]. It has funded research into High Frequency Fiber Optic F-P Cavity Dynamic Pressure Sensors [高频性光纤 F-P 腔动态压力传感器]. Wang Junjie [王俊杰], the researcher who carried out this work as well as several other defense-related projects, studied at the Centre for Microsystems and Photonics at the University of Strathclyde in the U.K. around 2017.[2128] The lab's fund has also supported research on simulations of bullet penetration of boron-carbide-ceramic composites.[2129]

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- Impact and injury assessment[2130]
- Damage assessment[2131]
- Small arms protection[2132]
- Light weaponry launch, combustion, and ballistics[2133]
- Explosion science, explosive projectile damage[2134]

In 2023, this lab released its research funding priorities. It was open to fund 5-7 2-year projects at 300k-700k RMB each. The research topics were:

1. Transient impact energy release of light weapons and their target action laws
2. Theory of transient effect evaluation and test verification of light weapons
3. Synergistic mechanisms and efficient application technology of multiple transient factors of light weapons
4. Personal protection theory and equipment for transient impact of light weapons[2135]

**Notable Applications:**

None found

**Leadership and Key Personnel:**

- Director: Wang Shu [王舒][2136]
- Deputy Director: Jin Yongxi [金永喜][2137]

*Key Personnel:*

- Mai Ruimin [买瑞敏]
  - Former Director and Director of Norinco 208th RI[2138]
- Zang Liwei [臧立伟]
  - Senior Engineer[2139]
- Lu Haitao [卢海涛]
  - Senior Engineer[2140]

**Notable Collaborations:**

*Domestic*

- The lab has an ongoing close collaborative relationship with Nanjing University of Science and Technology.[2141] This is consistent with NUAA's central role in munitions development.
- In 2017, this lab signed a strategic cooperation agreement with the State Key Lab of Explosion Science and Technology [爆炸科学与技术国家重点实验室] at Beijing Institute of Technology. The two agreed to cooperate on basic and applied basic research on explosion science and technology. The ostensibly civilian state key lab was described as "irreplaceable" for weapons and ammunition development.[2142]
- In 2018, this lab signed a strategic agreement with Hunan University of Science and Technology to cooperate on light weapons development.[2143]
- In 2019, the lab co-hosted the National Frontier Forum on Impact Dynamics [全国冲击动力学前沿论坛], along with the Impact Dynamics Group of the Explosive Mechanics Committee of the Chinese Mechanics Society, the South China University of Technology,

and the State Key Laboratory of Subtropical Building Science. The theme of the forum was "Dynamic Damage Evolution and its Deformation Mechanisms". Researcher Yan Wenmin [闫文敏] of this lab reported on his research on the characteristics of light weapon munitions acting with typical targets.[2144]

- In 2020, this lab co-hosted the 10th National Academic Conference on Strong Dynamic Load Effects and Protection and Symposium of the Innovative Research Group on Dynamic Mechanical Behavior of Complex Media/Structures [十届全国强动载效应及防护学术会议暨复杂介质/结构的动态力学行为创新研究群体学术研讨会]. The main host was Beijing Institute of Technology, and other hosts included the CASC 1st Academy Tactical Weapons Department. The conference was aimed at solving issues in strong dynamic load effects and protection. Participants included Xi'an Jiaotong University, Beihang University, Northwestern Polytechnical University, Tianjin University, Dalian University of Science and Technology, National University of Defense Technology, Army Medical University, Ningbo University, North University, China Academy of Engineering Physics, the China National Shipbuilding Research Center, and CSSC.[2145]
- This Lab was one of the main hosts for the 2022 Second Acta Amamentarii [兵工学报] Forum on Soldier Systems [士兵系统]. The subject was Light Weapons Transient Impact, Injury, Damage, and Protection Technology. This included topics such as new materials and structures for both new ammunition and protection technology. Other participants included the State Key Lab of Explosion Science and Technology, the Defense S&T Key Lab of Damage, Injury, and Protection, the Defense S&T Key Lab of Ballistics, the Defense Key Lab of Intelligent Ammunition Technology, the Norinco Materials Engineering Center, and others.[2146]

**Lab Equipment:**

None found

**Address**:

No. 57 Maxing Road, Changping District, Beijing [北京市昌平区马兴路 57 号][2147]

**Known Aliases:**

- Defense S&T Key Laboratory of Light Weaponry Endpoint Kill Technology [轻武器终点杀伤技术国防科技重点实验室]
- 轻武器终点杀伤技术国家级重点实验室
- 瞬态冲击技术重点实验室

## 91. Defense S&T Key Laboratory of Tunable Gas Lasers

**Official English Name:** National Key Laboratory of Science and Technology on Tunable Laser[2148]

**Chinese Name:** 可调谐气体激光国防科技重点实验室

**Post-2024 Name**: No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Space

Equipment:

- Space Vehicles
- *Secondary: Communications Equipment*

Functional Field:

- Communications Technologies
- *Secondary: Laser Technologies, Measurement Technologies, Optoelectronics, Sensing, Terahertz Technologies*

**Affiliations:**

- Harbin Institute of Technology (HIT) [哈尔滨工业大学]
    - School of Astronautics Institute of Optoelectronics [哈尔滨工业大学航天学院光电子技术研究所]

**Key Data:**

- Established: 1994
- Total Funding: Unknown
- Personnel: 42[2149]
- Official start of operations: 1997
- Floor Space: approx. 8,500 sqm

**Lab Overview:**

This lab is dedicated to narrowing the gap internationally in the field of optoelectronic technology. It researches tunable laser technology, nonlinear optical technology, and laser communications in space, with the goal of creating superior space-based communications and data transmission, remote sensing, and "control of the information initiative in space."[2150]

**Further Information:**

- The lab has five subordinate labs, three offices, and numerous research teams, including:
  - *Mid- and Far-Infrared Tunable Laser Technology Research Team* [中远红外可调谐激光技术研究团队], led by Professor Yao Baoquan [姚宝权], which conducts research on long-wave infrared solid-state lasers.
  - *Satellite Laser Communications Team* [卫星激光通信团队], established in 1991 and later attached to this lab. In 2011, it successfully completed China's first low-orbit satellite-ground laser communication test. Between May and August 2017, it successfully completed the world's first synchronous satellite and ground two-way high-speed laser communications with a data rate of 5 GB per second.
  - *Laser Space Information Technology and Applications Team* [激光空间信息技术与应用团队].[2151]
- This lab utilizes a laser damage dynamics experimental station [激光损伤动力学实验站] specializing in research on high-power laser-material interactions and damage mechanisms of optical components for laser-driven inertial confinement fusion engineering (ICF). It claims to be the only lab in China to conduct research on the interactions between high-power pulsed lasers and various materials.[2152]
- In 2020, HIT began construction of a Key Lab Cluster [重点实验室集群] in Shenzhen featuring research space for several of its key labs, including this one. The cluster will focus on automated products, high-end equipment design and distribution, technical transformation and improvements, and guiding production applications and industrialization. It is set to open in December 2023.[2153]
- This lab provides detailed information on its role in every recent Five-Year Plan:
  - During the 9th Five Year Plan (1996-2000), this lab was tasked with developing long-wave infrared CO2 pulsed external differential coherent detection laser imaging technology [长波红外 CO2 脉冲外差相干探测激光成像技术] with stronger cloud and fog penetration abilities, 3 km target laser intensity and range imaging [3 km 目标激光强度像和距离像].
  - During the 10th Five Year Plan (2001-2005), this lab was responsible for a major project on developing domestic flashing streak tub laser imaging radars [闪光式条纹管激光成像雷达技术] and made breakthroughs in high-sensitivity four-dimensional image detection, information reconstruction, and other technologies. A principal prototype was created and a 6 km target laser image obtained. Subsequently, the stripe tube LIDAR was promoted to work units, and two system LIDAR prototypes were developed.
  - During the 11th Five Year Plan (2006-2010), this lab was responsible for a major engineering project, integrating a distance-selective LIDAR prototype, completing airborne flight tests, and obtaining air-to-ground high-resolution laser images.

- During the 12th Five Year Plan (2011-2015), this lab studied laser and infrared composite imaging technology, making breakthroughs in common aperture spectroscopy and system integration technology [共口径分光及系统集成等技术], and integrating the composite image principle prototype.
- During the 13th Five Year Plan (2016-2020), this lab developed a Gm-APD focal plane detector, with single photon detection being used to study miniaturized high-power lasers, multi-frame statistical signal processing, and far-field 3D automatic target recognition technology. At present, a 32×32-pixel Gm-APD short-wave infrared laser imaging radar far-field target 3D distance image has been obtained.[2154]

**Research Direction:**

1. Tunable laser technology [ 可调谐激光技术]
2. Nonlinear optical technology [非线性光学技术]
3. Laser space communications [激光空间通信][2155]

*Other Notable Research Areas:*

- Capillary (or thin pipe) electrical discharge and soft X-ray laser amplification
- Mid- and far-infrared tunable laser technology
- Terahertz imaging and holographic technology
- Laser space information technology
- X-ray/XUV band and short wavelength laser research
- Nonlinear optics technology and applications
- Infrared laser technology
- New types of laser spectroscopy
- Space laser communications technology
- High-power light source and high-code rate modulation technology
- High-sensitivity anti-jamming optical signal reception technology
- Precision, reliable, high-gain transceiver and transmitter antennas
- Fast and precise capture, tracking, and targeting technology
- Atmospheric channel research
- Harmonic lasers
- Laws and mechanisms of stimulated Brillouin scattering (SBS)
- SBS optical phase conjugation
- SBS in optical fibers
- Laser spatio-temporal characteristics control
- Laser power synthesis
- Optical pulse controllers
- Optical limiters
- Fiberoptic SBS devices
- New concept lasers
- Dimer molecular spectroscopy
- Laser oscillations and dynamical processes
- Capillary (or thin pipe) electrical discharge
- Soft X-ray laser amplification
- Mid- and far-infrared tunable laser technology

- Terahertz imaging
- Two-dimensional scanning and digital holographic imaging
- Terahertz 2-D point-scan transmission imaging
- Two-dimensional surface-array transmission scanning imaging
- Two-dimensional confocal scanning imaging
- Digital holographic imaging
- Research on terahertz determination of object transmittance
- Backward scattering properties
- Holographic imaging and reverse reconstruction of holographic imaging using mathematical models
- High-power laser-material interactions
- Damage mechanisms of optical components for laser-driven inertial confinement fusion engineering (ICF)
- Distributed fiberoptic sensors
- Laser and infrared composite imaging technology[2156]

**Notable Applications:**

- Applications include the creation of a space-based satellite laser high-speed information network and a space-ground integrated information network. In 2007, this lab successfully completed China's first low Earth-orbit satellite-ground laser communications test. In 2011, the lab's Satellite Laser Communications Team successfully completed China's first low Earth orbit satellite-ground laser communications test. Between May and August 2017, it successfully completed the world's first synchronous satellite and ground two-way high-speed laser communications with a data rate of 5 GB per second.[2157]
- In 2015, the lab completed the "Satellite-Earth Laser Link Communication Test," an important milestone in the history of China's satellite communication technology development and high-speed information transmission from space.[2158]
- This lab is developing technology for distributed fiberoptic sensors and distributed fiberoptic strain monitoring [分布式光纤应变监测仪] targeted at safety monitoring of major infrastructure (e.g. energy pipelines, high-voltage cables, bridges, dams, and tunnels), aircraft monitoring, and natural disasters. This project was approved by the Ministry of Science and Technology [科技部] with funding of 41 million RMB. These sensors allow for continuous measurement in space, featuring long-range, high positioning accuracy, and the ability to measure temperature, strain, and vibration. They are lightweight, resistant to harsh environments, immune to electromagnetic interference/jamming, require no electricity at the sensing point, and can be used for long-distance distributed measurements with hundreds of thousands of points.[2159]
- Other projects include:
    - Development of long-wave infrared CO2 pulsed external differential coherent detection laser imaging technology.
    - Development of domestic flashing streak tub laser imaging radar technology.
    - Integrating a distance-selective LIDAR prototype leading to airborne flight tests and obtaining flight-to-ground high-resolution laser images.

- m-APD focal plane detector with single photon detection, used to study miniaturized high-power lasers, multi-frame statistical signal processing, and far-field 3D automatic target recognition. At present, the lab has a 32×32 pixel Gm-APD short-wave infrared laser imaging radar far-field target 3D distance image.[2160]

**Leadership and Key Personnel:**

- Director: (possibly dated) Lu Zhiwei [吕志伟][2161]
- Deputy Director: Chen Deying [陈德应][2162]

*Key Personnel:*

- Ma Zuguang [马祖光][2163]
  - Founder
  - Influential academic and pioneer in China's laser technology field who died in 2003
- Ma Jing [马晶] and Tan Liying [谭立英][2164]
  - Ma and Tan are experts on high-speed information transmission from space. They led this lab's efforts on technologies related to satellite laser communications, satellite laser link systems, and satellite high-speed laser communications networks. They took part in the 2015 "Satellite-Earth Laser Link Communication Test," a major milestone in the history of China's satellite communications technology development (see "Notable Applications").

**Notable Collaborations:**

*Domestic*

- Leaders from this lab took part in the opening ceremony for a CASC-HIT Joint Technology Innovation Center [中国航天科技集团公司-哈尔滨工业大学联合技术创新中心] with 10 million RMB in funding, implying this lab is an interested party in this agreement.[2165]
- Via a search of two scientific databases, this lab has worked with AVIC's China Air-to-air Missile Research Institute [中国空空导弹研究院] on GM-APD LIDAR distance-image neighborhood KDE reconstruction [GM-APD 激光雷达距离像邻域 KDE 重构]).

*International*

- In late 2020 this lab received a visit from the Dutch company Avantes, which specializes in fiberoptic spectroscopy instruments. Avantes personnel gave a talk outlining their spectrometer design and received a tour of the lab.[2166]

**Lab Equipment:**

- The lab's Mid- and Far-Infrared Tunable Laser Technology Team possesses a 3-5 μm mid-infrared optical parametric oscillator laser with output power over 40W (the highest international power level).[2167]

**Address**:

Possibly co-located with HIT at Harbin Institute of Technology, No. 92 West Dazhi Street, Nangang District, Harbin, Heilongjiang Province [哈尔滨市南岗区西大直街 92 号 哈尔滨工业大学]

**Website**:

http://www.opticsjournal.net/Lab/STTL.htm?action=index

**Known Aliases:**

- Defense S&T Key Laboratory on Tunable Laser [可调谐激光国防科技重点实验室]
    - Same name in English, but removes the characters "气体" (gas) in Chinese
- National Key Laboratory on Tunable Laser [可调谐激光国家级重点实验室]
- National S&T Key Laboratory on Tunable Laser [可调谐激光国家级重点实验室]
- Key Laboratory on Tunable Laser

## 92. Defense S&T Key Laboratory of UAV Special Technology

**Official English Name:** State Key Laboratory of UAV Special Technology[2168]

**Chinese Name:** 无人机特种技术国防科技重点实验室

**Post-2024 Name:** National Key Lab of Unmanned Flight Vehicle Technology[cxxii] [无人飞行器技术全国重点实验室][2169]

**Research Focus:**

Domain:

- Air

Equipment:

- Unmanned Systems
- *Secondary: Electronic Warfare*

Functional Field:

- Multiple (GNC, Propulsion, Simulation & Modeling, Stealth Technologies)

**Affiliations:**

- Northwestern Polytechnical University (NWPU) [西北工业大学]
    - School of Aeronautics [航空学院]
- PLA Air Force Engineering University [空军工程大学]
- Aviation Industry Corporation of China (AVIC) [中国航空工业集团]
    - Chengdu Aircraft Design Institute [航空工业成都飞机设计研究所]

**Key Data:**

- Established: 2001
- Total Funding: 300-420m RMB
- Personnel: 46[2170]
- Official start of operations: 2003
- Floor Space: approx. 10,000 sqm

**Lab Overview:**

This lab claims to be the PRC's only national-level key lab dedicated to UAVs, with the stated goal of becoming a national leader and internationally advanced platform for UAV

[cxxii] Literal translation, no official name given

technologies. It focuses on UAV integrated control systems, takeoff and landing technology, performance testing and verification, wing layout, RF simulation, and other research related to UAVs. It has eight subordinate labs.[2171]

NWPU's Xi'an ASN Technology Group Co. [西安爱生技术集团公司],[cxxiii] a major UAV manufacturing company which produces the ASN series of military and civilian UAVs, relies on the expertise of this lab for its UAV research (see Notable Applications below).[2172] Per one source, all of the UAVs which appeared in the 2009 PRC 60th Anniversary and 2017 PLA 90th Anniversary parades were developed by Northwestern Polytechnical University, suggesting this is a critical lab for the PRC's military UAV program.[2173]

In 2024, as part of the ongoing reorganization of the PRC's national key lab system, this lab was reconstituted as the National Key Lab of Unmanned Flight Vehicle Technology [无人飞行器技术全国重点实验室]. It is now subordinate to not just NWPU, but also the PLA Air Force Engineering University and AVIC's Chengdu Aircraft Design Institute.[2174]

**Further Information:**

- In 2013, this lab established a National Engineering Research Center for UAV Systems [无人机系统国家工程研究中心] which is dedicated to accelerating the development of China's UAVs for industry, academia, and research.[2175]
- In 2016, NWPU announced plans to create the PRC's largest UAV production base for small to midsized UAVs, called the "Aviation Science City - UAV Industrial Base" [航空科学城——无人机产业化基地]. The base will include product testing and manufacturing areas. It will utilize NWPU's two primary UAV institutions, namely this lab as well as the National Engineering Research Center for UAV Systems.[2176]

**Research Direction:**

1. UAV optimization technology
2. Integrated control technology for UAV systems
3. UAV takeoff and landing technology
4. UAV integrated performance testing and verification technology[2177]

*Other Notable Research Areas:*

- UAV wing layout
- RF simulation technology
- UAV virtual simulation software and hardware
- Special UAV pneumatic experimental research
- Jet engine control and semi-physical simulation

[cxxiii] a.k.a. the 365th Research Institute [365 研究所], a.k.a. the NWPU Drone Institute [西工大无人机所]

- Testing and evaluation of deformation, damage, and destruction of UAV materials and structures under special service conditions
- UAV control and whole-system semi-physical simulation verification
- UAV navigation verification
- UAV full-spectrum and all-frequency band terminal guidance simulation and verification
- UAV flight control system component testing
- UAV precision positioning (DGPS, pseudo-GPS) takeoff/landing simulation and verification
- UAV beam-guided takeoff and landing simulation and verification
- UAV visual takeoff/landing simulation and verification
- Wide Band High-power RF Simulation
- High-precision ultra-wideband antenna and stealth testing
- Data chain simulation testing in a complex electronic warfare environment[2178]

**Notable Applications:**

- This lab is responsible for much of the research for the ASN-series of military and civilian UAVs. The anti-radiation ASN-301[cxxiv] (a possible copy of the Israeli Harpy) was designed by husband and wife duo Zhou Zhou and Zhu Xiaoping of this lab. At the 2009 National Day parade, all of the military UAVs on display were ASN products. Three UAVs at the 2017 PLA Founding Day parade were also ASN products: the ASN-301 anti-radiation UAV, as well as a communications jamming UAV and a radar jamming UAV.[2179]
- Other public projects include the Phantom-6 Solar Powered, High-Endurance UAV, which set a record of 19 hours and 34 seconds of flight time, and the PRC's first solar powered 5G-enabled Fixed-Wing UAV [固定翼无人机], also developed by the NWPU Phantom Team. These can be used for civilian or military (remote comms, border patrol, stability maintenance, and anti-terrorism) purposes.[2180]
- On the civilian side, in 2024 a lab research team developed an autonomous robot for picking and pollinating fruit which utilized advanced intelligent robotics.[2181]

**Leadership and Key Personnel:**

- Director: Zhou Zhou [周洲][2182]

[cxxiv] The source also states that the anti-radiation UAV project was first test flown in 2001, but had propulsion problems due to international sanctions. The plan was to use an imported engine, but the exporting country did not allow for the engines to be exported. This forced the team to develop indigenous engines. The UAV also experienced control system problems, but a successful test was conducted on 24 December 2004. Through several years of work, the team was able to overcome the international sanctions via indigenous innovation. The source states that the model carried missiles, and may target THAAD.

- Academic Committee Director: Chen Yijian [陈一坚][2183]

*Key Personnel:*

- Zhu Xiaoping [祝小平][2184]
    - Awarded a 2nd Class National Defense S&T Progress Award in 2010 for his project "(REDACTED) System General Requirements Series of National Military Standards"
    - Oversees the NWPU Unmanned Navigation Technology Research Center [无人航行技术研究中心] in Ningbo
    - Husband of lab Director Zhou Zhou

**Notable Collaborations:**

*Domestic*

- This lab collaborates with CASC, AVIC, COMAC, and other prominent aerospace SOEs, as well as CARDC (PLA Base 29) as part of the Collaborative Innovation Center of Future Aerospace Vehicle (*sic*).[2185]
- This lab co-sponsors the NWPU Special UAV Technology Research Institute [特种无人机技术研究所], along with the First Class State Key Discipline of Aeronautics and Astronautics [航空宇航学科与技术一级国家重点学科]. This Institute conducts research on new concepts for clean energy UAVs, bionic UAVs, and new concepts for VTOL UAVs. It has been responsible for projects related to the 9th, 10th, and 11th Five Year Plans.[2186]
- In 2019, this lab signed a three-way strategic cooperation agreement with CASIC Hubei Sanjiang Astronautics Hongfeng Control Co., Ltd.[湖北三江航天红峰控制有限公司] and Xi'an Lyncon Co. [西安羚控电子科技有限公司]. The three parties will leverage their respective strengths to cooperate in the development of flight control systems, server systems, and fiberoptic inertial navigation systems.[2187]
- This lab has taken part in the China Aero Weaponry Conference, along with AVIC. Conference topics included UAV reconnaissance, strike, air combat, anti-sub, and anti-carrier operations, as well as drone swarms and manned-unmanned aircraft cooperation.[2188]
- Per searches of two scientific databases, this lab has cooperated with PLA units 63961 (multiple projects), 93975, 91503, 93861, 91599, and 69296.
- This lab appears to provide research support to Shaanxi Dexin Technology Co. [陕西德鑫智能科技有限公司], a UAV company.[2189]

*International*

- This lab was one among several co-organizers of the 2024 International Conference on Autonomous Unmanned Systems (ICAUS 2024) [2024 第四届国际自主无人系统大会]. Other major organizers and sponsors included the National University of Defense Technology, Northwestern Polytechnical University, Nanjing University of Science and

Technology, and several other PRC universities and companies, as well as the U.K. Institution of Engineering and Technology.[2190] While a list of participants was not available, conference organizers and committee members for the 2022 iteration of the conference came from the U.S. (University of California, University of Texas at Arlington, University of Nevada, Georgia Institute of Technology, Mind Research Institute), U.K. (Loughborough University, University of Manchester, Cranfield University, University of Cambridge, University of Lancaster), Germany (University of Hamburg, University of Freiburg), Australia (Australian National University), Canada (University of Guelph, York University), the Netherlands (Delft University of Technology), Israel (Technion–Israel Institute of Technology), Singapore (NUS, NTU). PRC participants came from National University of Defense Technology, the PLA Naval Research Institute, PLA Air Force Engineering University, CASIC, Beihang, Beijing Institute of Technology, Northwestern Polytechnical University. Research topics included autonomous unmanned air, ground, space, and maritime systems, intelligent environment sensing, navigation and positioning, communications and networking, payload technology, brain-computer fusion, AI algorithms, unmanned system countermeasures, and bionic technology.[2191]

- The lab claims to have a "long-term cooperative relationship" with Kingston University in the U.K., and possibly other unnamed institutions.[2192]
- The 2016 China-International UAV System Conference and Exhibition [中国国际无人驾驶航空器系统大会暨展览] featured this lab as a cooperating party, and also featured support from the American Institute of Aeronautics and Astronautics (AIAA) and U.K. Royal Aeronautical Society.[2193]

**Lab Equipment:**

- UWM4000 Doppler velocimeter docking array from U.S. company Linguest
    - Despite NWPU being on the U.S. Department of Commerce Entity List for export control since 2001, the lab received this equipment in 2014.
- Delmia&3DVIA virtual prototype assembly software from French company Dassault.[2194]

**Address**:

Building 2, No. 127 Youyi West Rd, Xi'an, Shaanxi Province [陕西省西安市友谊西路 127 号][2195]

**Website**:

http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=360

**Known Aliases:**

- Key Lab of UAV Special Technology [无人机特种技术重点实验室]
- National Key Lab of UAV Special Technology [无人机特种技术国家重点实验室]
- National Laboratory of UAV Special Technology
    - More common translation.
- National Key Laboratory of Science and Technology on UAV
- State Key Laboratory of UAV Special Technology
- Science and Technology of UAV Laboratory
- National Key Laboratory of Unmanned Aerial Vehicle Technology
- National Key Lab of Special Technology on UAV
- National Key Laboratory of Special Technology on UAV
- Laboratory of Science and Technology on UAV

## 93. Defense S&T Key Laboratory of Underwater Information and Control

**Official English Name:** State Key Laboratory for Underwater Information and Control[2196]

**Chinese Name:** 水下信息与控制国防科技重点实验室

**Post-2024 Name:** National Key Laboratory of Underwater Information and Control[cxxv] [水下信息与控制全国重点实验室][2197]

**Research Focus:**

Domain:

- Maritime

Equipment:

- Underwater Vehicles
- *Secondary: Communications Equipment*

Functional Field:

- GNC
- *Secondary: Communications Technologies, Information Processing*

**Affiliations:**

- Northwestern Polytechnical University (NWPU) [西北工业大学]
    - School of Marine Science and Technology [航海学院]
- China State Shipbuilding Corporation (CSSC) [中国船舶集团]
    - 705th Research Institute [705 研究所]

**Key Data:**

- Established: 1993
- Total Funding: Unknown
- Personnel: 20 researchers[2198]
- Official start of operations: 1997
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research into various aspects of underwater information technology, including autonomous control and processing technology, navigation, identification, positioning, and communications. It may also play a key role in the PRC's torpedo R&D, being subordinate to

[cxxv] Literal translation, no official name given

the CSSC 705th Research Institute, which is the primary designer of all of the PRC's torpedoes. The lab may be known internally as the Defense S&T Key Laboratory of Torpedo Guidance Technology [鱼雷制导技术国防科技重点实验室] and/or the Key Laboratory of Underwater Guidance Technology [水下制导技术重点实验] (see below). It is possible that these are internal names for this lab which are intentionally no longer used publicly, given their more explicitly military ring.[2199]

Despite the fact that NWPU has been on the U.S. Commerce Department Entity List for export control since 2001, this lab publicly advertises its use of imported high-tech equipment from the United States, European, and Japanese sources, much of which was acquired after 2001 (see lab Equipment section below). This lab has also been implicated in industrial espionage: Qin Shuren, who pleaded guilty in 2021 to illegal export of controlled technology related to underwater warfare from the U.S., was likely working at the direction of this lab. [2200] [cxxvi]

The CSIC (now CSSC, following a 2019 merger) 705th Research Institute was established in 1958 and today is cited as one of the 54 National Key Military Support Work Units [全国 54 个重点保军单位]. This RI conducts R&D of naval weaponry and equipment. Research areas include mechanical power, fluid transmission and control, computers, automatic control, power electronics, hydroacoustic engineering, and communications technology. It is heavily involved in the development of underwater weaponry and torpedo research and manufacture, including of the Yu-6 torpedo.[2201] It was placed on the U.S. Commerce Department's Entity List for export control in 2020.[2202]

Under the ongoing reorganization of the PRC's national key lab system, this lab is now known as the, National Key Lab of Underwater Information Control [水下信息与控制全国重点实验室].

**Further Information:**

- This lab is broken up into 3 subordinate entities:
  - *New Underwater Vehicle Control Technology Lab* [水下航行器控制新技术实验室]
  - *New Underwater Information Processing Technology Lab* [水下信息处理新技术实验室]
  - *Visualization and Data Processing Center* [可视化数据处理中心].[2203]
- Director Yang Yixin is associated with the 111 Plan [111 计划] "Ocean Information Sensing" Academic Innovation and Intelligence Base ["海洋信息感知"学科创新引智基地]. The 111 Plan, which aims to attract foreign talent to establish joint Sino-Foreign research bases in China, has been associated with tech transfer.[2204]

[cxxvi] For more information on how the Qin Shuren case related to this lab, see the author's piece in Defense One: Ma Xiu, Peter W. Singer, "How China Steals US Tech to Catch Up in Underwater Warfare," *Defense One*, 8 June 2021. https://www.defenseone.com/ideas/2021/06/how-china-steals-us-tech-catch-underwater-warfare/174558/

- The lab has a branch in Ningbo, where it contributes its resources to the NWPU Ningbo Research Institute [西北工业大学宁波研究院], particularly the Ningbo Research Institute Unmanned Navigation Technology Research Center [宁波研究院无人航行技术研究中心]. This team is led by lab affiliated Xu Demin and Song Baowei, and focuses on new underwater equipment such as autonomous underwater vehicles, underwater gliders, and manta ray-like flexible submersibles. It has invested nearly 100m RMB to creae a research platform for intelligent underwater vehicles. The research site is 4,708 sqm, and equipment includes an underwater dynamic capture system, circulating tank hydrodynamic and DPIV flow field test system, fully transparent integrated pool, towing test system, flexible battery production and test system, and underwater vehicle assembly and debugging system. It also includes a comprehensive evaluation system to test performance of key components, including the stability of the flow field, mechanical properties, and the stability of static/dynamic structures under deep-sea pressures. It has developed the world's first 500kg class manta-like flexible body submersible engineering prototype, completing a 1,025m dive.[2205]
- Evidence of different names: The Key Laboratory of Torpedo Guidance Technology (TGT) is rarely referred to publicly, but in one 2009 article it is revealed that it is also subordinate to the NWPU School of Marine Science and Technology, is also a collaboration with the 705th RI, and Xu Demin serves as the Academic Committee Director, just as he does with this lab. Professor Song Baowei is also affiliated with both labs. Further, searching an academic journal database brings up two articles ascribed to the TGT Lab and of the six authors cited, five are also affiliated with the DSTKL of Underwater Information and Control. The DSTKL of Underwater Information and Control also seems to be involved in torpedo technology research. The TGT lab is almost never referred to after around 2010, although a single unofficial source from 2019 lists it among NWPU's Key Labs, seemingly in lieu of the UIC Lab. In yet another instance, a single reference in 2009 was made to a Key Lab of Underwater Guidance Technology [水下制导技术重点实验], also a collaboration with the 705th RI and established and approved at the exact same time as the DSTKL of Underwater Information and Control. Given all these coincidences, it is probable that the Underwater Information and Control, Torpedo Guidance Technology, and Underwater Guidance Technology are three names for the same lab. Interestingly, in the latter article a banner can be seen in the background which is censored to obscure the name of the lab.[2206]

**Research Direction:**

Underwater information control and processing technology [水下信息控制与处理技术][2207]

*Other Notable Research Areas:*

- High-speed underwater wireless laser communications
- Underwater vehicle navigation and control

- Underwater vehicle path planning, tracking, and guidance
- Underwater information processing and identification
- Hydroacoustic communications and multi-vehicle coordination
- Underwater precision control, navigation, and positioning technology
- Underwater information processing and identification technology
- Underwater vehicle ballistic optimization technology
- Research and development of underwater equipment
- Basic research into underwater information processing and control under complex interference/jamming conditions[2208]

**Notable Applications:**

- While no specific programs could be found, this lab is broadly involved in the PRC's development of underwater warfare technologies related to submarines, UUVs and AUVs, and torpedoes.

**Leadership and Key Personnel:**

- Director: Yang Yixin [杨益新][2209]
- Academic Committee Director: Yang Huizhen [杨慧珍][2210]
- Deputy Directors: Yan Weisheng [严卫生]; Zhang Qunfei [张群飞]; Cui Songxin [崔荣鑫][2211]
- Former Director: Song Baowei [宋保维][2212]
- Former Academic Committee Director: Xu Demin [徐德民][2213]

**Notable Collaborations:**

*Domestic*

- NWPU has a Research Academy in the city of Ningbo, called the Ningbo Research Academy [宁波研究院], which controls five innovation centers, one of these is the Unmanned Navigation Technology Research Center [无人航行技术研究中心]. This Center is run jointly by this lab and another NWPU lab, the National Specialist Lab of Acoustic Engineering and Testing Technology [声学工程与检测技术国家专业实验室]. It is focused on unmanned aircraft, boats, and underwater vehicles, and is described as an "integrated air-land-sea unmanned navigation innovation research center." It is run by Zhu Xiaoping [祝小平] of the Defense S&T Key Lab of UAV Special Technology. Lab facilities include a high-speed water cavity/cave [高速水洞], large anechoic pool [大型消声水池], underwater physical field simulation [水下物理场仿真], underwater power

propulsion [水下动力推进], sound and vibration control [声与振动控制], and a navigation and control simulation center [导航与控制仿真中心].[2214]

- This lab works closely with the NWPU Autonomous Underwater Vehicle Team [自主水下航行器团队].[2215]

*International*

- This lab claims to have hosted academics from the University of North Carolina and George Mason University.[2216]
- This lab hosted the 2018 IEEE International Conference on Signal Processing, Communications, and Computing.[2217]

**Lab Equipment:**

NWPU has been on the U.S. Commerce Department Entity List for export control of sensitive technologies since 2001. Nevertheless, a list of high-tech equipment utilized by this lab includes multiple items sourced from U.S., European, and Japanese companies. U.S. technology used by this lab includes:

- AD RTS/6205 Real-time simulation system from Applied Dynamics International (ADI)
- IVER2-580-EP Small Unmanned Underwater Vehicle from L3 OceanServer (also utilized for research by the U.S. military[2218])
- TLA7012 Logic Analyzer from Tektronics
- X2-8 Server from Sun Microsystems
- AquaTrans underwater acoustics communications modem from Aquatic Sensor Network
- 1160A pulse 500MHz waveform arbitrary waveform generator from Agilent Technologies
- E4980A20MHz Precision LCR Tester from Agilent Technologies
- 16823A500MHZ Logic Analyzer from Agilent Technologies
- NovaTM Nano SEM450 Field Emission Scanning Electron Microscope from FEI
- IConn Automatic metal wire ball welding machine from KNS
- KNS 4522 Manual Ball Welder from KNS
- EPS150COAX and Summit-11000B-M Probe table from CASCADE

Other foreign-manufactured equipment includes:

- Track Link 1500 hydroacoustic positioning system from U.K. company LinkQuest
- DS1005 real-time simulation processing system from German company Dspace
- OCEANO 2500 acoustic translator from French company iXblue
- 8860 High Speed Data Logger from Japanese company Hioki
- MR304 infrared spectrometer from Canadian company ABB
- Oqus300 non-contact 3D motion analysis system from Swedish company Qualisys

Equipment coming from PLA sources includes:

- Doppler simulator manufactured by the Naval Engineering University
- Short-cycle high-speed gas film cooling heat transfer wind tunnel from PLA Unit 63837

Other domestically-manufactured equipment includes:

- Data processing system with visualization software and database processing software, capable of complex fluid dynamics calculation and visualization simulation
- Multi-channel programmable filters: 32 channels, high pass, low pass, and band pass filtering of signals as needed
- Flight simulation turntable: three degrees of freedom, CNC continuous rotation. Can carry out motion body space and motion attitude simulations
- 3KTD-630 inertial guidance system test turntable
- Torpedo body scaling model
- Angular motion simulator
- Laser inertial navigation system
- Servo control loop performance test stand
- Servo based simulator
- Depth simulator system
- G2+RT2 differential GPS receiver system
- TD1250C frequency response analyzer
- CWT-00 blade wind tunnel unit
- W780-G20E5*2/128G/2T+1.2TSSD GPU server
- TAS-25091.8/147Kpa roots-type supercharger
- Short-cycle heat transfer wind tunnel measurement system
- Front-end microelectronic chip test purification studio
- Fully automatic solder paste printing machine
- Medium speed automatic vision mounter
- Anechoic pool
    - This pool is mainly used for torpedo acoustic self-guided systems and hydroacoustic transducer performance research. It is 20 meters long, 8 meters wide, and 7 meters deep. It includes a six-sided installation of sound-absorbing tip split, sound absorption frequency of 2KHz-80KHz, and two traveling cranes which can make horizontal movements in the pool. Test devices installed on the traveling crane can carry out vertical movement and rotational movement.
- The total value of equipment at this lab is 23.78 million RMB.[2219]

**Address**:

Likely co-located with NWPU Chang'an Campus and spread across several buildings on Dongxiang Road, Chang'an District, Xi'an, Shaanxi Province [西安市长安区东祥路 1 号][2220]

**Website**:

http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=261

**Known Aliases:**

- Defense S&T Key Laboratory of Torpedo Guidance Technology [鱼雷制导技术国防科技重点实验室]
- Key Laboratory of Underwater Guidance Technology [水下制导技术重点实验]
- Key Laboratory for Underwater Information and Control [水下信息与控制重点实验室]
- National Key Laboratory for Underwater Information Processing and Control [水下信息处理与控制国家级重点实验室]
- Defense S&T Key Laboratory of Maritime Weaponry [水中兵器国防科技重点实验室]
- Key Laboratory of Maritime Weaponry [水中兵器重点实验室]

## 94. Defense S&T Key Laboratory of Underwater Measurement and Control Technology

**Official English Name:** (possible) Science and Technology on Underwater Test and Control[2221]

**Chinese Name:** 水下测控技术国防科技重点实验室

**Post-2024 Name**: No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Maritime
- *Secondary: Air, Space*

Equipment:

- Underwater Vehicles
- *Secondary: Space Vehicles, Surface Vessels, Unmanned Systems*

Functional Field:

- Multiple (Acoustics, GNC, Sensors, Target Detection/Recognition)

**Affiliations:**

- China State Shipbuilding Corporation (CSSC) [中国船舶集团]
    - Dalian Institute of Measurement and Control Technology [大连测控技术研究所]
        - *a.k.a. CSSC 760th Research Institute*

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab appears to conduct research on various oceanographic fields and technologies relevant to naval warfare, including hydroacoustics and sonar, detection and tracking of underwater, surface, and low-altitude targets, and maritime guidance, navigation, and control. Its work may also extend beyond the maritime realm to navigation and tracking of aerospace vehicles as well.[2222] While there is relatively little public information on this lab, it is active in organizing domestic and international conferences in acoustics and other ocean science fields.

The CSSC Dalian Institute of Measurement and Control Technology [大连测控技术研究所] (a.k.a. the CSSC 760th Research Institute) conducts research on maritime noise and vibration testing, marine engineering testing, underwater target characterization, marine applied physics, and marine environmental factors.[2223]

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

A sampling of research publications included:

- Detecting and tracking surface and low-altitude maritime targets (with PLAN Unit 92771)[2224]
- Hydroacoustic signal detection and recognition (with PLAN and PLA Unit 31001)[2225]
- Electromagnetic sensors for the sea battlefield[2226]
- Underwater sonar for target detection[2227]
- Direction finding for space vehicles[2228]

**Notable Applications:**

None found

**Leadership and Key Personnel:**

- Director: Zhang Jing [张琼]
    - Graduated with a degree in military-civil dual use maritime studies
    - Named as a "Military 10th Five Year Plan Weapons and Equipment Advanced Individual" [军队 "十五"武器装备预先研究先进个人][2229]

**Notable Collaborations:**

*Domestic*

- In 2023, this lab co-organized the Underwater Unmanned Systems Frontier Science and Technology Forum [水下无人系统前沿科技论坛], hosted by the Journal of Unmanned Underwater Systems [水下无人系统学报]. Other organizers included the Chinese Society of Naval Architects and Marine Engineers [中国造船工程学会], CSSC 705th RI, Dalian Maritime University, International Joint Research Center of Undersea Engineering Technology and Equipment [海底工程技术与装备国际联合研究中心], and others.

Research topics included hydroacoustic communications and networking, underwater unmanned equipment and its operation, underwater unmanned system informatization, sea cable magnetic exploration, underwater grasping technology based on visual and tactile sensing, intelligent soft-body robotics, underwater yield prediction and fishing robots, unmanned autonomous platforms, underwater biomimetic electric field localization inspired by weakly electrically powered fish, and friction-based underwater flow field energy and nano-generation.[2230]

- In 2022, this lab co-organized the International Conference on Information Processing in Ocean Science and Technology (ICIPOST) [2022年海洋科技信息处理国际会议]. The primary organizer was the National University of Defense Technology [国防科技大学], and other organizers included the Ocean University of China, Xiamen University, Central South University, Guangdong Ocean University, Nanjing University of Information Science and Technology, Changsha University of Science and Technology, Ministry of Natural Resources, and several key labs. Research topics included ocean climate, air-sea interaction, ocean mesoscale and small-scale processes, marine data analysis and processing, marine environmental forecasting, marine environmental support, marine exploration technology, marine optics, marine acoustics, and marine artificial intelligence. The conference was also focused on reform of marine science university teaching to promote common development of military and civilian industries, universities, and research institutes. While the announcement did not name international participants, it appears to be very similar to the below 2023 conference, also hosted by NUDT and featuring participation from several international scholars.[2231]

*International*

- In 2023, this lab co-organized the International Conference on Frontiers of Ocean Science and Technology (ICFOST) [2023年海洋科技前沿国际会议]. The primary organizer was the PLA National University of Defense Technology, along with Oceanic University of China, Xiamen University, Harbin University of Engineering, Central South University, Sun Yat-sen University, Zhejiang University, Guangdong Ocean University, Nanjing University of Information Engineering, Changsha University of Science and Technology, the State Key Laboratory of Satellite Marine Environmental Dynamics, and multiple other key labs. Topics included ocean circulation, sea-air interaction and ocean climate, small and medium scale processes in the ocean, ocean remote sensing and data processing and analysis, ocean forecasting, safety and security of the marine environment, ocean detection technology, artificial intelligence in oceanography, hydroacoustics, and hydroacoustic signal processing. International participants and organizers came from the European and Australian Academies of Sciences and University of Algarve in Portugal, University College London and University of Sheffield in the U.K., Memorial University in Canada, National Technical University of Athens in Greece, and École Polytechnique Fédérale de Lausanne.[2232]
- In 2021, this lab co-organized the IEEE/OES China Ocean Acoustics Conference, along with the IEEE Oceanic Engineering Society, Harbin Engineering University, and several

other key labs. The conference focused on underwater acoustics and acoustical oceanography, ocean sound propagation, marine sediment acoustics, problems of ocean noise and reverberation, sonar modeling, signal detection and estimation, acoustical sensors and arrays, underwater acoustic communication, polar acoustics, and other related fields. The conference's scientific committee included researchers from the PLA's Naval Research Academy and Dalian Naval Academy alongside the U.S. Penn State University, University of Washington, Lehigh University, University of Mississippi, UMass Dartmouth, and University of Hawaii, University of Bath and Loughborough University in the U.K., University of Algarve in Portugal, National Taiwan University, University of Oslo in Norway, and University of Victoria in Canada. PLAN personnel took part throughout. A professor from UMass Dartmouth spoke on advances in broadband underwater acoustic transducers and navigation, and a professor from Northeastern University spoke on acoustic communication. U.K., Canadian, and Norwegian researchers also gave talks.[2233]

- In 2021, this lab co-organized the China International Conference on Ocean Acoustics and Science and Technology Competition on Hydroacoustic and Ocean Technology [2021年中国海洋声学国际会议暨水声与海洋技术科技竞赛], along with the Institute of Electrical and Electronics Engineers and multiple key labs. Participants came from 7 countries/regions, including MIT and UMass in the U.S., and National Taiwan University.[2234]

**Lab Equipment:**

None found

**Address**:

Dalian, Liaoning Province 116013 [辽宁省大连市][2235]

**Known Aliases:**

- 水下测控技术国家重点实验室
- 水下测控技术国家级重点实验室
- 水下测控技术重点实验室

## 95. Defense S&T Key Laboratory of Vacuum Technology and Physics

**Official English Name:** Unknown

**Chinese Name:** 真空技术与物理国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Space

Equipment:

- Space Vehicles

Functional Field:

- Reliability/Environmental Engineering
- *Secondary: Electrical Power, Materials, Propulsion*

**Affiliations:**

- China Aerospace Science and Technology Corporation (CASC) [中国航天科技集团]
  - China Academy of Space Technology (CAST) Lanzhou Institute of Physics [中国空间技术研究院兰州空间技术物理研究所]
    - *CASC 5th Academy 510th Research Institute [第五院 510 研究所]*

**Key Data:**

- Established: c. 2014-2015
- Total Funding: Unknown
- Personnel: Unknown[2236]
- Official start of operations: 2023
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research on the interaction between space vehicles and the space environment to improve lifespan and reliability. According to one unofficial source, its primary research foci are extreme high-vacuum technology and surface physics, space environment and spacecraft material interaction and protection technology, and space cooling technology. The lab's research has been applied to the Chang'e lunar program, the PRC space station, and various other satellite and space vehicle programs.[2237]

In its current form, this lab was likely first established sometime around late 2014 or early 2015 when two former Defense S&T Key Labs under the CASC 510th Research Institute were reorganized and combined.[2238] The first of these was the DSTKL of Vacuum and Low Temperature Technology and Physics [真空低温技术与物理国防科技重点实验室], which dated to at least 2004 and had branches in both Beijing and Lanzhou.[2239] This lab was further expanded and upgraded around 2011, adding significant new equipment, including from a Canadian company, as part of the CASC 510th RI's expansion of its vacuum research capabilities.[2240] The second lab was the DSTKL of Surface Engineering Technology [表面工程技术国防科技重点实验室]. Combined, these two labs formed the current DSTKL of Vacuum Technology and Physics. Although first established around 2014-2015, the new lab was only formally approved by SASTIND in 2023.[2241]

The Lanzhou Institute of Physics (a.k.a. CASC 510th Research Institute), under CASC's China Academy of Space Technology (a.k.a. the CASC 5th Academy) was established in 1962 and conducts R&D of space vehicle equipment and components, including vacuum technologies, electric propulsion systems, power supplies, space payloads, atomic clocks, surface engineering, electromechanical products, and pressure vessels. The PRC has launched over 200 satellites and other space vehicles using this Institute's products.[2242] While older descriptions of the 510th RI will state that it oversees three DSTKLs,[2243] by 2022 newer descriptions stated that it oversees two DSTKLs, accounting for the combination of the two former labs.[2244]

**Further Information:**

- Xi Jinping visited both of the above-mentioned predecessor labs in 2009.[2245]
- This lab has a presence at the Lanzhou Military-Civil Integration Industrial Base [兰州军民结合产业基地][2246]
- Teams under this lab include:
  - *National Security Major Basic Research Project Team* [国家安全重大基础研究项目团队]
    - Awarded the title of Outstanding Innovation Team of the CASC Fifth Academy
  - *Chang'e-3 Lunar Dust Measuring Instrument Development Team* [嫦娥三号月尘测量仪研制团队]
  - *Space Station Electric Potential Active Control Team* [空间站电位主动控制团队]
  - *Lunar Dust Measuring Instrument Development Team* [月尘测量仪研制团队][2247]
    - Awarded the title of Advanced Collective of the Fifth Academy in 2013
- In recent years, the lab has completed more than 10 scientific research projects with "significant" impact, and has won one first prize for National Defense S&T Progress, one second prize for Gansu Provincial Science and Technology Progress, and five third prizes for National Defense Science and Technology Progress. In 2013, it was honored with the title of "Longyuan Pioneer" in Gansu Province [甘肃省"陇原先锋号"称号].[2248]

- The lab's academic committee includes members from the General Armaments Department's S&T Committee, the PLA "designated general station" [解放军定为总站], NUDT, CAST, Beihang, PRC National Timing Center, and Xi'an Jiaotong University.[2249]

**Research Direction:**

(The below research direction comes from an unofficial source, but is likely copied from a previous official source)

1. Extreme High Vacuum Technology and Surface Physics [极高真空技术和表面物理]
   This includes physical phenomena in extremely low vacuum environments and how these phenomena affect and are affected by surface physical processes. This direction aims to reveal new phenomena and theories under extreme conditions and provide theoretical support and innovative ideas for related fields.
2. Space environment and spacecraft material interaction and protection technology [空间环境与航天器材料相互作用及防护技术]
   This includes material properties of spacecraft in space and their interaction with the space environment, and development of effective protection technologies to ensure that spacecraft can operate normally under extreme conditions and guarantee the successful implementation of space missions.
3. Space cooling technology [空间制冷技术]
   Efficient cooling methods in microgravity and low-temperature environments for energy management in space exploration and fields requiring low-temperature applications.[2250]

*Other Notable Research Areas:*

- Carbon nanometer field emission devices, space application of nanotechnology[2251]
- Chang'e lunar vehicle program[2252]
- Space vehicle simulations[2253]
- Satellite propulsion[2254]
- Materials under extreme temperature environments[2255]
- The former DSTKL of Surface Engineering Technology conducted research on optical thin films for space vehicles, including infrared filters, ultra-narrow band filters for lightning detection and linear gradient filters[2256]
- The two predecessor labs worked on thermally controlled thin films for satellites, laser etching, and space integrated environmental research[2257]

*Notable Research Projects:*

- In 2023, this lab received 1.348m RMB in funding for a project called "Research on Key Technologies and Applications of Space Vacuum Probe Metrology" [空间真空探测计量关键技术及应用研究][2258]

- In 2015, this lab was working on a project titled "New Approach to the Study of Spatial Environmental Effects of Space-Earth Integration" [天地一体化空间环境效应研究新方法][2259]

**Notable Applications:**

- This lab developed a "space station cable atomic oxygen protective coating" [空间站电缆原子氧防护涂层宇航技术]. The project lasted four years, during which the team mastered core technologies such as precise control of and adaptive adjustment to small tension [小张力精准控制与自适应调节等核心技术]. It has since been utilized in transparent oxide high-barrier film produced by the CASC 5th Academy.[2260]
- This lab has been involved in the Chang'e lunar program, including a team which created an instrument to measure lunar dust for the Chang'e 3.[2261]
- This lab was involved in developing electrical power for the PRC space station.[2262]
- The former DSTKL of Surface Engineering Technology developed a satellite thermal control technology that broke through a major bottleneck and embargo for the PRC and was utilized in the Dongfang Hong 3 and 4 and Changmao 1 satellites.[2263]
- The former DSTKL of Surface Engineering Technology has developed space optical thin film technology and has made breakthroughs in preparation process, performance testing, and space environment simulation tests. This has included infrared bandpass filters and transmittance enhancement films for the infrared multi-spectral scanner of the China-Brazil cooperation satellite "Resource 1" series, ultra-narrow band filters for the lightning detector of the "Fengyun 4" satellite, and linear gradient filters developed as a new technology.[2264]

**Leadership and Key Personnel:**

- Academic Committee Director: Ye Dajian [叶培建][2265]
- Academic Committee Deputy Director: Fan Benyao [范本尧][2266]
- Academic Committee Deputy Director: Chen Xuekang [陈学康][2267]
- Standing Deputy Director: Li Detian [李得天]
    - Also served as 20th Party Congress Rep and CAE Academician
    - Was Lab Director and Deputy Director of 510th RI in 2013
    - Research interests in vacuum technology and physics, space environment effects and protection
    - Worked at Federal Physical and Technical Research Institute of Germany in 2001-2002
    - Also Director of National Cryogenic Vessel Quality Supervision and Inspection Center [国家低温容器质量监督检验中心] in 2013[2268]

*Key Personnel*

- Xiong Yuqing [熊玉卿]
  - Prominent researcher at former DSTKL of Surface Engineering Technology
  - Expert on vacuum and optical thin-film technology
  - Member of the American Optical Society, and also participated in a U.K. Engineering and Physical Sciences Research Council key project, possibly related to nano-films
  - Conducted post-doc work in U.K. from 2001-2002 before returning to PRC to join CASC[2269]
- Feng Yudong [冯煜东]
  - Prominent researcher at the former DSTKL of Surface Engineering Technology
  - Developed a satellite thermal control technology that broke through a major bottleneck and embargo for the PRC and was utilized in the Dongfang Hong 3 and 4 and Changmao 1[2270]

**Notable Collaborations:**

*Domestic*

- In 2024, this lab co-organized the "19th Annual Meeting of the Vacuum Metrology Committee of the Chinese Society of Metrology and Testing, the 22nd Annual Meeting of the Vacuum Mass Spectrometry and Leak Detection Committee of the Chinese Vacuum Society, and the 2024 Academic Conference of Vacuum and Cryogenic Specialized Group of the Science and Technology Committee of the Chinese Academy of Space Technology" [中国计量测试学会真空计量专委会第十九届年会、中国真空学会真空质谱分析与检漏专委会第二十二届年会、中国空间技术研究院科技委真空与低温专业组 2024 年学术会议]. Other organizers included the Vacuum Metrology Committee of Chinese Society of Metrology and Testing [中国计量测试学会真空计量专委会], Vacuum Mass Spectrometry and Leak Detection Committee, Chinese Vacuum Society [中国真空学会真空质谱分析与检漏专业委员会], the Science and Technology Committee of China Academy of Space Technology [中国空间技术研究院科技委], CASC 510th RI, Wenzhou University, and the SASTIND Vacuum Measurement Station [国防科技工业真空一级计量站]. Research topics included vacuum measurement technology, mass spectrometry, leakage detection, low-temp technology, and hydrogen storage and transport for aerospace, nuclear power, microelectronics, bioengineering, and various civilian industries.[2271]
- In 2024, this lab co-organized the 12th National Conference on Entry, Deceleration, Landing and Ascent (EDLA) Technology [第十二届进入、减速、着陆与上升（EDLA）技术全国学术会议]. Other organizers included the Chinese Society of Astronautics Return and Re-entry Committee [中国宇航学会返回与再入专业委员会], the CASC Space Entry Deceleration and Landing Technology Laboratory [中国航天科技集团有限

公司航天进入减速与着陆技术实验室], CAST Entry, Deceleration, Landing and Ascent Specialized Group [科技委航天器进入、减速、着陆、上升专业组], China Academy of Launch Vehicle Technology Pneumatic and Hydrodynamic Technology Specialized Group of Science and Technology Committee [中国运载火箭技术研究院科技委气动与水动技术专业组], Lanzhou University, Beijing Space Electromechanical Research Institute [北京空间机电研究所], Beijing Long March Vehicle Research Institute [北京航天长征飞行器研究所], and Lanzhou Institute of Physics [兰州空间技术物理研究所]. The conference focused on EDLA technology for human spaceflight, moon exploration, and deep space.[2272]

- In 2020, this lab co-organized the High-Level Forum on Future Space Technology [未来空间技术高峰论坛] along with the Chinese Society of Optical Engineering [中国光学工程学会], CAS Lanzhou Institute of Physics [兰州空间技术物理研究所], CASIC 8511 RI, Shanghai Institute of Aerospace Systems Engineering [上海宇航系统工程研究所], CAS Lanzhou Institute of Chemical Physics [中国科学院兰州化学物理研究所], Lanzhou University, DSTKL of Space Intelligent Control Technology [空间智能控制技术国防科技重点实验室], CAS Northwest Institute of Ecological Environment and Resource Research [西北生态环境资源研究院], and Xi'an Tianyuan Optoelectronics Technology Co. [西安天圆光电科技有限公司]. Committee members also came from the Chinese Academy of Military Sciences.[2273] [cxxvii]
- In 2018, the 510th RI and East China Normal University signed an agreement on behalf of their two labs, this lab and ECNU's State Key Laboratory of Precision Spectroscopy Science and Technology [精密光谱科学与技术国家重点实验室], to cooperate in talent development, scientific research, and lab construction.[2274]

*International*

- The former DSTKL of Surface Engineering Technology developed space optical thin films used in China and Brazil's Resource One series of satellites, including infrared bandpass filters and transmittance enhancement films for the infrared multi-spectral scanner.[2275]
- In 2011, representatives of this lab's immediate predecessor and the 510th RI met with a representative of the Canada Materials Comprehensive Testing Lab Co. [加拿大材料综合测试实验室公司] who spoke about his company's test equipment for outgassing and condensation kinetics of spacecraft materials [航天器材料出气及凝结动力学特性测试设备]. The Canadian company then apparently sold this equipment to the lab. The equipment was seen as an important part of the ongoing upgrades and expansion of this lab and the CASC 510th RI's Vacuum Branch [真空分部][2276]

[cxxvii] A detailed list of research topics and presentations/presenters is available.

**Lab Equipment:**

- As noted above, this lab purchased test equipment for outgassing and condensation kinetics of spacecraft materials from the Canada Materials Comprehensive Testing Lab Co.[2277]

**Address**:

Lanzhou, Gansu Province [甘肃省兰州市]

**Known Aliases:**

- 真空技术与物理国家级重点实验室
- 真空技术与物理国家重点实验室
- 真空技术与物理重点实验室
- Former names:
    - Defense S&T Key Laboratory of Surface Engineering Technology [表面工程技术国防科技重点实验室]
    - 表面工程技术重点实验室
    - Defense S&T Key Laboratory of Vacuum and Low Temperature Technology and Physics [真空低温技术与物理国防科技重点实验室]
    - 真空低温技术与物理重点实验室
    - 真空低温技术与物理国家重点实验室
    - 真空低温技术与物理国家级重点实验室

## 96. Defense S&T Key Laboratory of Vehicle Transmission

**Official English Name:** Unknown

**Chinese Name:** 车辆传动国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Ground

Equipment:

- Ground Vehicles

Functional Field:

- Vehicle Parts & Technology

**Affiliations:**

- Beijing Institute of Technology (BIT) [北京理工大学]
    - School of Mechanical Engineering [机械与车辆学院]
- China Ordnance Industries Group Corporation (Norinco) [中国兵器工业集团]
    - China North Vehicle Research Institute [中国北方车辆研究所]
        - *a.k.a. Norinco 201st Research Institute [201 研究所]*

**Key Data:**

- Established: 1992
- Total Funding: 20m RMB/year
- Personnel: 27[2278]
- Official start of operations: 1999
- Floor Space: 2,329-4,500 sqm

**Lab Overview:**

This lab conducts research into tank and other vehicle transmission systems. It is regarded as one of the top work units in the PRC for transmission design for fourth-generation tanks.[2279]

The lab's parent institution, the Norinco China North Vehicle Research Institute (a.k.a the Norinco 201st Research Institute), claims to be the PRC's only institution dedicated to the research and design of tanks and armored vehicles. It is also engaged in diverse areas such as high-speed rail, riot control vehicles, roadblock vehicles, and various civilian endeavors.[2280]

**Further Information:**

- This lab is sometimes referred as the "Defense S&T Key Lab of Tank Transmission" [坦克传动国防科技重点实验室]. This more military name can be found in multiple scattered sources. These two labs are confirmed to be one and the same, as lab Director Xiang Changle and others have been confirmed to be associated with both.[2281]
- The lab has several subordinate research labs, including:
    - Dynamic Design Research Laboratory [动态设计研究室]
    - Multi-stream Stepless Transmission Laboratory [多流无级传动研究室]
    - Automatic Operation Laboratory [自动操作研究室]
    - New transmission Research Laboratory [新型传动研究室]
    - Dynamic-Hydraulic Transmission Research Laboratory [动液传动研究室][2282]
- This lab also has a subordinate Multi-Stream Transmission Team [多流传动课题组] which has around 12 research personnel and around 40 PhD and Master's students. It is focused on five main areas:[cxxviii]
    1. Unmanned vehicle dynamics and overall design [无人车辆动力学与总体设计]
    2. Fluid drive and control [流体传动与控制]
    3. Electromechanical composite transmission theory and technology [机电复合传动理论与技术]
    4. Transmission system design and topology synthesis [传动系统方案设计与拓扑综合]
    5. Transmission system friction and lubrication [传动系统摩擦磨损与润滑][2283]
- This lab takes on an average of 28 projects each year. There is evidence this lab's resources have grown significantly. An older source from 2012 states it has an average of only 5 million RMB in funding and takes on 10-15 projects annually.[2284]

**Research Direction:**

1. Transmission system dynamic design theory [传动系统动态设计理论]
2. Multi-stream stepless transmission and steering [多流无级传动与转向]
3. Transmission system automatic operations and adaptive control [传动系统自动操纵与自适应控制]
4. Current change, viscous liquid transmission, and other new theories [电流变、粘液传动等新理论]
5. New dynamic liquid transmission and liquid machine joint braking [新型动液传动与液机联合制动][2285]

[cxxviii] More information is available on the Team's website (see below)

**Notable Applications:**

- This lab was involved in the design of parts of the Type-99A tank, including the integrated hydro-mechanical transmission with automatic gear shifting, steering wheel steering system, and joint braking. The 99A transmission designed by this lab is known as the CH-1000.[2286]
- This lab also designed the CH-400 tank transmission.[2287]
- This lab was involved in the design of the VT-4 and VT-5 export tanks.[2288]
- The Special Vehicle Research lab under this lab appears to have been involved in the development of several tanks and armored vehicles in the PLA's inventory, as evidenced by photos on their webpage. Another series of photos showing armored vehicles related to the research of the Special Vehicle Research Lab shows several types of armored vehicles this lab presumably had a hand in, including the ZBL-08 IFV.[2289]
- A video celebrating the 201st RI's 60th anniversary shows a variety of armored vehicles, including the Type 99 main battle tank and ZBD-04 IFV. A four wheeled armored vehicle and an unmanned vehicle with mounted machine gun are also shown. This lab would presumably be involved in aspects of these projects.[2290]
- One source states that BIT has been instrumental in the development of several armored vehicles, including the Type-15 light tank, PCL-181 vehicle-mounted howitzer, and the 3rd-generation Dongfeng Mengshi MRAP. Although a connection to these systems is not explicitly drawn, the source does specifically mention this lab, and it is probable that it was involved in some or all of these projects.[2291]

**Leadership and Key Personnel:**

- Director (BIT Branch): Xiang Changle [项昌乐][2292]
    - CAE Academician.

**Notable Collaborations:**

*Domestic*

- This lab manages the BIT New Energy Intelligent Vehicle Technology Innovation Center [新能源智能车辆技术创新中心] along with the MIIT Key Lab of Unmanned Vehicles [无人车技术工业和信息化部重点实验室] and the Future 3-D Infrastructure Research Academy [未来立体交通研究院].[2293]
- This lab (under its more military "Tank Transmission" name), jointly oversees the Special Vehicle Research Laboratory [特种车辆研究所实验室], along with the Shanxi Transmission Lab [西山传动实验室], the Oil Fluid Analysis Lab [油液分析实验室], the Armored Vehicle Engineering Practice and Teaching Center [装甲车辆工程实践教学中心], and the Modern Design and Analysis Center [现代设计分析中心]. This lab is focused

on armored vehicle engineering and on military vehicle transmission technology in particular. It has 29 researchers on staff. It has apparently (per photos on its website) been responsible for several current armored vehicles in the PLA inventory.[2294][cxxix]

*International*

- This lab co-sponsored the 2019 International Conference on Rotating Machinery Transmission and Control (RMTC2019) [2019 年旋转机械传动与控制国际会议]. The conference included American participants from University of Virginia and Texas Tech, and private companies BRG, Pratt & Whitney, Siemens, Mitsubishi, ANSYS, MSC Software, and Dassault. The article also states that BIT and the University of Virginia have a Joint Laboratory for Rotating Machinery [京理工大学-弗吉尼亚大学旋转机械联合实验室].[2295]
- International experts have allegedly come as guests to this lab, including U.S. researchers from Wayne State and University of Wisconsin.[2296][cxxx]
- The lab claims to have sent students to study in the U.S., Germany, and Russia.[2297]

**Lab Equipment:**

- The lab has 28 major pieces of equipment worth over 100,000 RMB each, with a total equipment value of approximately 23.22m RMB.[2298]

Equipment utilized by this lab that is imported from U.S. and other foreign sources includes:

- Virtual test system for vehicle electronic control (from U.S.)
- HP3565S data acquisition system (U.S.)
- HP715 workstation (U.S.)
- Oil spectrometer (U.S.)
- Dynamic simulation test bench (Germany)
- Current variable rotation viscometer (Germany)
- Modal analysis software 10 (Belgium)
- XR-5000 tape recorder and acceleration sensor (Japan)

Other equipment utilized by this lab includes:

- Current variable rotational viscometer
- Spectral oil analysis system
- Data acquisition and modal analysis system
- Constant speed and torque adaptive power system
- Power measurement control and torque and flow measurement systems
- Transmission test bench
- Comprehensive transmission test bench

[cxxix] Further data on this Lab is available upon request.
[cxxx] A more detailed list is available upon request.

- Computer-aided design means
- 50kW transmission test bench
- Hydraulic transmission test bench
- Automatic variable speed manipulation test bench
- Iron spectrum analyzer[2299]
- 1000kW electrically enclosed transmission test stand
- 60Mpa high-pressure hydraulic center station
- High-power vehicle transmission high and low temperature and vibration impact environment simulation test stand
- Electromechanical composite transmission test stand
- Vehicle dynamics simulation test stand
- Vehicle noise test stand
- Land and air platform test system
- Variety of intelligent unmanned platforms[2300]

**Address**:

No. 5 Zhongguancun S. Street, Haidian District, Beijing [北京市海淀区中关村南大街五号][2301]

**Website**:

https://web.archive.org/web/20121026082800/http://www.bit.edu.cn/kyxs1/zdsys/27325.htm

Multi-stream Transmission Team: http://www.bitmpft.com/

**Known Aliases:**

- Defense S&T Key Lab of Tank Transmission [坦克传动国防重点实验室]
- State Key Laboratory of Vehicular Transmission [车辆传动国家重点实验室]
- Key Laboratory of Vehicle Transmission [车辆传动重点实验室]
- National Key Laboratory of Vehicle Transmission
- Science and Technology on Vehicular Transmission Laboratory

## 97. Defense S&T Key Laboratory of Vessel Integrated Power Technology

**Official English Name:** National Key Laboratory for Vessel Integrated Power System Technology[2302]

**Chinese Name:** 舰船综合电力技术国防科技重点实验

**Post-2024 Name:** National Key Laboratory of Electromagnetic Energy [电磁能技术全国重点实验室][2303]

**Research Focus:**

Domain:

- Maritime

Equipment:

- Surface Vessels
- *Secondary: High-energy Weapons*

Functional Field:

- Electrical Power
- *Secondary: Propulsion*

**Affiliations:**

- PLA Naval Engineering University (NEU) [海军工程大学]
- China State Shipbuilding Corporation (CSSC) [中国船舶集团]
    - Wuhan Institute of Marine Electric Propulsion [武汉船用电力推进装置研究所][cxxxi]
        - *a.k.a. CSSC 712th Research Institute [712 研究所]*

**Key Data:**

- Established: 2007
- Total Funding: Unknown
- Personnel: 73 researchers[2304]
- Official start of operations: Unknown
- Floor Space: over 20,000 sqm

[cxxxi] This Institute was previously subordinate to CSIC, but has presumably been absorbed by CSSC following the 2019 merger.

**Lab Overview:**

This lab conducts research into vessel electrical generation for propulsion, high-energy weapons, high-power sensors, and day-to-day use. It is focused on integrated power generation, new forms of electrical power propulsion, and high-capacity electric power conversion technology. In addition to new propulsion systems, it is also pursuing development of electromagnetic launchers for large surface ships.[2305]

Integrated electrical power systems are considered a major element of 21st century naval power, with their ability to simplify power system architectures, optimize vessel design, more effectively utilize ship-based weapons systems, reduce vessel acoustic signatures, and improve vessel viability and integrated operations. At the time of this lab's founding in 2007, integrated power was considered a major bottleneck for PRC naval vessel development, and this lab was seen as filling a major area of need. This lab is especially focused on breaking the PRC's reliance on foreign imports and the foreign blockade on ship electrical power systems (oftentimes referred to as the ship's "heart" [心脏]). Since 2007, this lab has been a key player in establishing the PRC's international leading position in the field of integrated generator systems. It was the first to propose using medium voltage DC power systems, and the first to successfully develop medium voltage DC integrated power systems for ships, making China the first country in the world to fully master this second-generation of integrated power technology and allegedly putting it at a more advanced level than the United States.[2306]

Like many other Defense S&T Key Labs around the same period, this lab was apparently integrated into the civilian National Key Lab around 2023, and is now known as the National Key Lab of Electromagnetic Energy [电磁能技术全国重点实验室].

**Further Information:**

- The lab has a subordinate Systems Network Architecture and Intelligent Monitoring and Management Technology Research Lab [系统网络结构与智能化监控管理技术研究室] which studies grid architecture theory, systems operations, and energy dispatch of ship integrated power systems. It has worked on a grid architecture form of distributed medium-voltage DC transmission, DC regional substations, and distribution of naval integrated power systems, as well as new principles and methods of systems modeling and electromagnetic transient calculation, stability analysis and control, integrated and coordinated systems protection, network reconfiguration and self-healing, and intelligent energy management.[2307]
- This lab oversees an Integrated Power Innovation Team [电力集成创新团队].[2308]
- One article, about lab researcher Xiao Fei, states that foreign countries deliberately publish incorrect information to hurt the naval shipbuilding capabilities of other countries, forcing Xiao Fei to create his own calculations.[2309]

**Research Direction:**

1. High density integrated power generation technology [高功率密度集成化发电技术]
2. New electric power propulsion technology [新型电力推进技术]
3. High-capacity electric power conversion technology [大容量电能变换技术]
4. Systems network structures and intelligent monitoring and management technology [系统网络结构及智能化监控管理技术][2310]

*Sources also list an additional three main fields:*

1. Ship energy and power [舰船能源与动力]
2. Electromagnetic emissions [电磁发射]
3. New energy access [和新能源][2311]

*Other Notable Research Areas:*

- Electromagnetic compatibility[2312]

**Notable Applications:**

- In 2023, the lab allegedly made a major advance in the development of an electromagnetic railgun for naval artillery, successfully and accurately firing 120 times without damaging the gun barrel.[2313]
- This lab is a major source of research into naval electromagnetic launch applications, including electromagnetic catapults for aircraft carrier launch and electromagnetic energy weapons. This research is led by Ma Weiming and his "Integrated Electric Power Innovation Team" [电力集成创新团队]. NEU also added a new major for electromagnetic launch engineering beginning in 2017. The new Type 003 Carrier will allegedly include electromagnetic launch capabilities.[2314]
- The lab's development of medium voltage DC integrated power systems (also known as medium-voltage direct current full electric propulsion (FEP)) for naval vessels was awarded a 1st Class National S&T Progress Award in 2017. This technology may be included in the power systems for the new Type 076 Landing Helicopter Dock warships, the second batch of Type 055 Destroyers, the Type 003 Aircraft Carrier, and a new generation of frigates and destroyers, which will be able to carry electromagnetic rail guns, laser weapons, and integrated RF systems. According to PRC media, this technology represents the second generation of integrated power systems, whereas U.S. ships such as the Zumwalt-class Destroyers are still using the first generation, thus putting the PRC's technology 15 years ahead of the U.S.[2315]
- The DC area power distribution subsystem developed by Xiao Fei of this lab was used to power the Type 054A Frigate, as well as an unidentified new type of frigate.[2316]

- Ma Weiming was the first to develop a motor which could simultaneously send both AC and DC electricity, with superior density, reliability, and size. Ma followed this up with a high-speed induction rectifier generator power supply system with smaller volume and weight and larger power generation capacity, meeting large warships' need for more shipboard power. This design was then used on subsequent PRC submarines.[2317]
- This lab is a leading institution for research into electromagnetic railgun technology.[2318]
- This lab conducts research on island-based wind, solar, and multi-energy intelligent micro-grids, improving island power supply problems for military personnel stationed on small islands (presumably including in the South China Sea).[2319]
- This lab created a 2 MW permanent magnet direct-drive wind power converter which broke a foreign blockade on this technology.[2320]
- Ma Weiming developed a new immersion evaporative cooling technology which solves problems with efficient cooling during power integration. A double-winding structure and static excitation control technology solves problems of traditional induction generators, including low power factor and efficiency and inflexible voltage regulation. This also solved problems of electromagnetic incompatibility in many national defense projects.[2321]
- The 712th RI was involved in creating the PRC's first permanent magnetic-propulsion electric engine for the Kilo-Class submarine. This lab may have been involved in this project, as it has conducted related research, although it is not explicitly stated.[2322]
- In the 1990s (thus predating the lab), the PRC purchased a 12-phase rectifier generator system for its new submarines which had a problem with inherent oscillation. Ma Weiming solved this issue by developing a multi-phase synchronous motor stabilizer with rectifier load and inventing a multi-phase rectifier generator with stable winding which solved the problem. Foreign companies had to purchase the patent. Further, these companies gave Ma Weiming the design drawings of their motors, which were regarded as a core secret and had previously been tightly blocked by the foreign country.[2323]
- The lab utilizes military-civil fusion [军民融合] in patent and IP transfer to private enterprises. Its naval variable current device technology has been utilized in new energy access and intelligent micro-grids. It has also developed a direct-drive wind power inverter, breaking a foreign monopoly and forcing companies to reduce their prices by 60 percent%. This lab is also the first new-energy development center in the PLA. A multi-energy intelligent power station [多能源智能电站] was built in the South China Sea based on its IP.[2324]

**Leadership and Key Personnel:**

- Director/Founder: Ma Weiming [马伟明][2325]
    - Corps Leader Grade Rear Admiral
    - NPC Representative
    - Youngest ever CAE Academician

*Key Personnel*

- Fu Lijun [付立军][2326]
  - Director of subordinate Systems Network Architecture and Intelligent Monitoring and Management Technology Research Lab
- Xiao Fei [肖飞][2327]
  - PLAN Regiment Deputy Leader Grade Captain (possibly promoted to Senior Captain by 2017)
  - Based on fawning media coverage, Xiao appears to be the heir apparent to Ma Weiming's intellectual throne in this field in China
  - Conducts research into submarine electrical power short-circuits

**Notable Collaborations:**

*Domestic*

- This lab has a military-civil fusion [军民融合] agreement with Hunan Province to build a joint technology innovation center for MCF equipment.[2328]
- This lab is associated with the Institute of Power Electronics Technology [电力电子技术研究所] at NEU. Ma Weiming also serves as Director of this Institute.[2329]
- This lab (or specifically Ma Weiming) has cooperated with CEP Hwaray [中电华瑞] on various unnamed projects related to naval electronics. CEP Hwaray supplies marine electronics to both military and civilian customers, including semiconductors, multi-functional display consoles, vibration isolators, and radar parts. Shenzhen Prince New Materials [王子新材] owns a majority stake in this company.[2330]

*International*

- Personnel of the 712th RI visited U.S. university UC Merced in 2015 to discuss possible cooperation.[2331]

**Lab Equipment:**

- The lab has nine test platforms and two simulation centers, 700m RMB in fixed assets, and over 700 pieces of equipment.[2332]

**Address**:

Based on photos, appears to be co-located with NEU at No. 717 Jiefang Avenue, Qiaokou District, Wuhan, Hubei Province [湖北省武汉硚口区解放大道 717 号]

**Known Aliases:**

- National Key Laboratory of Science and Technology on Vessel Integrated Power System [舰船综合电力技术国家重点实验室]
- National Key Laboratory of Science and Technology on Vessel Integrated Power System Technology
- National Key Laboratory of Vessel Integrated Power System Technology
- National Key Laboratory for Vessel Integrated Power System Technology
- 电磁能技术全国重点实验室

## 98. Defense S&T Key Laboratory of Weapons and Equipment Systems Research

**Official English Name:** National Key Laboratory for Complex Systems Simulation[2333]

**Chinese Name:** 武器装备体系研究国防科技重点实验室

**Post-2024 Name:** No evidence of name change as of January 2025

**Research Focus:**

Domain:

- Multi-Domain (Air, Ground, Maritime)

Equipment:

- Command & Control Systems
- *Secondary: Aircraft, Ballistic Missiles, Equipment/Acquisitions Strategy, Surface Vessels*

Functional Field:

- Simulation & Modeling
- *Secondary: Intelligent Technologies, Logistics & Maintenance*

**Affiliations:**

- PLA Academy of Military Sciences [中国人民解放军军事科学研究院]
    - Institute of Systems Engineering [系统工程研究院]

**Key Data:**

- Established: Unknown
- Total Funding: Unknown
- Personnel: Unknown
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab is concerned with a wide range of research in all domains on behalf of the PLA Academy of Military Sciences. Diverse research areas include ballistic missile simulations,[2334] joint testing of weapons and equipment,[2335] simulation of joint air and ballistic missile strikes to suppress enemy airfields,[2336] management of naval equipment,[2337] and algorithms for efficient equipment repair during wartime.[2338] Use of intelligent technologies to better manage complex systems and joint operations also appears to be a major point of interest. If there is a common

theme running through the lab's research, it is on coordinating overall effective management or C2 of complex military systems, including joint operations, logistics, and equipment acquisition. In this way, the lab appears to play a key role conducting research toward the PLA's concept of systems engineering and coordinated "overall design" of complex systems.[cxxxii]

The lab's "Weapons and Equipment Research" name is rarely used, and it is unclear if it is still in use at all. Today, the lab is much more commonly referred to as the National Key Laboratory for Complex Systems Simulation. These two are evidently the same lab, as personnel overlap is high (including one researcher who used both lab names when publishing the same study in multiple places).[2339] Further, the name change from one emphasizing weapons research to one emphasizing complex systems simulation is in line with recent name changes to the service-level labs performing the same function (e.g., the Defense S&T Key Lab of Army Weapons and Equipment Systems Research has changed its name to the Defense S&T Key Lab of Ground Complex Systems Simulation; the equivalent PLAN and PLAAF labs have also made this change).

This lab is subordinate to the PLA Academy of Military Science (PLAAMS) Institute of Systems Engineering, also known as the Beijing Institute of Systems Engineering [北京系统工程研究所]. Prior to the 2016 PLA reforms, this lab was subordinate to the General Armaments Department Weapons and Equipment Demonstration and Research Center [总装备部武器装备论证研究中心].[2340]

**Research Direction:**

No formal research direction found

*Other Notable Research Areas:*

- Joint testing of weapons and other equipment[2341]
- Simulation of joint airstrike and ballistic missile strike on enemy airfields[2342]
- Efficient management of naval equipment[2343]
- Algorithms for efficient equipment repair in wartime[2344]
- Ballistic missile simulations[2345]

**Notable Applications:**

None found

[cxxxii] For more on this subject, see Alex Stone, "A Complex Systems Engineering Undertaking: The Qian Xuesen School of Systems Engineering," China Aerospace Studies Institute, 2024.

**Leadership and Key Personnel:**

- Deputy Director: Xiao Gang [肖刚][2346]

*Key Personnel:*

- Chen Yingwu [陈英武][2347]
    - NUDT Professor
    - Member of lab academic committee

**Notable Collaborations:**

*Domestic*

- In 2019, this lab co-hosted the China Aerospace Congress Professional Forum on Flight Vehicle Mission Planning Technology under New Circumstances [2019年中国航天大会新形势下飞行器任务规划技术专业论坛], alongside the Chinese Society of Astronautics Vehicle Mission Planning Committee [中国宇航学会飞行器任务规划专业委员会], the Planning and Decision-Making Committee of the China Command and Control Society [中国指挥与控制学会筹划与决策专业委员会], and the 3rd Overall Design Department of CASIC [中国航天科工集团第三总体设计部]. It was attended by military personnel, including from the PLARF, as well as personnel of CASC, CASIC, AVIC, CSSC, Norinco, and CETC, and focused on intelligent mission planning technology and applications.[2348]
- In 2022, this lab co-hosted the National Intelligent Joint Maritime Operations Algorithmic Competition [全国智能联合海上作战算法赛] along with the China Command and Control Society [中国指挥与控制学会]. The competition was intended to promote research on AI in maritime joint operations, develop new national defense research talent, and spur development of military AI.[2349][cxxxiii] This lab also solicited papers on the same topic in 2022, indicating a particular interest in this subject. Winning paper topics included rejecting long-range forces in the South China Sea, manned and unmanned surface vessel cooperation, and using intelligent drone swarms for far-seas submarine hunting operations.[2350][cxxxiv] A further competition was held in April 2023. The winning team came from North University of China. Other participants came from the National University of Defense Technology, Southeast University, North Central University, Beihang University, Nanjing University, Nankai University, Dalian University of Technology, the CAS Institute of Automation, and the Hefei Xunfei Company [合肥讯飞公司]. One winning topic was titled "Conceptualization of Maritime and Landing Operations under Typical Combat Scenarios" [典型作战运用场景下的海上及登陆作战概念想定]. The theme of the competition was "Intelligent defense guards the maritime border, military intelligence empowers future operations" [智汇国防守护深蓝海疆，军事智能赋能未来作战].[2351]

[cxxxiii] A list of winners is available.
[cxxxiv] A complete list of winning essay titles is available.

Sources further state that speeches were given on the topics of U.S. military operational and combat concept innovations, joint combat intelligent algorithms, and the future of air, space, sea, and electromagnetic joint operations.[2352]

**Lab Equipment:**

None found

**Address**:

No. 2 Courtyard Fengti S. Road, Fengtai District, Beijing 100166 [北京市丰台区丰体南路 2 号院][2353]

**Known Aliases:**

- Key Laboratory of National Defense Science and Technology for Weaponry System Research
- 复杂系统仿真总体国家级重点实验室
- 复杂系统仿真总体重点实验室
- 复杂系统仿真总体实验室

## Known Former Defense S&T Key Laboratories

Beside the labs profiled above, the author has found three other labs which are no longer classified as Defense S&T Key Labs. Two of these labs were either downgraded or reorganized around 2006, having failed a COSTIND inspection. The third may have also been culled in this way, although no information was found to confirm this. They are presented below for informational purposes. Other than founding date, these three labs are not included in the statistics found in Part One of this report.

## Defense S&T Key Laboratory of Flexible Manufacturing Systems Technology

**Official English Name:** Unknown

**Chinese Name:** 柔性制造系统技术国防科技重点实验室

**Research Focus:**

Domain:

- Unknown

Manufacturing:

- Unknown

Functional Field:

- Manufacturing

**Affiliations:**

- China Ordnance Industries Group Corporation (Norinco) [中国兵器工业集团]
    - Changchun Equipment & Technology Institute [长春设备工艺研究所]
        - *a.k.a. Norinco 55th Research Institute [55 研究所]*

**Key Data:**

- Established: Unknown, early 1990s
- Total Funding: Unknown
- Personnel: Unknown[2354]
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab may no longer exist. A source from around 2006 states that this lab was one of three which failed to pass a regular evaluation and had its credentials revoked by COSTIND, and the last academic papers attributed to this lab appeared soon after in 2007. Since then, there is no indication of this lab's fate or current status. The lab's parent institution, the Norinco Changchun Equipment & Technology Institute (a.k.a. Norinco 55th Research Institute) does today have a Digital Manufacturing Technology Research Office [数字化制造技术研究室] whose available research is similar to this lab's, indicating this could be the successor to the lab.[2355]

The Changchun Equipment & Technology Institute (a.k.a. the Norinco 55th Research Institute) is mainly engaged in research of advanced manufacturing technology, providing capabilities in the areas of digital and intelligent manufacturing, safety automation engineering, metal spinning and forming, precision and ultra-precision processing, automation and experimental testing, and non-standard equipment and production lines. It has cooperated extensively with the weaponry, aerospace, aviation, ship, and civilian transport industries.[2356]

**Further Information:**

- The lab had a Nanjing branch [南京分部] in the early 1990s.[2357]

**Research Direction:**

- No formal research direction was found. A survey of studies produced by this lab between 1999 and 2007 included a range of topics, including the internet and networked databases, CAD/CAM, human-machine collaboration, and advanced manufacturing.

**Notable Applications:**

None found

**Leadership and Key Personnel:**

None found

**Notable Collaborations:**

None found

**Lab Equipment:**

- The Lab has/had a CH-85FMS (flexible manufacturing) main experiment system [主实验系统(CH-85FMS)].[2358]

**Address**:

None found, possibly co-located with the 55th RI at No. 738 Huguang Road, Chaoyang District, Changchun, Jilin Province [长春市朝阳区湖光路 738 号][2359]

**Known Aliases:**

None found

## Defense S&T Key Laboratory of Pulsed Power Technology

**Official English Name:** Unknown

**Chinese Name:** 脉冲功率技术国防科技重点实验室

**Research Focus:**

Domain:

- Multi-domain (Nuclear, likely others)

Equipment:

- Multiple (Nuclear Weaponry & Power, Semiconductors, likely others)

Functional Field:

- Multiple
- *Secondary: Electromagnetics, Laser Technologies, Plasma Technologies,*

**Affiliations:**

- Huazhong University of Science and Technology (HUST) [华中科技大学]
    - School of Electrical and Electronic Engineering (SEEE) Department of High Voltage Engineering [华中科技大学电气与电子工程学院高电压工程系]

**Key Data:**

- Established: 1999
- Total Funding: Unknown
- Personnel: Unknown[2360]
- Official start of operations: Unknown
- Floor Space: Unknown

**Lab Overview:**

This lab conducts research into high-powered energy in support of projects involving laser technologies, electromagnetics (including electromagnetic launch and railgun technologies), and advanced energy.

Today, it is identified as a Provincial-level Ministry of Education Key Lab, or Ministry of Education National Defense Key Lab, indicating it was downgraded in status at some point. It may have been one of the three labs which failed a 2006 COSTIND inspection. [2361]

**Further Information:**

- SEEE also has two other research organizations that deal with similar fields—the Wuhan National High Magnetic Field Center (WHMFC) [国家脉冲强磁场中心] (which has a pulsed power field facility) and the State Key Laboratory of Advanced Electromagnetic Engineering and Technology [强电磁工程与新技术国家重点实验室].
- There are two similarly named labs: one at the National University of Defense Technology called the State Key Laboratory of Pulsed Power Laser Technology [脉冲功率激光技术国家重点实验室], which is sometimes be referred to (possibly incorrectly) as the State Key Laboratory of Pulsed Power Technology [脉冲功率技术国家重点实验室], and one at CAEP called the Key Laboratory of Pulsed Power [脉冲功率科学与技术重点实验室].

**Research Direction:**

1. High-energy storage density pulse forming network technology [高储能密度脉冲成形网络技术]
    - Energy storage devices [储能器件]
    - Network structure electrical, magnetic, and thermal stress simulation analysis and optimization [网络结构的电、磁、热应力仿真分析和优化]
    - High-precision charging and intelligent control and testing technology [高精度充电和智能化控制、测试技术]
2. High-current switching technology [大电流开关技术]
    - Nanosecond-level high-repetition frequency field distortion switches [纳秒级高重复频率场畸变开关]
    - Gas gap switches [气体间隙开关]
    - Triggered vacuum switches [触发真空开关]
    - Semiconductor switches and switch trigger control technology [半导体开关和开关的触发控制技术等]
3. Gas discharge laws and special discharge technology [气体放电规律及特种放电技术]
    - The influence of discharge products on discharge, the influence of ion background on the discharge path, and the laws of multi-phase body discharge [放电生成物对放电的影响、离子背景对放电路径的影响、多相体放电规律]
    - Pulse discharge, glow discharge, and dielectric barrier discharge and other special discharge technologies and applications [脉冲放电、辉光放电及介质阻挡放电等特种放电技术及应用]
4. Discharge plasma environmental pollution control [放电等离子体环境污染治理]
    - Pulse discharge plasma catalytic reduction, desulfurization, and denitrification [脉冲放电等离子体催化还原脱硫脱硝]
    - Wastewater and waste gas treatment [废水废气处理]

- Other environmental pollution controls and treatment technologies [环境污染控制与治理技术]
- Discharge plasma medical applications [放电等离子体医疗应用][2362]

**Notable Applications:**

None found

**Leadership and Key Personnel:**

- Academic Committee Director: Pan Yuan [潘垣][2363]

**Notable Collaborations:**

*Domestic*

- Most of the lab's publicly available research has been with the State Key Laboratory of Advanced Electromagnetic Engineering and Technology (AEET) [强电磁工程与新技术国家重点实验室], which is part of the same School at HUST, has a tokamak nuclear fusion reactor [托卡马克实验装置], and does some national defense work. The two labs worked together for a study on electromagnetic railguns.[2364]
- The lab has worked with the CAEP on electrodes.[2365]

**Lab Equipment:**

None found

**Address**:

Possibly co-located with SEEE at HUST Electrical Building Block A, No. 1037 Luoyu Road, Hongshan District, Wuhan, Hubei Province [湖北省武汉市洪山区珞瑜路 1037 号华中科技大学电气大楼 A 座][2366]

**Website**:

http://ceee.hust.edu.cn/info/1068/1866.htm

**Known Aliases:**

- Pulsed Power Technology Research and Development Center [脉冲功率技术研究与发展中心]
- Pulsed Power Center [脉冲功率中心]

## Defense S&T Key Laboratory of Ultra-Precision Machining Technology

**Official English Name:** Aviation Key Laboratory of Science and Technology on Precision Manufacturing[2367]

**Chinese Name:** 超精密加工技术国防科技重点实验室

**Research Focus:**

Domain:

- Air

Equipment:

- Aircraft
- *Secondary: Helicopters, Unmanned Systems*

Functional Field:

- Manufacturing
- *Secondary: GNC, Intelligent Technologies, Measurement Technologies, Propulsion, Semiconductors*

**Affiliations:**

- Aviation Industry Corporation of China (AVIC) [中国航空工业集团]
  - Beijing Precision Engineering Institute for Aircraft Industry (BPEI) [北京航空精密机械研究所]
    - *a.k.a. AVIC 303rd Research Institute [303 研究所]*
    - *a.k.a. AVIC Precision Institute [中航工业精密所]*

**Key Data:**

- Established: 1992
- Total Funding: Unknown
- Personnel: over 30[2368]
- Official start of operations: 1995
- Floor Space: 4,650 sqm

**Lab Overview:**

The Defense S&T Key Laboratory of Ultra-precision Machining Technology may no longer be a Defense S&T Key Lab, as it was apparently downgraded around 2006 when it failed a regular evaluation and had its credentials revoked by COSTIND. It has not published new research since 2006. Soon after, a new lab with a similar name, mission, and personnel, the Aviation Key

Laboratory of Science and Technology on Precision Manufacturing [精密制造技术航空科技重点实验室], appears to have taken its place.[2369]

The original lab conducted research into ultra-precision processing technology, targeting key aerospace parts like aspherical components. It was also able to process components related to inertial navigation and semiconductors. The new lab conducts similar research into ultra-precision, anti-fatigue, and intelligent manufacturing, geared toward the needs of the military aviation industry.[2370]

The lab's parent institution, the AVIC Beijing Precision Engineering Institute for Aircraft Industry (BPEI) (a.k.a. the AVIC 303rd Research Institute or AVIC Precision Institute, and formerly the China Precision Engineering Institute for Aircraft Industry (CPEI) [中国航空精密机械研究所] or AVIC-I Precision Institute [一航精密所]), researches aviation precision/ultra-precision manufacturing, measurement, and testing technology. It produces military and civilian inertial navigation and motion test/simulation equipment, ultra-precision processing equipment, special equipment for mechatronics, aero-engine test equipment, and special parts for flight control systems, airborne detection systems, airborne surveillance/reconnaissance systems, aviation hydraulic systems, and aero-engines.[2371]

**Further Information:**

- There are several other labs with similar names: Hunan Province Key Laboratory of Ultra-Precision Machining Technology [超精密加工技术湖南省重点实验室/湖南省超精密加工技术重点实验室], which is affiliated with NUDT, the State Key Laboratory of Ultra-precision Machining Technology [香港理工大学超精密加工技术国家重点实验室] at the Hong Kong Polytechnic University, and the Ultra-precision Machining Technology Key Laboratory at CAEP [中国工程物理研究院超精密加工技术重点实验室].

**Research Direction:**

2. Precision manufacturing technology theory, methods, and mechanisms [精密制造技术理论、方法及机理]
3. Precision measurement, testing, and control technology [精密测量、测试及控制技术]
4. Aeronautical micro-mechanical and micro-optical component manufacturing technology [航空微机械、微光学元件制造技术]
5. Aviation precision manufacturing, measurement, and testing equipment technology [航空精密制造及测量、测试装备技术]
6. Technologies for manufacturing of typical precision parts for aviation products [航空产品典型精密零件制造的适用(技术)][2372]

**Notable Applications:**

- The lab has also made achievements in precision and ultra-precision basic components and integration technology, precision inspection technology for key components of aero-engines, and anti-fatigue manufacturing technology. This includes for air and liquid hydrostatic spindles and guide rails, flight control systems, UAVs, and aero-engines.[2373]
- The lab may have developed its own version of a Nanosys-1000 ultra-precision machining tool, with a processing diameter of Φ1000mm.[2374]

**Leadership and Key Personnel:**

- Deputy Director: Yang Hui [杨辉][2375]

**Notable Collaborations:**

*Domestic*

- This lab carried out a 2017 study, "Modeling and Simulation of Helicopter Cable Position System" [直升机缆位系统建模与仿真], with the Naval Delegate Group of Equipment for the Missile (*sic*) [海军驻北京地区导弹配套设备军事代表室].[2376]
- This lab carried out a 2019 study, "Experimental Research on the Focus Evaluation Function of Air Film Hole Image" [气膜孔图像对焦评价函数的实验研究], with the AECC South Industry Company Limited [中国航发南方工业有限公司].[2377]

**Lab Equipment:**

- The lab has numerous pieces of equipment from U.S. company Nanosys, including a Nanosys-300 aspheric surface ultra-precision composite/compound machining system/tool and Nanosys-1000 LODTM CNC Optical Processing Machine.[2378]

This lab has developed at least 11 pieces of ultra-precision machining equipment, 9 of which are used in the lab. Some of this technology was developed indigenously by the lab in the face of "foreign technological blockades." Ultra-precision processing equipment used in the lab has included:

- Ultra-precision lathes
- Ultra-precision boring machines
- Diamond tool grinding machines
- Ultra-precision surface grinder
- Ultra-precision cylindrical grinder
- Precision end gear disc grinding machine
- High-precision coordinate measuring machines

- Aspherical ultra-precision machining system
- Coupling ultra-precision machining system
- Form and position tolerance measuring instrument
- Roughness measuring instrument
- Laser interferometry system[2379]
- The new lab (as of around 2013) has 1,080 square meters of experimental space with constant temperature and humidity, which are 100- and 1,000-class [100 级和 10000 级]. It also has a 2,000 sqm temperature-controlled CNC workshop.[2380]

**Address**:

None found, possibly co-located with its parent institution at No. 5 Nanyuan East Road, Fengtai District, Beijing [北京市丰台区南苑东路 5 号][2381]

**Website**:

https://web.archive.org/web/20130821012445/http:/www.bj303.com/1s/1s_index.html

**Known Aliases:**

- National Ultra-Precision Machining Defense S&T Key Laboratory [国家级超精密加工技术国防科技重点实验室]
- National Ultra-Precision Machining Laboratory [国家级超精密加工技术实验室] (national-level lab)
- Aviation Key Laboratory of Science and Technology on Precision Manufacturing [精密制造技术航空科技重点实验室]
- Key Laboratory of Ultra-precision Machining for Defense Science & Technology

## Endnotes

[1] "Defense S&T Key Lab Management Methods" [国防科技重点实验室管理办法], *People's Government of Hunan Province* [湖南省人民政府], 30 July 2020, http://www.hunan.gov.cn/xxgk/wjk/zcfgk/202007/t20200730_49e591fb-4a99-45ad-be15-975ab78951b2.html
[2] "Defense S&T Key Lab Management Methods" [国防科技重点实验室管理办法], *People's Government of Hunan Province* [湖南省人民政府], 30 July 2020, http://www.hunan.gov.cn/xxgk/wjk/zcfgk/202007/t20200730_49e591fb-4a99-45ad-be15-975ab78951b2.html
[3] "Multiple sea-related! The list of key laboratories approved for construction in Qingdao in 2022 is announced!" [多个涉海！2022 年度批准建设青岛市重点实验室名单公布！], *Sohu*, 11 November 2022, https://www.sohu.com/a/604851024_726570
[4] Alex Stone and Ma Xiu, "The PRC State & Defense Laboratory System: An Overview," *China Aerospace Studies Institute*, April 2022, https://www.airuniversity.af.edu/Portals/10/CASI/documents/Research/Infrastructure/2022-04-11%20PRC%20State%20and%20Defense%20Labs.pdf
[5] Li Zhongjie [李忠杰], "Journey of the People's Republic" [共和国之路], *Central Party School Press*, 2019, 156-158.
[6] "Fujian Decision-making Information Reference" [福建决策信息参考], *Fujian Province Culture and Tourism Office*, 2019, 238(10), https://www.fjlib.net/zt/fjstsgjcxx/zbzl/jcckxx/2019/2019nd10q/201910/P020191012394992033155.pdf
[7] Alex Joske, "The China Defence Universities Tracker," *Australian Strategic Policy Institute*, 2019, https://s3-ap-southeast-2.amazonaws.com/ad-aspi/2019-11/The%20China%20Defence%20Universities%20Tracker_0.pdf
[8] Wang Qin [王秦] et al., "Military scientific researchers welcome the 19th National Congress of the Communist Party of China" [军队科研工作者迎十九大：科研攻关忙强军脚步急], *ScienceNet* [科学网], 19 October 2017. https://news.sciencenet.cn/htmlnews/2017/10/391513.shtm
[9] "National University of Defense Technology 2021 Recruitment" [国防科技大学 2021 年招聘], *China Education Online* [中国教育在线旗下网站], Accessed May 2021. https://zpjob.acabridge.cn/frontend/frm/?id=lm5wjWJs
[10] "CETC Group: Fulfilling the Sacred Mission of Military Centralized Enterprises with Innovation-Driven Strategy" [中国电科集团：以创新驱动战略履行军工央企神圣使命], *SASTIND*, 1 July 2016, https://www.sastind.gov.cn/n10086200/n10086344/c10205161/content.html
[11] "From college students to scientific and technological innovation talents, how China's first-class aerospace talents are mass-produced" [从大学生到科技创新人才 中国航天一流人才怎么批量生产], *Science Net*, 7 June 2011, https://news.sciencenet.cn/htmlnews/2011/6/248059-2.shtm
[12] "Defense S&T Key Lab Management Methods" [国防科技重点实验室管理办法], *People's Government of Hunan Province* [湖南省人民政府], 30 July 2020, http://www.hunan.gov.cn/xxgk/wjk/zcfgk/202007/t20200730_49e591fb-4a99-45ad-be15-975ab78951b2.html
[13] "Defense S&T Key Lab Management Methods" [国防科技重点实验室管理办法], *People's Government of Hunan Province* [湖南省人民政府], 30 July 2020, http://www.hunan.gov.cn/xxgk/wjk/zcfgk/202007/t20200730_49e591fb-4a99-45ad-be15-975ab78951b2.html
[14] "Defense S&T Key Lab Management Methods" [国防科技重点实验室管理办法], *People's Government of Hunan Province* [湖南省人民政府], 30 July 2020, http://www.hunan.gov.cn/xxgk/wjk/zcfgk/202007/t20200730_49e591fb-4a99-45ad-be15-975ab78951b2.html
[15] "One word, one change: more than 150 national key laboratories reorganized and renamed within a year" [一字之差，一场变革：一年内超 150 个国家重点实验室重组更名], *SouthCN.com,* 12 July 2023, https://news.southcn.com/node_64549305f1/34cb753b9d.shtml
[16] "Defense S&T Key Lab Establishment and Ratification" [国防科技重点实验室设立审批], *SASTIND*, 18 July 2022, https://www.sastind.gov.cn/history/n6195634/n6195706/n6195716/n6427883/n6428119/c6429368/content.html
[17] "Defense S&T Key Lab Management Methods" [国防科技重点实验室管理办法], *People's Government of Hunan Province* [湖南省人民政府], 30 July 2020, http://www.hunan.gov.cn/xxgk/wjk/zcfgk/202007/t20200730_49e591fb-4a99-45ad-be15-975ab78951b2.html

[18] "Academic Committee Meeting of the Key Laboratory of Liquid Rocket Motor Technology" [三院士莅临 | 液体火箭发动机技术重点实验室召开学术委员会会议], *Sohu*, 3 March 2023, https://www.sohu.com/a/649299463_121117464

[19] "Hunan Province Department of Industry and Information Technology on the issuance of the "Hunan Provincial Defense Science and Technology Key Laboratory Management Measures" notice" [湖南省工业和信息化厅关于印发《湖南省国防科技重点实验室管理办法》的通知], *Hunan Province Department of Industry and Information Technology* [湖南省工业和信息化厅], 3 February 2018, http://fgcx.bjcourt.gov.cn:4601/law?fn=lar1550s108.txt

[20] "From State Key Lab to National Key Lab, what does it mean!" [国家重点实验室到全国重点实验室意味着什么！] , *Sohu*, 21 April 2024, https://www.sohu.com/a/773342872_823256

[21] "Clarifying the Historical and Practical Logic of National Key Laboratory Construction" [厘清全国重点实验室建设的历史与实践逻辑], *China Education Online* [中国教育新闻网], 9 October 2023, http://www.jyb.cn/rmtzgjyb/202310/t20231009_2111100518.html

[22] "From State Key Lab to National Key Lab, what does it mean!" [国家重点实验室到全国重点实验室意味着什么！] , *Sohu*, 21 April 2024, https://www.sohu.com/a/773342872_823256

[23] "From State Key Lab to National Key Lab, what does it mean!" [国家重点实验室到全国重点实验室意味着什么！] , *Sohu*, 21 April 2024, https://www.sohu.com/a/773342872_823256

[24] Alex Stone, "China's Model of Science: Rationale, Players, Issues," *China Aerospace Studies Institute*, 2022, https://www.airuniversity.af.edu/Portals/10/CASI/documents/Research/Infrastructure/2022-02-07%20Model%20of%20Science.pdf

[25] "Naval Engineering University Team: Dynamic Load Capacity Analysis of Magnetic Bearing System Considering Partial Channel Failure" [海军工程大学团队：考虑部分通道故障的磁轴承系统动态承载力分析], *Sohu*, 24 August 2023, https://www.sohu.com/a/714417055_321349

[26] ""If you lead, you lead the U.S.", China's electromagnetic gun breaks through again with 120 high-speed, high-precision shots" ["领先就领先美国"，中国电磁炮再次突破，高速高精度射击 120 次], *Sohu*, 13 December 2023, https://www.sohu.com/a/743664529_120582872

[27] "Meng Fanwei" [孟范伟], *Northeast University*, 4 March 2024, http://graduate.neuq.edu.cn/info/1136/2926.htm

[28] "A Laboratory of CALT Won the First Place in the Evaluation of State-level Key Laboratories of Group Companies" [火箭院一实验室在集团公司国家级重点实验室考评中荣获第一名], *China Academy of Launch Vehicle Technology*, 1 June 2023, http://www.calt.com/n481/n497/n853/c27594/content.html

[29] "Conference Structure" [会议机构], *2024 International Conference on Guidance, Navigation and Control*, Accessed January 2025, https://web.archive.org/web/20241102143316/https://icgnc.buaa.edu.cn/Organizations.htm "2023 7th Chinese Conference on Swarm Intelligence and Cooperative Control" [全国集群智能与协同控制大会], *CCICC*, Accessed January 2025, http://ccsicc.c2.org.cn/

[30] Matthew Bruzzese, "PRC Transfer of Military and Dual-Use Technology: the Case of the International Conference on Defence Technology," *China Brief*, 24(12), 7 June 2024, https://jamestown.org/program/prc-transfer-of-military-and-dual-use-technology-the-case-of-the-international-conference-on-defense-technology/

[31] "Key Laboratory of Advanced Composite Materials for National Defense Science and Technology" [先进复合材料国防科技重点实验室], *Aerospace Special Literature Resource Library* [航天特色文献资源库], Accessed 2021, http://www.jiuyelib.com:33390/Journal/Detail?articleId=10749
"The research of these 3 key laboratories of national defense science and technology is inseparable from ceramic materials" [这 3 家国防科技重点实验室的研究，与陶瓷材料密不可分], *CN Powder* [中国粉体网], 23 March 2020. https://news.cnpowder.com.cn/54522.html

[32] "The research of these 3 key laboratories of national defense science and technology is inseparable from ceramic materials" [这 3 家国防科技重点实验室的研究，与陶瓷材料密不可分], *CN Powder* [中国粉体网], 23 March 2020. https://news.cnpowder.com.cn/54522.html
Chen Xiangbao [陈祥宝], Bao Jianwen [包建文] et al., "Research and Development Progress of National Key Laboratory of Advanced Composites on Advanced Aeronautical Resin Matrix Composites" [先进复合材料国防科技重点实验室的航空树脂基复合材料研发进展], *Journal of Aeronautical Materials* [航空材料学报] (36) 2016. http://jam.biam.ac.cn/article/app/id/72508300-9e18-4b99-823d-b12299785513

[33] "The research of these 3 key laboratories of national defense science and technology is inseparable from ceramic materials" [这 3 家国防科技重点实验室的研究，与陶瓷材料密不可分], *CN Powder* [中国粉体网], 23 March 2020. https://news.cnpowder.com.cn/54522.html

[34] "Long-air Sword Casting Material Competition" [长空铸剑 材料争先], *Technology Innovation and Brand* [科技创新与品牌], 1 March 2011. http://www.kjcxpp.com/html/qkgl/113jskj_2618_4509.html
"Beijing Institute of Aerospace Materials (621 Institute)" [中国航发北京航空材料研究院(621 所)], *Zhonghua-PE* [私募股权投资网], 4 March 2020. http://www.zhonghua-pe.com/2020/0304/234495.html

[35] "PART 744—CONTROL POLICY: END-USER AND END-USE BASED," *e-CFR*, 23 December 2020. https://www.ecfr.gov/cgi-bin/text-idx?node=pt15.2.744&rgn=div5

[36] Yi Xiaosu [益小苏], "Advanced Composite Materials Technology R&D" [先进复合材料技术研究与发展], National Defense Industry Press [国防工业出版社], 2006. https://book.douban.com/subject/1825103/
Xiao-su Yi et al., "Composite Materials Engineering, Volume 2: Different Types of Composite Materials (Paperback)," *Chemical Industry Press*, 2018. https://www.nowherebookshop.com/book/9789811354632

[37] "Composite Material Specialists" [复合材料专业], *AECC BIAM*, Accessed 2021, http://www.biam.ac.cn/tabid/174/InfoID/1423/frtid/77/Default.aspx

[38] "The research of these 3 key laboratories of national defense science and technology is inseparable from ceramic materials" [这 3 家国防科技重点实验室的研究，与陶瓷材料密不可分], *CN Powder* [中国粉体网], 23 March 2020. https://news.cnpowder.com.cn/54522.html

[39] "The research of these 3 key laboratories of national defense science and technology is inseparable from ceramic materials" [这 3 家国防科技重点实验室的研究，与陶瓷材料密不可分], *CN Powder* [中国粉体网], 23 March 2020. https://news.cnpowder.com.cn/54522.html
"Composite Material Specialists" [复合材料专业], *AECC BIAM*, Accessed 2021, http://www.biam.ac.cn/tabid/174/InfoID/1423/frtid/77/Default.aspx

[40] Chen Xiangbao [陈祥宝], Bao Jianwen [包建文] et al., "Research and Development Progress of National Key Laboratory of Advanced Composites on Advanced Aeronautical Resin Matrix Composites" [先进复合材料国防科技重点实验室的航空树脂基复合材料研发进展], *Journal of Aeronautical Materials* [航空材料学报] (36) 2016. http://jam.biam.ac.cn/article/app/id/72508300-9e18-4b99-823d-b12299785513

[41] Chen Xiangbao [陈祥宝], Bao Jianwen [包建文] et al., "Research and Development Progress of National Key Laboratory of Advanced Composites on Advanced Aeronautical Resin Matrix Composites" [先进复合材料国防科技重点实验室的航空树脂基复合材料研发进展], *Journal of Aeronautical Materials* [航空材料学报] (36) 2016. http://jam.biam.ac.cn/article/app/id/72508300-9e18-4b99-823d-b12299785513

[42] "Resin-based composite products" [树脂基复合材料制品], *AECC BIAM*, Accessed 2021, http://www.biam.ac.cn/tabid/265/InfoID/1383/frtid/168/Default.aspx

[43] "Yi Xiaosu: Super Magician" [益小苏：超级"魔法师"], *kkNews*, 7 November 2014. https://kknews.cc/news/zmmgjm3.html

[44] "Yi Xiaosu: Super Magician" [益小苏：超级"魔法师"], *kkNews*, 7 November 2014. https://kknews.cc/news/zmmgjm3.html

[45] "Talking about the military丨"Heart" dispute: when the J-20 fighter is equipped with domestic engines" [讲武谈兵丨"心脏"之争：歼 20 战机何时装备国产发动机], *Sohu*, 21 March 2017. https://www.sohu.com/a/129520093_260616

[46] See two sources:

1. "Composite materials make the C919 internationally competitive" [复合材料让 C919 拥有国际竞争力], *China Nonwovens & Industrial Textiles Association* [中国产业用纺织品行业协会], 21 June 2016. http://www.cnita.org.cn/china/magazinedetail.aspx?sid=51&aid=2850
2. "Behind the glory of C919: China's leading aviation composite materials " [C919 光鲜背后：中国航空复合材料世界领先(图)], *Tiexue*, Accessed 2021, https://bbs.tiexue.net/post2_5214737_1.html.0
   NOTE: this forum is an unofficial source but appears to have copy-pasted from a since-deleted official news report. Treat accordingly.

[47] "Tongfei team won the first prize of China Aviation Innovation and Entrepreneurship Competition" [通飞团队喜获中国通航创新创业大赛一等奖], *Sohu*, 5 December 2018. https://www.sohu.com/a/279895696_742602

[48] "Chen Xiangbao" [陈祥宝], *Peking University*, Accessed 2021, https://www.coe.pku.edu.cn/jzyg/qbjylb/925093.htm
[49] "Dr. Jianwen Bao, winner of the Young Scientist Award of the Composites Society" [复合材料学会青年科学家奖获得者包建文博士], *CNFRP* [复材网], 28 May 2015. www.cnfrp.com/news/show-47731.html
[50] "Resin-based composite products" [树脂基复合材料制品], AECC BIAM, Accessed 2021, http://www.biam.ac.cn/tabid/265/InfoID/1383/frtid/168/Default.aspx
[51] "Shanghai Jiaotong University team successfully developed carbon fiber composite waste recycling technology" [上海交大团队成功开发碳纤维复合材料废弃物回收技术], *CFIAFRP* [中国纤维复材网], 14 July 2020. https://www.cfiafrp.com/news/show.php?itemid=5552
[52] "Cooperation Overview" [合作概况], *AECC BIAM*, Accessed 2021, http://www.biam.ac.cn/tabid/108/Default.aspx
[53] "Tongfei team won the first prize of China Aviation Innovation and Entrepreneurship Competition" [通飞团队喜获中国通航创新创业大赛一等奖], *Sohu*, 5 December 2018. https://www.sohu.com/a/279895696_742602
[54] "Yi Xiaosu: Super Magician" [益小苏：超级"魔法师"], *kkNews*, 7 November 2014. https://kknews.cc/news/zmmgjm3.html
[55] "Boeing China Newsletter No. 15.", *Boeing*, December 2009. http://www.boeing.cn/presscenter/newsletter/2009-12(3).pdf
[56] "Prof. Xiaosu Yi was appointed as the principal researcher of our institute" [益小苏教授受聘为我所首席研究员], *CNI Tech Laboratory of Polymers and Composites* [高分子与复合材料实验室], Accessed 2021, https://polymer.nimte.ac.cn/view-7655.html
[57] "2018 Sino-German High-end Manufacturing Summit held in Shaoxing, Zhejiang Province, guests to discuss innovation and cultivate new dynamic energy " [2018 中德高端制造峰会浙江绍兴举行 嘉宾共话创新培育新动能], *China News* [中国新闻网], 1 December 2018. http://www.zj.chinanews.com/2018-12-01/detail-ifzahrcq0600916.shtml
[58] "PART 744—CONTROL POLICY: END-USER AND END-USE BASED," *e-CFR*, 23 December 2020. https://www.ecfr.gov/cgi-bin/text-idx?node=pt15.2.744&rgn=div5
[59] "Long-air Sword Casting Material Competition" [长空铸剑 材料争先], *Technology Innovation and Brand* [科技创新与品牌], 1 March 2011. http://www.kjcxpp.com/html/qkgl/113jskj_2618_4509.html
"Key Laboratory of Advanced High Temperature Structural Materials, Beijing Institute of Aerospace Materials, AVIC" [中航工业北京航空材料研究院先进高温结构材料重点实验室], *Journal of Materials Engineering* [材料工程], 2016. http://www.clgczz.cn/index.php?m=content&c=index&a=show&catid=95&id=1455
[60] "Long-air Sword Casting Material Competition" [长空铸剑 材料争先], *Technology Innovation and Brand* [科技创新与品牌], 1 March 2011. http://www.kjcxpp.com/html/qkgl/113jskj_2618_4509.html
"Key Laboratory of Advanced High Temperature Structural Materials, Beijing Institute of Aerospace Materials, AVIC" [中航工业北京航空材料研究院先进高温结构材料重点实验室], *Journal of Materials Engineering* [材料工程], 2016. http://www.clgczz.cn/index.php?m=content&c=index&a=show&catid=95&id=1455
"Beijing Institute of Aerospace Materials, Research Network" [北京航空材料研究院], *Research Recruitment Online* [研招网], Accessed 2021, https://yz.chsi.com.cn/sch/schoolInfo--schId-367799,categoryId-434611.dhtml
"Long-air Sword Casting Material Competition" [长空铸剑 材料争先], *Technology Innovation and Brand* [科技创新与品牌], 1 March 2011. http://www.kjcxpp.com/html/qkgl/113jskj_2618_4509.html
[61] "Long-air Sword Casting Material Competition" [长空铸剑 材料争先], *Technology Innovation and Brand* [科技创新与品牌], 1 March 2011. http://www.kjcxpp.com/html/qkgl/113jskj_2618_4509.html
Beijing Institute of Aerospace Materials (621 Institute)" [中国航发北京航空材料研究院(621 所)], *Zhonghua-PE* [私募股权投资网], 4 March 2020. http://www.zhonghua-pe.com/2020/0304/234495.html
[62] "PART 744—CONTROL POLICY: END-USER AND END-USE BASED," *e-CFR*, 23 December 2020. https://www.ecfr.gov/cgi-bin/text-idx?node=pt15.2.744&rgn=div5
[63] "Powder Metallurgy Metal Products" [粉末冶金金属产品], *AECC BIAM*, Accessed 2021, http://www.biam.ac.cn/tabid/248/InfoID/1812/frtid/150/Default.aspx

[64] "Long-air Sword Casting Material Competition" [长空铸剑 材料争先], *Technology Innovation and Brand* [科技创新与品牌], 1 March 2011. http://www.kjcxpp.com/html/qkgl/113jskj_2618_4509.html
[65] "Advanced High-Temperature Structural Materials and Technologies: Up" [先进高温结构材料与技术：上, ], *WSGPH* [网上馆配会], 1 June 2012. http://www.wsgph.com/bookshow.asp?id=41058#
[66] "Beijing Institute of Aerospace Materials, Research Network" [北京航空材料研究院], *Research Recruitment Online* [研招网], Accessed 2021, https://yz.chsi.com.cn/sch/schoolInfo--schId-367799,categoryId-434611.dhtml
"Long-air Sword Casting Material Competition" [长空铸剑 材料争先], *Technology Innovation and Brand* [科技创新与品牌], 1 March 2011. http://www.kjcxpp.com/html/qkgl/113jskj_2618_4509.html
[67] "Key Laboratory of Advanced High Temperature Structural Materials, Beijing Institute of Aerospace Materials, AVIC" [中航工业北京航空材料研究院先进高温结构材料重点实验室], *Journal of Materials Engineering* [材料工程], 2016. http://www.clgczz.cn/index.php?m=content&c=index&a=show&catid=95&id=1455
"What strategic applications exist for advanced high temperature alloys?" [先进高温合金都存在哪些战略应用?], *Zhihu* [知乎], 19 November 2017. https://zhuanlan.zhihu.com/p/31199037
"China's major material breakthroughs, titanium alloy heat-resistant ability sharply improved, the future can improve the turbofan 15" [中国材料重大突破，钛合金耐热能力急剧提升，未来可改进涡扇 15], *Netease*, 14 January 2020. https://www.163.com/dy/article/F2SOV3L9051597E8.html
"The fourth generation of domestic aero-engine single crystal turbine blades to achieve mass production, can make the aero-engine thrust jump 10%" [国产航发第四代单晶涡轮叶片实现量产，能让航发推力猛增 10%], *Netease*, 14 May 2020. https://www.163.com/dy/article/FCJ3Q0H70535BC3B.html
"Key Laboratory of Advanced High Temperature Structural Materials, Beijing Institute of Aerospace Materials, AVIC" [中航工业北京航空材料研究院先进高温结构材料重点实验室], *Journal of Materials Engineering* [材料工程], 2016. http://www.clgczz.cn/index.php?m=content&c=index&a=show&catid=95&id=1455
[68] "High-temperature alloy industry in-depth study: why continue to be optimistic about the high-temperature alloy track?" [高温合金行业深度研究：为什么持续看好高温合金赛道？ ], *Tencent*, 18 October 2022, https://news.qq.com/rain/a/20221018A00XZR00
[69] "Key Laboratory of Advanced High Temperature Structural Materials, Beijing Institute of Aerospace Materials, AVIC" [中航工业北京航空材料研究院先进高温结构材料重点实验室], *Journal of Materials Engineering* [材料工程], 2016. http://www.clgczz.cn/index.php?m=content&c=index&a=show&catid=95&id=1455
[70] "Zhang Guoqing" [张国庆], *University of Science and Technology Beijing*, Accessed 2021, https://skl.ustb.edu.cn/rcdw/zjxqy/46d303b8db874d87a078bd4e27cadc84.htm
"Antai Technology held a report on the development of new material industry" [安泰科技举办新材料产业发展报告会], *AT&M* [安泰科技], 15 December 2020. http://www.atmcn.com/mtzx/gsxw/2020/1215/4601.html
[71] "Long-air Sword Casting Material Competition" [长空铸剑 材料争先], *Technology Innovation and Brand* [科技创新与品牌], 1 March 2011. http://www.kjcxpp.com/html/qkgl/113jskj_2618_4509.html
[72] "Long-air Sword Casting Material Competition" [长空铸剑 材料争先], *Technology Innovation and Brand* [科技创新与品牌], 1 March 2011. http://www.kjcxpp.com/html/qkgl/113jskj_2618_4509.html
[73] "Antai Technology held a report on the development of new material industry" [安泰科技举办新材料产业发展报告会], *AT&M* [安泰科技], 15 December 2020. http://www.atmcn.com/mtzx/gsxw/2020/1215/4601.html
[74] "What strategic applications exist for advanced high temperature alloys?" [先进高温合金都存在哪些战略应用?], *Zhihu* [知乎], 19 November 2017. https://zhuanlan.zhihu.com/p/31199037
[75] "Long-air Sword Casting Material Competition" [长空铸剑 材料争先], *Technology Innovation and Brand* [科技创新与品牌], 1 March 2011. http://www.kjcxpp.com/html/qkgl/113jskj_2618_4509.html
[76] "PART 744—CONTROL POLICY: END-USER AND END-USE BASED," *e-CFR*, 23 December 2020. https://www.ecfr.gov/cgi-bin/text-idx?node=pt15.2.744&rgn=div5
[77] "Image Wall" [形象墙], *Beijing Hongxiang Weiye Advertising Co*. [北京宏翔伟业广告有限公司], Accessed 2021, http://www.hongxiangad.com/product_show.asp?id=31
[78] "No.010 State Key Laboratory of Aero-engine Thermodynamics " [No.010 航空发动机气动热力国家科技重点实验室], *Changzhou Military-Civil Fusion Public Service Platform* [常州军民融合公共服务平台], 14 June 2016. http://www.czjmrh.com/content/?998.html

"National Key Labs" [国家重点实验室], *Beihang University*, Accessed 2021, http://sepe.buaa.edu.cn/xygk/xssz/gjzdsys/index.htm

[79] "National Key Labs" [国家重点实验室], *Beihang University*, Accessed 2021, http://sepe.buaa.edu.cn/xygk/xssz/gjzdsys/index.htm

[80] "Henan Luoyang Zhongchen Science and Technology Equipment Selects Zhikai Large Servo Medium Walking Wire EDM Wire Cutting Machine" [河南洛阳中宸科技装备甄选智凯大型伺服中走丝电火花线切割机床], *Suzhou Zhikai Shukong Technology Co*. [苏州智凯数控技术有限公司], 4 March 2024, https://web.archive.org/web/20241212040147/http://www.ltcnc.com/case/14142.html

"Aerospace Equipment Manufacturing Development Overview | Transportation Strategy Study" [高端装备之航空装备制造业发展概述 | 交通战略研究], *Eastmoney*, 12 April 2024, https://finance.eastmoney.com/a/202404123042076417.html

[81] "National Key Labs" [国家重点实验室], *Beihang University*, Accessed 2021, http://sepe.buaa.edu.cn/xygk/xssz/gjzdsys/index.htm

[82] "No.010 State Key Laboratory of Aero-engine Thermodynamics " [No.010 航空发动机气动热力国家科技重点实验室], Changzhou Military-Civil Fusion Public Service Platform, 14 June 2016. http://www.czjmrh.com/content/?998.html

"Department of Thermal Engineering" [热能工程系], *Beihang University*, Accessed 2021, https://sepe.buaa.edu.cn/xygk/xssz/rngcx.htm

[83] "Aero-engine aerodynamics and thermodynamics national defense science and technology key laboratory fund 2019 guidelines release announcement" [航空发动机气动热力国防科技重点实验室基金 2019 年指南发布公告], *QQ*, 11 October 2019. https://mp.weixin.qq.com/s?__biz=MzUyNzkwMzk5Nw==&mid=2247485305&idx=1&sn=170e04332c54a6d80fac7b558c777880&chksm=fa793aebcd0eb3fda0f1756333163a5344055bdb0ba6059ea6fc4c59e15fe29d795d1ff1fced

[84] "Zou Zhengping: Aero-engineering research is not based on model traction" [邹正平： 航发研究不以型号牵引为主], *S&T Daily* [中国科技网], 13 March 2017. http://www.stdaily.com/zhuanti01/lianghui/2017-03/13/content_523888.shtml

[85] "Postdoctoral Recruitment 2019 for Academician Chen Maozhang's Team at Beijing University of Aeronautics and Astronautics" [北京航空航天大学陈懋章院士团队 2019 年招聘博士后启事], *Higher Education Job* [高校人才网], 21 May 2019. http://www.gaoxiaojob.com/zhaopin/zhuanti/bjhkhtdxcmzys2019/index.html

"The new "Taihang" to build China's power: improve the load of the Y-20" [新"太行"打造中国动力：提升运-20 载重], *CE.cn* [中国经济网], 7 April 2013. http://www.ce.cn/aero/201304/07/t20130407_60968.shtml

[86] Postdoctoral Recruitment 2019 for Academician Chen Maozhang's Team at Beijing University of Aeronautics and Astronautics" [北京航空航天大学陈懋章院士团队 2019 年招聘博士后启事], *Higher Education Job* [高校人才网], 21 May 2019. http://www.gaoxiaojob.com/zhaopin/zhuanti/bjhkhtdxcmzys2019/index.html

[87] "Beihang Symposium|Xu Guoqiang: Achieve first-class talents in engine field and make first-class contribution to engine industry" [北航专题讲座|徐国强：成就发动机领域一流人才，为发动机行业做一流贡献], *MBA China*, 20 October 2022, https://www.mbachina.com/html/bhmemc/20250103/497447.html

[88] "Information: Tao Zhi Biography" [资料：陶智简历], *China Economy Online* [中国经济网], 12 September 2017. http://district.ce.cn/zt/zggx/bh/rsdt/201709/12/t20170912_25921693.shtml

"Member Tao Zhi: Formulate a long-term plan for the development of Beidou industry as soon as possible" [陶智委员：尽快制定北斗产业发展长远规划], *People* [人民网], 8 March 2021. http://bj.people.com.cn/n2/2021/0308/c349239-34610642.html

[89] "Wuning scientist Cheng Ronghui, full-time model chief of China Aerospace Development, won the Aerospace Laurel Award" [武宁籍科学家中国航发专职型号总师程荣辉获航空航天月桂奖], *Sohu*, 12 November 2024, https://www.sohu.com/a/826134448_121124569

[90] "Professor Shen Shiduan was appointed as our senior advisor" [沈士团教授受聘我校高级顾问], *Tongji University* [同济大学], 8 June 2004. https://news.tongji.edu.cn/info/1003/24340.htm

"Yu Xiaoqi as Secretary of Party Committee and Li Qiushi as Vice President of Xihua University" [余孝其任西华大学党委书记、李秋实任副校长], *Xinhua*, 18 December 2020. http://www.xinhuanet.com/renshi/2020-12/18/c_1126879594.htm

"School of Energy and Power Engineering -- Lu Lipeng, Beijing University of Aeronautics and Astronautics" [能源与动力工程学院 —— 陆利蓬, 北京航空航天大学], *Beihang* University, 9 December 2019. http://www.jxbuaa.com/NewsView.aspx?id=1554

[91] "Work Unit Introduction" [单位简介], *Cingta* [青塔人才], Accessed 2021, https://job.cingta.com/detail/35494
"Zou Zhengping: Aero-engineering research is not based on model traction" [邹正平： 航发研究不以型号牵引为主], S&T Daily [中国科技网], 13 March 2017. http://www.stdaily.com/zhuanti01/lianghui/2017-03/13/content_523888.shtml

[92] "Professor Jacques Renvier, the world famous aero-engine expert, came to our university for the second time to give lectures" [世界著名航空发动机专家 Jacques Renvier 教授第二次来我院讲学], *Beihang University*, 28 June 2013. http://sepe.buaa.edu.cn/info/1072/1890.htm
"Zhengping Zou, Hypersonic strong pre-cooling engine - a disruptive technology in the field of air and space power" [邹正平, 高超声速强预冷发动机——空天动力领域的颠覆性技术], *kkNews*, 26 August 2019. https://kknews.cc/news/amb2nqj.html

[93] "Yu Xianjun" [于贤君], "Experimental and Numerical Investigation on the Flow Near the Leading-Edge of Controlled Diffusion Airfoil" [CDA 叶型前缘流动的实验和数值研究], *Journal of Engineering Thermophysics* [工程热物理学报] (8) 2019.
"Collaborative Innovation Center for Advanced Aero Engines" [先进航空发动机协同创新中心], *Baike* [百科], Accessed 2021, https://m.baike.com/wiki/%E5%85%88%E8%BF%9B%E8%88%AA%E7%A9%BA%E5%8F%91%E5%8A%A8%E6%9C%BA%E5%8D%8F%E5%90%8C%E5%88%9B%E6%96%B0%E4%B8%AD%E5%BF%83/7663108?baike_source=innerlink

[94] "China Aerospace Third Professional Information Network 37th Technical Exchange Conference and the 1st Joint Conference on Air and Space Power Call for Papers" [中国航天第三专业信息网第三十七届技术交流会 暨第一届空天动力联合会议 征文通知], *CASC*, 28 April 2016. http://wap.casc11.com/wap/news/show.asp?id=1466

[95] "Postdoctoral Recruitment 2019 for Academician Chen Maozhang's Team at Beijing University of Aeronautics and Astronautics" [北京航空航天大学陈懋章院士团队 2019 年招聘博士后启事], *Higher Education Job* [高校人才网], 21 May 2019. http://www.gaoxiaojob.com/zhaopin/zhuanti/bjhkhtdxcmzys2019/index.html

[96] "9th National Young Scholar Meeting on Combustion Research" [第九届全国青年燃烧学术会议*], Combustion 2024*, Accessed January 2024, https://combustion2024.casconf.cn/static/1739111595851780096/pages/file/39eeec6707d64a7dad9826d74377554b.pdf

[97] "Professor Jacques Renvier, the world famous aero-engine expert, came to our university for the second time to give lectures" [世界著名航空发动机专家 Jacques Renvier 教授第二次来我院讲学], *Beihang University*, 28 June 2013. http://sepe.buaa.edu.cn/info/1072/1890.htm

[97] "Jacques Renvier", *Linkedin*, Accessed 2021, https://www.linkedin.com/in/jacques-renvier-ba757030/?originalSubdomain=fr

[98] "Department of Thermal Engineering" [热能工程系], *Beihang University*, Accessed 2021, https://sepe.buaa.edu.cn/xygk/xssz/rngcx.htm

[99] "National Key Labs" [国家重点实验室], *Beihang University*, Accessed 2021, http://sepe.buaa.edu.cn/xygk/xssz/gjzdsys/index.htm

[100] Per a search of Baidu map

[101] "No.010 State Key Laboratory of Aero-engine Thermodynamics " [No.010 航空发动机气动热力国家科技重点实验室], *Changzhou Military-Civil Fusion Public Service Platform*, 14 June 2016. http://www.czjmrh.com/content/?998.html
"Create a high-tech industry gathering place, Langfang Municipal People's Government" [打造高新产业聚集地], *Langfang People's Government* [廊坊市人民政府], 11 August 2017. http://www.lf.gov.cn/Item/71002.aspx

[102] See the following three sources:
1. "President of China Quality Association Jia Fuxing and his party inspected the work of the Second Department of the Second Hospital" [中国质量协会会长贾福兴一行视察二院二部工作], *CASIC*, 24 August 2012. http://webcache.googleusercontent.com/search?q=cache%3Awww.casic.com.cn%2Fn12377419%2Fn12378172%2

Fc12630720%2Fcontent.html&rlz=1C1CHBD_enUS949US949&oq=cache%3Awww.casic.com.cn%2Fn12377419%2Fn12378172%2Fc12630720%2Fcontent.html&aqs=chrome..69i57j69i58.1457j0j4&sourceid=chrome&ie=UTF-8
2. "Production Safety Month New employees learn safety in the field and build up high quality in scientific research" [安全生产月新员工实地学安全 蓄力科研高质量], *Sohu*, 30 June 2020. https://www.sohu.com/a/404949178_749889
3. "Academic Exchange Meeting on Modeling and Simulation Technology of Second Academy Second Department was held" [二院二部建模与仿真技术学术交流会召开], *CASIC*, 18 July 2012. http://webcache.googleusercontent.com/search?q=cache%3Awww.casic.com.cn%2Fn12377419%2Fn12378177%2Fc12744261%2Fcontent.html&rlz=1C1CHBD_enUS949US949&oq=cache%3Awww.casic.com.cn%2Fn12377419%2Fn12378177%2Fc12744261%2Fcontent.html&aqs=chrome..69i57j69i58.1295j0j4&sourceid=chrome&ie=UTF-8

[103] "Development of the Defense S&T Key Laboratory of Missile Control System Simulation" [发展中的导弹控制系统仿真国防科技重点实验室], *System Simulation Journal* [系统仿真学报], Accessed 2021, https://www.ixueshu.com/document/df587df9d5dafac7c43d19a377f66d03318947a18e7f9386.html

[104] "Beijing Simulation Center hosts 2018 China Simulation Conference" [北京仿真中心承办"2018 年中国仿真大会]", *China Simulation Federation*, 19 November 2018. http://www.csf-sim.org.cn/showNewsDetail.asp?nsId=466

[105] "Satellite mobile communications three key technologies" [卫星移动通信三大关键技术], *c114.com*, 2 August 2010. https://m.c114.com.cn/w2519-568048.html

"Beijing Simulation Center Key Laboratory of Aerospace System Simulation Participated in China Simulation Conference 2017" [北京仿真中心航天系统仿真重点实验室 参加 2017 年中国仿真大会], *China Simulation Federation* [中国仿真学会], 13 November 2017. http://www.csf-sim.org.cn/showNewsDetail.asp?nsId=249

Liu Boting [刘柏廷] et al., "Method of Missile Salvo Hardware-in-the-loop Simulation Based on Multi Scattering Center Analog Measurement" [基于多散射中心模拟的导弹连射半实物仿真方法], *Journal of System Simulation* [系统仿真学报] (12) 2018.

"Academic Exchange Meeting on Modeling and Simulation Technology of Second Academy Second Department was held" [二院二部建模与仿真技术学术交流会召开], *CASIC*, 18 July 2012. http://webcache.googleusercontent.com/search?q=cache%3Awww.casic.com.cn%2Fn12377419%2Fn12378177%2Fc12744261%2Fcontent.html&rlz=1C1CHBD_enUS949US949&oq=cache%3Awww.casic.com.cn%2Fn12377419%2Fn12378177%2Fc12744261%2Fcontent.html&aqs=chrome..69i57j69i58.1295j0j4&sourceid=chrome&ie=UTF-8

[106] See two articles, each with Tao Yuhui: Tao Yuhui [陶渝辉] et al., "Calculation of simulated target energy in hardware-in-the-loop" [用目标模拟器仿真真实目标能量的计算方法], *2006 National Photovoltaic Technology Academic Exchange Conference* [2006 年全国光电技术学术交流会会议], November 2006. and Liu Boting [刘柏廷] et al., "Method of Missile Salvo Hardware-in-the-loop Simulation Based on Multi Scattering Center Analog Measurement" [基于多散射中心模拟的导弹连射半实物仿真方法], *Journal of System Simulation* [系统仿真学报] (12) 2018.

[107] "Development of the Defense S&T Key Laboratory of Missile Control System Simulation" [发展中的导弹控制系统仿真国防科技重点实验室], *Journal of System Simulation* [系统仿真学报], Accessed 2021, https://www.ixueshu.com/document/df587df9d5dafac7c43d19a377f66d03318947a18e7f9386.html

[108] "Method and apparatus for determining grid occlusion of digital elevation model cells" [确定数字高程模型单元网格遮挡的方法及装置], *Google Patents*, 20 January 2014. https://patents.google.com/patent/CN103778633A/zh

"Beijing Simulation Center Key Laboratory of Aerospace System Simulation Participated in China Simulation Conference 2017" [北京仿真中心航天系统仿真重点实验室 参加 2017 年中国仿真大会], *China Simulation Federation* [中国仿真学会], 13 November 2017. http://www.csf-sim.org.cn/showNewsDetail.asp?nsId=249

Liu Boting [刘柏廷] et al., "Method of Missile Salvo Hardware-in-the-loop Simulation Based on Multi Scattering Center Analog Measurement" [基于多散射中心模拟的导弹连射半实物仿真方法], *Journal of System Simulation* [系统仿真学报] (12) 2018.

Xiong Xinping [熊新平] et al., "Research on Survivability Modeling and Simulation of Network Air Defense Missile Systems" [网络化防空导弹体系生存能力建模与仿真研究], *Journal of System Simulation* [系统仿真学报] (18) 2006. https://www.ixueshu.com/document/2ce46cf6c9e37420318947a18e7f9386.html
Li Zhiping [李志平], "Research on Development and Integration Method of BMDS Integrated Test and Training Environment" [反导体系试训一体化环境开发集成方法研究], *Journal of System Simulation* [系统仿真学报] (4) 2016. http://yuxiqbs.cqvip.com/Qikan/Article/Detail?id=668558070
"Conference Program - Advanced Air and Space Defense Technology High Level Forum, Historical Articles" [会议日程 先进空天防御技术高端论坛," *History Essays* [历史文章], 13 June 2019. https://lishiwenzhang.com/p/5ef301a7d96cbcb0efaaa2aa
[109] "Beijing Simulation Center Key Laboratory of Aerospace System Simulation Participated in China Simulation Conference 2017" [北京仿真中心航天系统仿真重点实验室 参加 2017 年中国仿真大会], China Simulation Federation [中国仿真学会], 13 November 2017. http://www.csf-sim.org.cn/showNewsDetail.asp?nsId=249
[110] "Key Laboratory of Aerospace System Simulation Successfully Held 2022 Academic Committee Meeting" [航天系统仿真重点实验室顺利召开 2022 年学术委员会会议], *China Simulation Federation* [中国仿真学会], 18 August 2022, http://www.csf-sim.org.cn/showNewsDetail.asp?nsId=1188
[111] "Key Laboratory of Aerospace System Simulation Successfully Held 2022 Academic Committee Meeting" [航天系统仿真重点实验室顺利召开 2022 年学术委员会会议], *China Simulation Federation* [中国仿真学会], 18 August 2022, http://www.csf-sim.org.cn/showNewsDetail.asp?nsId=1188
[112] "Key Laboratory of Aerospace System Simulation held the 2020 academic committee meeting" [航天系统仿真重点实验室召开 2020 年度学术委员会议], China Simulation Federation, 15 October 2020. http://www.csf-sim.org.cn/showNewsDetail.asp?nsId=846
[113] "The 1st China Conference on Target and Environment Modeling and Simulation Technology" [第一届中国目标与环境建模仿真技术大会], *AConf* [艾会网], 11 September 2015. https://www.aconf.cn/conf_56489.html
[114] ""The 4th China Conference on Target and Environment Modeling and Simulation Technology"" ["第四届中国目标与环境建模仿真技术大会"召开], *China Simulation Federation*, 19 November 2018. http://www.csf-sim.org.cn/showNewsDetail.asp?nsId=465
[115] "Key Laboratory of Aerospace System Simulation Successfully Held "The 5th China Conference on Target and Environment Modeling and Simulation Technology" [航天系统仿真重点实验室成功举办"第五届中国目标与环境建模仿真技术大会], *China Simulation Federation*, 21 November 2019. http://www.csf-sim.org.cn/showNewsDetail.asp?nsId=712
[116] "The Sixth China Conference on Target and Environment Modeling and Simulation Technology hosted by our university" [我校主办的第六届中国目标与环境建模仿真技术大会召开], *School of Information and Communication* [信息与通信学院], 12 Septmber 2020. http://www.gliet.edu.cn/dept2/info/1063/2772.htm
[117] "Satellite mobile communications three key technologies" [卫星移动通信三大关键技术], *c114.com*, 2 August 2010. https://m.c114.com.cn/w2519-568048.html
[118] ""Crossing the Singularity, Foreseeing the Future" VR Summit held in Beijing " ["跨越奇点、预见未来"VR 峰会在京举行], *Sohu*, 10 May 2016. https://www.sohu.com/a/74541310_395737
[119] "Aerospace Simulation System Professional Committee "2017 Academic Exchange Meeting on Simulation Technology"" [航空航天仿真系统专业委员会"2017 年仿真技术学术交流会"], *China Simulation Federation*, 6 September 2017. http://www.csf-sim.org.cn/showNewsDetail.asp?nsId=176
[120] "Beijing Simulation Center hosts 2018 China Simulation Conference" [北京仿真中心承办"2018 年中国仿真大会]", *China Simulation Federation*, 19 November 2018. http://www.csf-sim.org.cn/showNewsDetail.asp?nsId=466
[121] "The 8th International Symposium on New Photoelectric Detection Technology and its Applications" [第八届国际新型光电探测技术及其应用研讨会], *Chinese Journal of Optics* [中国光学期刊], 24 March 2021. http://www.ap.opticsx.org/M/gxgdjs/News/PT21032400002gMjPm.cshtml
[122] "President of China Quality Association Jia Fuxing and his party inspected the work of the Second Department of the Second Hospital" [中国质量协会会长贾福兴一行视察二院二部工作], *CASIC*, 24 August 2012. http://webcache.googleusercontent.com/search?q=cache%3Awww.casic.com.cn%2Fn12377419%2Fn12378172%2Fc12630720%2Fcontent.html&rlz=1C1CHBD_enUS949US949&oq=cache%3Awww.casic.com.cn%2Fn12377419

%2Fn12378172%2Fc12630720%2Fcontent.html&aqs=chrome..69i57j69i58.1457j0j4&sourceid=chrome&ie=UTF-8

[123] "Prof. Dong Xiwang: Leading the development of cluster intelligence field and helping UAV cluster technology advantage!" [董希旺教授：引领集群智能领域发展，助力无人机集群技术优势!], *Sina*, 29 September 2019. https://k.sina.com.cn/article_5883189062_15eaa574600100hyyo.html

[124] "2024 The 8th Youth Forum on Cluster Intelligence and Cooperative Control and the Dean's Eagle Forum on Unmanned Systems Research of Beihang University are held" [2024 第八期集群智能与协同控制青年论坛暨北航无人系统研究院长鹰论坛举办], *Beihang University*, 16 May 2024, https://wrj.buaa.edu.cn/info/1007/2094.htm

[125] "Beihang Key Laboratory of Aircraft Control Integration Technology was accepted, CERNIC [China Education and Research Network Network Center]" [北航飞行器控制一体化技术重点实验室获验收], *CERNIC* [中国教育和科研计算机网网络中心], 25 June 2010. https://www.edu.cn/rd/gao_xiao_cheng_guo/gao_xiao_zi_xun/201006/t20100625_489843.shtml

[126] "Addition of `Military End User' (MEU) List to the Export Administration Regulations and Addition of Entities to the MEU List," *Federal Register*, 23 December 2020. https://www.federalregister.gov/documents/2020/12/23/2020-28052/addition-of-military-end-user-meu-list-to-the-export-administration-regulations-and-addition-of

"Who are we?" [我们是谁], *FACRI*, Accessed 2021, http://www.facri.com/aboutus

"Xi'an Institute of Automatic Flight Control of China Aviation Industry Corporation (618 Institute)" [中国航空工业集团公司西安飞行自动控制研究所(618 所)], *Bowmann Consulting*, Accessed 2021, http://www.bowmann.cn/case_view.aspx?TypeId=155&Id=820&FId=t8:155:8

"Xi'an Flight Automatic Control Institute of China Aviation Industry Corporation" [中国航空工业集团公司西安飞行自动控制研究所], *NUAA*, 16 October 2020. http://nuaa.91job.org.cn/teachin/view/id/219650

[127] "Conference Structure" [会议机构], *2024 International Conference on Guidance, Navigation and Control*, Accessed January 2025, https://web.archive.org/web/20241102143316/https://icgnc.buaa.edu.cn/Organizations.htm

"2023 7th Chinese Conference on Swarm Intelligence and Cooperative Control" [全国集群智能与协同控制大会], *CCICC*, Accessed January 2025, http://ccsicc.c2.org.cn/

[128] "Commerce Department Will Publish the First Military End User List Naming More Than 100 Chinese and Russian Companies," *US Department of Commerce*, 21 December 2020, https://2017-2021.commerce.gov/news/press-releases/2020/12/commerce-department-will-publish-first-military-end-user-list-naming.html

[129] "[User Sharing] Safety control of quadcopter drones" [[用户分享]四旋翼无人机的安全控制], *Unimationtech*, 10 October 2020. http://www.unimationtech.com/m/newsshow.php?cid=16&id=89

[130] "[User Sharing] Safety control of quadcopter drones" [[用户分享]四旋翼无人机的安全控制], *Unimationtech*, 10 October 2020. http://www.unimationtech.com/m/newsshow.php?cid=16&id=89

"Postdoctoral Recruitment for Bionic Autonomous Flight Systems Research Group at Beijing University of Aeronautics and Astronautics" [北京航空航天大学仿生自主飞行系统研究组博士后招聘], *Beijing Overseas Scholars Center* [北京海外学人中心], 8 December 2020. https://www.8610hr.cn/docs/qcjx/gx/20201208/pc_1336186657472249856.html

[131] "National Key Laboratory of Science and Technology for Flight Vehicle Control Integration Technology" [飞行器控制一体化技术国家级科技重点实验室], *Beihang University*, Accessed 2021, http://dept3.buaa.edu.cn/zdsys/gjzdsys.htm

[132] "Postdoctoral Recruitment for Bionic Autonomous Flight Systems Research Group at Beijing University of Aeronautics and Astronautics" [北京航空航天大学仿生自主飞行系统研究组博士后招聘], *Beijing Overseas Scholars Center* [北京海外学人中心], 8 December 2020. https://www.8610hr.cn/docs/qcjx/gx/20201208/pc_1336186657472249856.html

[133] Tian Lei [田磊] et al., "Research on Escort Strategy based on Loyal Wingman under Denial Environment" [拒止环境下基于"忠诚僚机"的护航策略研究], Journal of Beijing University of Aeronautics and Astronautics [北京航空航天大学学报], June 2020.

[134] Yu Yue [余跃] et al., "Deep Learning-based Reentry Predictor-corrector Fault-tolerant Guidance for Hypersonic Vehicles" [基于深度学习的高超声速飞行器再入预测校正容错制导], *Acta Armamentarii* [兵工学报] (4) 2020.

[135] Qiu Huaxin [邱华鑫], "From collective flight in bird flocks to unmanned aerial vehicle autonomous swarm formation" [从鸟群群集飞行到无人机自主集群编队], *Chinese Journal of Engineering* [中国工程学学报] (3) 2017.
[136] "The Second Symposium on New Navigation Technologies and Applications concluded successfully" [第二届新型导航技术及应用研讨会顺利闭幕], *CSOE* [中国光学工程学会], 16 May 2017. http://webcache.googleusercontent.com/search?q=cache%3Ahttps%3A%2F%2Fwww.csoe.org.cn%2F3g%2Fshow.asp%3Fm%3D1%26d%3D3014&rlz=1C1CHBD_enUS895US895&oq=cache%3Ahttps%3A%2F%2Fwww.csoe.org.cn%2F3g%2Fshow.asp%3Fm%3D1%26d%3D3014&aqs=chrome..69i57j69i58.1252j0j4&sourceid=chrome&ie=UTF-8
[137] "[User Sharing] Safety control of quadcopter drones" [[用户分享]四旋翼无人机的安全控制], *Unimationtech*, 10 October 2020. http://www.unimationtech.com/m/newsshow.php?cid=16&id=89
[138] "Xi'an Institute of Automatic Flight Control" [西安飞行自动控制研究所], *China Enterprise Confederation, China Entrepreneur Association* [中国企业联合会, 中国企业家协会], Accessed 2021, http://www.cec1979.org.cn/famousdb/qiye1469/intro.html
"How about the J-16's telemetry manipulation system? Understand after reading!" [歼 16 的电传操纵系统怎么样？看完后明白了!], *QQ*, 22 September 2020. https://xw.qq.com/cmsid/20200922A05D2X00. Also see 央视公开歼 15 坠机故障铁证 电传问题沈飞西飞都有责任, *Sina*, 6 August 2018. https://jmqmil.sina.cn/ifeng/doc-ihhhczfc6711272.d.html?vt=4
[139] "Professor Jiao Zongxia" [焦宗夏 教授], *Chinese Hydraulics and Pneumatics Network* [液压气动网], 17 January 2019. http://www.yeyanet.com/newsitem/278251600
[140] "Our institute signed a strategic cooperation agreement with the National Defense Key Laboratory of Aircraft Control Integration Technology of the 68th Institute of Aviation Industry" [我院与航空工业第六一八研究所飞行器控制一体化技术国防重点实验室签署战略合作协议], *Beihang University*, 28 May 2019. http://sa.hit.edu.cn/2019/0528/c6678a225085/page.htm
"Professor Ren Zhang from Beijing University of Aeronautics and Astronautics visited our college and gave an academic report" [北京航空航天大学任章教授来我院访问并作学术报告], *Shandong University* [山东大学], 6 January 2017. http://control.sdu.edu.cn/info/1058/2228.htm
"Professor Guo Lei from Beijing University of Aeronautics and Astronautics was invited to give an academic report to the college" [北京航空航天大学郭雷教授应邀来学院作学术报告], *Qingdao University* [青岛大学], Accessed 2021, https://zdh.qdu.edu.cn/info/1027/1084.htm
[141] "Duan Haibin" [段海滨], *X-MOL*, Accessed 2021, https://www.x-mol.com/university/faculty/220892
[142] "Ministry of Industry and Information Technology approved the formation of the National Innovation Center for Micro-Nano Manufacturing" [工信部批复组建国家微纳制造创新中心], *Brightstone MEMS*, 30 December 2024, http://www.brightstonemems.com/?company/106.html
[143] "CLP Construction is deeply involved in the construction of the national major scientific and technological infrastructure system" [向"新"而行丨中电建设深度参与国家重大科技基础设施体系建设], *Xinhua*, 4 July 2024, http://www.news.cn/enterprise/20240704/1a0438d50c9b41cd949a5a3af1069849/c.html
[144] "Joint Laboratory of Large Aircraft Innovation Valley was inaugurated" [大飞机创新谷联合实验室在上飞院揭牌], *Shanghai Aircraft Design & Research Institute* [大飞机创新谷联合实验室], 26 February 2019. http://sadri.comac.cc/xwzx/sfyxw/201902/27/t20190227_6725665.shtml
[145] "Our institute signed a strategic cooperation agreement with the National Defense Key Laboratory of Aircraft Control Integration Technology of the 68th Institute of Aviation Industry" [我院与航空工业第六一八研究所飞行器控制一体化技术国防重点实验室签署战略合作协议], *Beihang University*, 28 May 2019. http://sa.hit.edu.cn/2019/0528/c6678a225085/page.htm
[146] Wen Yige [文奕格] et al., "Attitude Control of Quadrotor Aircraft Based on Extended State Observer And Backstepping" [基于扩张状态观测器和反步法的四旋翼飞行器姿态控制], *Measurement and Control Technology* [测控技术] (11) 2020. P
[147] Tian Lei [田磊] et al., "Research on Escort Strategy based on Loyal Wingman under Denial Environment" [拒止环境下基于"忠诚僚机"的护航策略研究], *Journal of Beijing University of Aeronautics and Astronautics* [北京航空航天大学学报], June 2020.

[148] "The Second Symposium on New Navigation Technologies and Applications concluded successfully" [第二届新型导航技术及应用研讨会顺利闭幕], *CSOE* [中国光学工程学会], 16 May 2017. http://webcache.googleusercontent.com/search?q=cache%3Ahttps%3A%2F%2Fwww.csoe.org.cn%2F3g%2Fshow.asp%3Fm%3D1%26d%3D3014&rlz=1C1CHBD_enUS895US895&oq=cache%3Ahttps%3A%2F%2Fwww.csoe.org.cn%2F3g%2Fshow.asp%3Fm%3D1%26d%3D3014&aqs=chrome..69i57j69i58.1252j0j4&sourceid=chrome&ie=UTF-8

[149] "The 4th National Conference on Cluster Intelligence and Cooperative Control was held" [第四届全国集群智能与协同控制大会隆重召开], *Sohu*, 24 November 2020. https://www.sohu.com/a/434037659_749889

[150] "2022 International Conference on Guidance, Navigation and Control Successfully Organized" [2022 国际制导、导航与控制学术会议成功举办], *Chinese Society of Aeronautics and Astronautics*, 9 August 2022, http://www.csaa.org.cn/art/2022/8/9/art_410_334740.html
"2024 International Conference on Guidance, Navigation and Control Successfully Organized" [2024 国际制导、导航与控制学术会议成功举办], *China Daily*, 14 August 2024, https://qiye.chinadaily.com.cn/a/202408/14/WS66bc2481a310054d254ecc1d.html

[151] "Department of Automation Throne Team Wins Top Honors at 2013 International Aerial Robotics Competition" [自动化系 Throne 代表队在 2013 国际空中机器人大赛中获得最高荣誉], *Tsinghua University* [清华大学], 2013. http://www.au.tsinghua.edu.cn/info/1062/1145.htm

[152] "Honeywell, AVIC to extend cooperation in flight control systems," *Xinhua*, 8 December 2018. http://www.xinhuanet.com/english/2018-12/08/c_137659975.htm

[153] "National Key Laboratory of Science and Technology for Flight Vehicle Control Integration Technology" [飞行器控制一体化技术国家级科技重点实验室], *Beihang University*, Accessed 2021, http://dept3.buaa.edu.cn/zdsys/gjzdsys.htm

[154] "State Key Labs," *NWPU*, Accessed 2021, https://en.nwpu.edu.cn/Research1/CentersandInstitutions.htm

[155] "National Key Laboratory of Flight Vehicle Basic Layout" [飞行器基础布局全国重点实验室], *Northwestern Polytechnical University*, 20 June 2024, https://hangkong.nwpu.edu.cn/info/1074/36844.htm
"Guidelines for the 2024 Open Fund (Stabilization Support Funding) of the National Key Laboratory of Basic Layout of Flying Vehicles" [飞行器基础布局全国重点实验室 2024 年开放基金（稳定支持经费）指南], *Zhongguancun Comprehensive Innovation Service Platform* [中关村创新服务平台], Accessed 9 July 2024, http://www.zgcjm.org/NewsInfo?id=3969

[156] "No.022 Defense S&T Key Laboratory of Airfoil and Blading Aerodynamics" [No.22 翼型、叶栅空气动力学重点实验室], *Changzhou Military-Civil Fusion Public Service Platform* [常州军民融合公共服务平台], 14 June 2016. www.czjmrh.com/content/?1038.html

[157] "Defense S&T Key Laboratory of Airfoil and Blading Aerodynamics" [翼型、叶栅空气动力学国家级重点实验室], *NWPU* [西北工业大学], 2018. http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=260
"Defense S&T Key Laboratory of Airfoil and Blading Aerodynamics" [翼型、叶栅空气动力学国家级重点实验室], *NWPU*, 20 May 2020. https://hangkong.nwpu.edu.cn/info/1278/7233.htm

[158] "Asia's largest and leading wing wind tunnel" [亚洲最大和国内领先的翼型风洞, 西北工业大学], *NWPU*, October 2013. https://z.nwpu.edu.cn/info/1351/8246.htm

[159] "National Key Laboratory of Flight Vehicle Basic Layout" [飞行器基础布局全国重点实验室], *Northwestern Polytechnical University*, 20 June 2024, https://hangkong.nwpu.edu.cn/info/1074/36844.htm
"Guidelines for the 2024 Open Fund (Stabilization Support Funding) of the National Key Laboratory of Basic Layout of Flying Vehicles" [飞行器基础布局全国重点实验室 2024 年开放基金（稳定支持经费）指南], *Zhongguancun Comprehensive Innovation Service Platform* [中关村创新服务平台], Accessed 9 July 2024, http://www.zgcjm.org/NewsInfo?id=3969

[160] "Defense S&T Key Laboratory of Airfoil and Blading Aerodynamics" [翼型、叶栅空气动力学国家级重点实验室], *NWPU*, 2018. http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=260

[161] "National Key Laboratory of Flight Vehicle Basic Layout" [飞行器基础布局全国重点实验室], *Northwestern Polytechnical University*, 20 June 2024, https://hangkong.nwpu.edu.cn/info/1074/36844.htm

[162] “Defense S&T Key Laboratory of Airfoil and Blading Aerodynamics” [翼型、叶栅空气动力学国防科技重点实验室], *Collaborative Innovation Center of Future Aerospace Vehicle* [未来飞行器协同创新中心], Accessed 2021, http://hangkong.nwpu.edu.cn/info/1204/2621.htm
[163] “No.022 Defense S&T Key Laboratory of Airfoil and Blading Aerodynamics” [No.22 翼型、叶栅空气动力学重点实验室], *Changzhou Military-Civil Fusion Public Service Platform* [常州军民融合公共服务平台], 14 June 2016. www.czjmrh.com/content/?1038.html
[164] "Guidelines for the 2024 Open Fund (Stabilization Support Funding) of the National Key Laboratory of Basic Layout of Flying Vehicles" [飞行器基础布局全国重点实验室 2024 年开放基金（稳定支持经费）指南], *Zhongguancun Comprehensive Innovation Service Platform* [中关村创新服务平台], Accessed 9 July 2024, http://www.zgcjm.org/NewsInfo?id=3969
[165] “Hui Zenghong” [惠增宏], *NWPU*, Accessed 2021, https://teacher.nwpu.edu.cn/huizenghong.html
“Air Force’s Special Aircraft – KJ-200” [空军重要的特种机型——空警-200], *360doc* [个人图书馆]. 8 May 2018. http://www.360doc.com/content/18/0508/17/33540468_752212043.shtml
[166] "National Key Laboratory of Flight Vehicle Basic Layout inaugurated at NWPU" [飞行器基础布局全国重点实验室在西北工大揭牌], *Science Net*, 30 June 2024, https://paper.sciencenet.cn/htmlnews/2024/6/525532.shtm
"CCTV featured the National Key Laboratory of Basic Layout of Flying Vehicles in our university" [央视专题报道我校飞行器基础布局全国重点实验室], *Northwestern Polytechnical University*, 21 December 2024, https://www.nwpu.edu.cn/info/1198/97938.htm
[167] Hui Zenghong [惠增宏], *NWPU*, Accessed 2021, https://teacher.nwpu.edu.cn/huizenghong.html
[168] “Defense S&T Key Laboratory of Airfoil and Blading Aerodynamics” [翼型叶栅空气动力学国防科技重点实验室], *360inno.com*, 4 June 2012. info.360inno.com/Resource/Organ/e81abacf-9b0c-4bee-9df0-8af06fa33c74
“Asia’s largest and leading wing wind tunnel” 亚洲最大和国内领先的翼型风洞, 西北工业大学, *NWPU*, October 2013. https://z.nwpu.edu.cn/info/1351/8246.htm
[169] "China's first release of aerospace aircraft wing spectrum" [我国首次发布航空飞行器翼型谱系], *NCSTI.gov.cn*, 21 October 2024, https://www.ncsti.gov.cn/kjdt/kjrd/qtrd_kjrd/202410/t20241021_182891.html
[170] "National Key Laboratory of Flight Vehicle Basic Layout" [飞行器基础布局全国重点实验室], *Northwestern Polytechnical University*, 20 June 2024, https://hangkong.nwpu.edu.cn/info/1074/36844.htm
[171] "National Key Laboratory of Flight Vehicle Basic Layout" [飞行器基础布局全国重点实验室], *Northwestern Polytechnical University,* 20 June 2024, https://hangkong.nwpu.edu.cn/info/1074/36844.htm
[172] "National Key Laboratory of Flight Vehicle Basic Layout" [飞行器基础布局全国重点实验室], *Northwestern Polytechnical University*, 20 June 2024, https://hangkong.nwpu.edu.cn/info/1074/36844.htm
[173] “Defense S&T Key Laboratory of Airfoil and Blading Aerodynamics” [翼型、叶栅空气动力学国家级重点实验室], *NWPU*, 20 May 2020. https://hangkong.nwpu.edu.cn/info/1278/7233.htm
[174] “Key lab of airfoil and blading aerodynamics: Advances in airfoil design methods for co-axial twin-rotor helicopters” [翼型、叶栅空气动力学重点实验室：在共轴双旋翼直升机的翼型设计方法方面取得进展], *Science and Innovation Center* [科创中心], 16 December 2019. http://www.49orless.com/info/1022/3096.htm
[175] Asia’s largest and leading wing wind tunnel” 亚洲最大和国内领先的翼型风洞, 西北工业大学, *NWPU*, October 2013. https://z.nwpu.edu.cn/info/1351/8246.htm
[176] Per searches of two scientific databases
[177] “2012 China Floatplane Conference held in Northwestern Polytechnic University “ [2012 中国浮空器大会在西北工业大学召开], *Chinese Society of Aeronautics and Astronautics* [中国航空学会], 19 October 2012. http://webcache.googleusercontent.com/search?q=cache%3Awww.csaa.org.cn%2Fart%2F2012%2F10%2F19%2Fart_410_15212.html&rlz=1C1CHBD_enUS895US895&oq=cache%3Awww.csaa.org.cn%2Fart%2F2012%2F10%2F19%2Fart_410_15212.html&aqs=chrome..69i57j69i58.1331j0j4&sourceid=chrome&ie=UTF-8
[178] “Dr. Lijun He participated in the 5th Western Mechanics Young Scholars Academic Salon” [何力军博士参加第五届西部力学青年学者学术沙龙], *Ningxia University* [宁夏大学], 16 November 2015. https://guangfu.nxu.edu.cn/info/1011/1310.htm
[179] "School of Aeronautics in Northwestern Polytechnical University" [西北工业大学航空学院], *Northwestern Polytechnical University*, Accessed 2021, http://yzb.nwpu.edu.cn/__local/4/52/2F/26C55E2291DC0A2D3CD0356CA40_CA89358C_4E3011.pdf

[180] "School of Aeronautics in Northwestern Polytechnical University" [西北工业大学航空学院], *Northwestern Polytechnical University*, Accessed 2021, http://yzb.nwpu.edu.cn/__local/4/52/2F/26C55E2291DC0A2D3CD0356CA40_CA89358C_4E3011.pdf
[181] "No.022 Defense S&T Key Laboratory of Airfoil and Blading Aerodynamics" [No.22 翼型、叶栅空气动力学重点实验室], *Changzhou Military-Civil Fusion Public Service Platform* [常州军民融合公共服务平台], 14 June 2016. www.czjmrh.com/content/?1038.html
[182] "Defense S&T Key Laboratory of Airfoil and Blading Aerodynamics" [翼型叶栅空气动力学国防科技重点实验室], *360inno.com*, 4 June 2012. info.360inno.com/Resource/Organ/e81abacf-9b0c-4bee-9df0-8af06fa33c74
"Asia's largest and leading wing wind tunnel" 亚洲最大和国内领先的翼型风洞, 西北工业大学, *NWPU*, October 2013. https://z.nwpu.edu.cn/info/1351/8246.htm
[182] "Asia's largest and leading wing wind tunnel" 亚洲最大和国内领先的翼型风洞, 西北工业大学, *NWPU*, October 2013. https://z.nwpu.edu.cn/info/1351/8246.htm
[183] "Asia's largest and leading wing wind tunnel" 亚洲最大和国内领先的翼型风洞, 西北工业大学, *NWPU*, October 2013. https://z.nwpu.edu.cn/info/1351/8246.htm
[184] "Asia's largest and leading wing wind tunnel" 亚洲最大和国内领先的翼型风洞, 西北工业大学, *NWPU*, October 2013. https://z.nwpu.edu.cn/info/1351/8246.htm
[185] "Asia's largest and leading wing wind tunnel" 亚洲最大和国内领先的翼型风洞, 西北工业大学, *NWPU*, October 2013. https://z.nwpu.edu.cn/info/1351/8246.htm
[186] "The National Key Laboratory of Aerodynamic Design and Research," *NWPU*, Accessed 2021, http://hangkong.nwpu.edu.cn/English/Research/LaboratoryxxxResearchxCenters/xxThexNationalxKeyxLaboratoryxofxAerodynamicxDes.htm
[187] "The National Key Laboratory of Aerodynamic Design and Research," *NWPU*, Accessed 2021, http://hangkong.nwpu.edu.cn/English/Research/LaboratoryxxxResearchxCenters/xxThexNationalxKeyxLaboratoryxofxAerodynamicxDes.htm
[188] "The National Key Laboratory of Aerodynamic Design and Research," *NWPU*, Accessed 2021, http://hangkong.nwpu.edu.cn/English/Research/LaboratoryxxxResearchxCenters/xxThexNationalxKeyxLaboratoryxofxAerodynamicxDes.htm
[189] "The National Key Laboratory of Aerodynamic Design and Research," *NWPU*, Accessed 2021, http://hangkong.nwpu.edu.cn/English/Research/LaboratoryxxxResearchxCenters/xxThexNationalxKeyxLaboratoryxofxAerodynamicxDes.htm
[190] "The National Key Laboratory of Aerodynamic Design and Research," *NWPU*, Accessed 2021, http://hangkong.nwpu.edu.cn/English/Research/LaboratoryxxxResearchxCenters/xxThexNationalxKeyxLaboratoryxofxAerodynamicxDes.htm
[191] "Key Lab of Antennas and Microwave Technology" [天线与微波技术重点实验室], Accessed 2021, https://amt.xidian.edu.cn/index.html
[192] "Introduction of National Key Laboratory of Radar Detection and Sensing" [雷达探测感知全国重点实验室简介], *Xidian University*, Accessed January 2025, https://amt.xidian.edu.cn/m/list.php?tid=11
[193] "Addition of Certain Entities; and Modification of Entry on the Entity List," *Federal Register*, 1 August 2018. https://www.federalregister.gov/documents/2018/08/01/2018-16474/addition-of-certain-entities-and-modification-of-entry-on-the-entity-list
[194] "Introduction of National Key Laboratory of Radar Detection and Sensing" [雷达探测感知全国重点实验室简介], *Xidian University*, Accessed January 2025, https://amt.xidian.edu.cn/m/list.php?tid=11
[195] "Business Overview" [企业概况], *CETC*, Accessed 2021, http://webcache.googleusercontent.com/search?q=cache%3A14.cetc.com.cn%2F14%2F338552%2F338540%2Findex.html&rlz=1C1CHBD_enUS895US895&oq=cache%3A14.cetc.com.cn%2F14%2F338552%2F338540%2Findex.html&aqs=chrome..69i57j69i58.1537j0j4&sourceid=chrome&ie=UTF-8
[196] "Addition of Certain Entities; and Modification of Entry on the Entity List," *Federal Register*, 1 August 2018. https://www.federalregister.gov/documents/2018/08/01/2018-16474/addition-of-certain-entities-and-modification-of-entry-on-the-entity-list
[197] "Introduction of National Key Laboratory of Radar Detection and Sensing" [雷达探测感知全国重点实验室简介], *Xidian University*, Accessed January 2025, https://amt.xidian.edu.cn/m/list.php?tid=11

[198] "Key Lab of Antennas and Microwave Technology" [天线与微波技术重点实验室], Accessed 2021, https://amt.xidian.edu.cn/index.html
[199] "Key Laboratory of Antenna and Microwave Technology Held 2018 Work Summary Meeting" [天线与微波技术重点实验室举办 2018 年工作总结会], *China Academy of Smart Internet of Things Engineering Technology* [中智物联工程技术研究院], 13 January 2019. http://www.siotchina.com/e/action/ShowInfo.php?classid=14&id=138
[200] "Key Laboratory of Antenna and Microwave Technology Held 2018 Work Summary Meeting" [天线与微波技术重点实验室举办 2018 年工作总结会], *China Academy of Smart Internet of Things Engineering Technology* [中智物联工程技术研究院], 13 January 2019. http://www.siotchina.com/e/action/ShowInfo.php?classid=14&id=138
[201] "Successful test flight! CEC's 14th institute innovates and develops the lightest and smallest radar-optical-electronic integrated ground sensing system in China" [成功试飞！中国电科 14 所创新研制国内最轻最小雷达光电一体化对地感知系统], *CETC*, 9 October 2024, https://www.cetc.com.cn/zgdk/1593322/1593325/1817512/index.html
[202] "Introduction of National Key Laboratory of Radar Detection and Sensing" [雷达探测感知全国重点实验室简介], *Xidian University*, Accessed January 2025, https://amt.xidian.edu.cn/m/list.php?tid=11
[203] "Key Laboratory of Antenna and Microwave Technology Held 2018 Work Summary Meeting" [天线与微波技术重点实验室举办 2018 年工作总结会], *China Academy of Smart Internet of Things Engineering Technology* [中智物联工程技术研究院], 13 January 2019. http://www.siotchina.com/e/action/ShowInfo.php?classid=14&id=138
"Key Laboratory of National Defense Science and Technology for Antenna and Microwave Technology" [天线与微波技术国防科技重点实验室], *Mancos-co* [蛋蛋赞], 20 July 2020. http://www.mancos-co.com/article-72-140072-0.html
[204] "Key Laboratory of Antenna and Microwave Technology Held 2018 Work Summary Meeting" [天线与微波技术重点实验室举办 2018 年工作总结会], *China Academy of Smart Internet of Things Engineering Technology* [中智物联工程技术研究院], 13 January 2019. http://www.siotchina.com/e/action/ShowInfo.php?classid=14&id=138
"Key Laboratory of National Defense Science and Technology for Antenna and Microwave Technology" [天线与微波技术国防科技重点实验室], *Mancos-co* [蛋蛋赞], 20 July 2020. http://www.mancos-co.com/article-72-140072-0.html
[205] "China reveals prototype configuration of jam-resistant and counter-stealth quantum radar," *Military and Aerospace Electronics*, 1 January 2019. https://www.militaryaerospace.com/home/article/16709670/china-reveals-prototype-configuration-of-jamresistant-and-counterstealth-quantum-radar
"Israel suspected of blowing up Syrian radar, this Chinese-made radar can detect stealthy aircraft" [疑似以色列炸毁叙军这款中国造雷达可探测隐身飞机], *Sina*, 24 January 2019. https://mil.news.sina.com.cn/jssd/2019-01-24/doc-ihrfqzka0492791.shtml
"Decrypting the 14th RI to see the world's five major combat early warning systems" [解密电科 14 所看遍全球"五大作战预警体系"], *China News* [中新网], 7 November 2018. https://m.chinanews.com/wap/detail/chs/zw/8670445.shtml and "Remembering China's radar's momentous years, taking the first move of science and technology innovation | CCTV Podium" [忆中国雷达的峥嵘岁月，走科技创新的先手棋 | 央广演讲台], *Sohu*, 8 March 2019. https://www.sohu.com/a/299891168_100170731
[206] "Graduate students from Key Laboratory of Antenna and Microwave Technology won the first prize of Mathworks Enterprise Competition in the 13th China Postgraduate Electronic Design Competition" [电院天线与微波技术重点实验室研究生在第十三届中国研究生电子设计竞赛中获 Mathworks 企业赛一等奖], *Xidian University*, 3 September 2018. https://amt.xidian.edu.cn/html/news/321.html
[207] "5G miniaturized high-performance antenna layout design solution" [5G 小型化高性能天线布局设计方案], *elecfans.com*, 27 March 2023, https://www.elecfans.com/application/Communication/2043888.html
[208] "Successful test flight! CEC's 14th institute innovates and develops the lightest and smallest radar-optical-electronic integrated ground sensing system in China" [成功试飞！中国电科 14 所创新研制国内最轻最小雷达光电一体化对地感知系统], *CETC*, 9 October 2024, https://www.cetc.com.cn/zgdk/1593322/1593325/1817512/index.html
[209] "Innovation breakthroughs, being in the key laboratory, they are very confident" [创新突破，身在重点实验室的他们很有信心], *Sohu*, 15 August 2019, https://www.sohu.com/a/333996317_779538

[210] "Key Lab of Antennas and Microwave Technology" [天线与微波技术重点实验室], Accessed 2021, https://amt.xidian.edu.cn/index.html
[211] "Hu Mingchun" [胡明春], *SciCat* [科学猫], 3 January 2021. http://www.scicat.cn/baike/20210103/4545446.html "Decrypting the 14th RI to see the world's five major combat early warning systems" [解密电科 14 所看遍全球"五大作战预警体系"], *China News* [中新网], 7 November 2018. https://m.chinanews.com/wap/detail/chs/zw/8670445.shtml
[212] "Decrypting the 14th RI to see the world's five major combat early warning systems" [解密电科 14 所看遍全球"五大作战预警体系"], *China News* [中新网], 7 November 2018. https://m.chinanews.com/wap/detail/chs/zw/8670445.shtml
[213] "Decrypting the 14th RI to see the world's five major combat early warning systems" [解密电科 14 所看遍全球"五大作战预警体系"], *China News* [中新网], 7 November 2018. https://m.chinanews.com/wap/detail/chs/zw/8670445.shtml
[214] "Lu Hongmin" [路宏敏], *X-MOL*, Accessed 2021, https://www.x-mol.com/university/faculty/203177
[215] "Shanghai Holevo Electronic System Technology Co." [上海霍莱沃电子系统技术股份有限公司], International *Intelligent Manufacturing Online Expo*, Accessed April 2025, https://www.icimexpo.com/View/Shop/Shop4348.html
[216] "Xidian University-Huawei Terminal Antenna Joint Lab inaugurated" [西安电子科技大学-华为终端天线联合实验室揭牌], *Xidian University*, 26 June 2018. https://amt.xidian.edu.cn/html/news/294.html
[217] "Joint Laboratory of Shanghai Supercomputing Center and Key Laboratory of Antenna and Microwave Technology (Xi'an Branch) was established" [上海超级计算中心-天线与微波技术重点实验室(西安分部)联合实验室成立], *EE Focus* [技术社区], 16 November 2010. https://rf.eefocus.com/article/id-260575
[218] "Key Lab of Antennas and Microwave Technology" [天线与微波技术重点实验室], Accessed 2021, https://amt.xidian.edu.cn/index.html
[219] "Key Lab of Antennas and Microwave Technology" [天线与微波技术重点实验室], Accessed 2021, https://amt.xidian.edu.cn/index.html
[220] "Xidian held the 2017 Annual Academic Conference of Key Laboratory of Antenna and Microwave Technology" [西电举办天线与微波技术重点实验室 2017 学术年会], *Sina*, 5 December 2017. http://blog.sina.com.cn/s/blog_7c6f3fe90102xoal.html
[221] "Xidian held the 2018 Annual Academic Conference of Key Laboratory of Antenna and Microwave Technology" [西电举办天线与微波技术重点实验室 2018 学术年会], *xdnice* [好网], 14 November 2018. https://www.xdnice.com/portal/article/index/id/18.html
[222] "Professor Tong Meisong from Tongji University visited Xidian for academic exchange" [同济大学童美松教授访问西电开展学术交流], *Xidian University*, 14 May 2019. https://amt.xidian.edu.cn/html/news/399.html
[223] "Key Lab of Antennas and Microwave Technology" [天线与微波技术重点实验室], Accessed 2021, https://amt.xidian.edu.cn/index.html
[224] "Key Lab of Antennas and Microwave Technology" [天线与微波技术重点实验室], Accessed 2021, https://amt.xidian.edu.cn/index.html
[225] "Key Lab of Antennas and Microwave Technology" [天线与微波技术重点实验室], Accessed 2021, https://amt.xidian.edu.cn/index.html
[226] "Honored Guests" [重磅嘉宾], *AWiTec*, Accessed October 2024, https://web.archive.org/web/20241003095711/http://www.awitec-cmm.com/jiabin/
[227] "The 9th Conference on Microwave Photonics Technology and Applications" [第九届微波光子学技术及应用会议], *NCSTI*, Accessed January 2025, https://www.ncsti.gov.cn/kcfw/hy/202407/P020240729621436553050.pdf
[228] "The 14th International Conference on Antennas, Propagation and Electromagnetic Theory in Hefei" [第十四届天线、传播及电磁理论国际会议在合肥召开], *Chinese Journal of Radio Science*, 3 November 2024, http://www.cjors.cn/news/217 (not saved as pdf because it was massive for some reason, but should be saved in Internet Archive)
[229] "Key Lab of Antennas and Microwave Technology" [天线与微波技术重点实验室], Accessed 2021, https://amt.xidian.edu.cn/index.html

[230] "Professor Gao Shichang from University of Kent visited Xidian to talk about "Compact MIMO antennas for 5G and next generation mobile terminals" [英国肯特大学高式昌教授访问西电开展学术交流 讲述“应用于 5G 及下一代移动终端的紧凑型 MIMO 天线”], Key Laboratory of Antennas and Microwave Technology, 29 August 2019. https://amt.xidian.edu.cn/html/news/421.html
[231] "Professor Gao Shichang from University of Kent visited Xidian to talk about "Compact MIMO antennas for 5G and next generation mobile terminals" [英国肯特大学高式昌教授访问西电开展学术交流 讲述“应用于 5G 及下一代移动终端的紧凑型 MIMO 天线”], Key Laboratory of Antennas and Microwave Technology, 29 August 2019. https://amt.xidian.edu.cn/html/news/421.html
[232] "Professor Gao Shichang from University of Kent visited Xidian to talk about "Compact MIMO antennas for 5G and next generation mobile terminals" [英国肯特大学高式昌教授访问西电开展学术交流 讲述“应用于 5G 及下一代移动终端的紧凑型 MIMO 天线”], Key Laboratory of Antennas and Microwave Technology, 29 August 2019. https://amt.xidian.edu.cn/html/news/421.html
[233] “Introduction of National Key Laboratory of Radar Detection and Sensing” [雷达探测感知全国重点实验室简介], *Xidian Universit*y, Accessed January 2025, https://amt.xidian.edu.cn/m/list.php?tid=11
[234] "China's new world-class aero-engine high-altitude simulation laboratory" [我国新建世界水平航空发动机高空模拟试验室], *Sina*, 23 August 2012, http://mil.news.sina.com.cn/2012-08-23/1707698833.html
[235] "Teachers from College of Aeronautics and Astronautics went to the Key Laboratory of Aero-engine High Altitude Simulation Technology for research and exchange" [航空学院教师赴航空发动机高空模拟技术重点实验室调研交流], *Chongqing Jiao Tong University*, 14 August 2023, https://news.cqjtu.edu.cn/info/1026/52676.htm
[236] "China's new world-class aero-engine high-altitude simulation laboratory" [我国新建世界水平航空发动机高空模拟试验室], *Sina*, 23 August 2012, http://mil.news.sina.com.cn/2012-08-23/1707698833.html
[237] "Sichuan Gas Turbine Research Institute of AECC" [中国航发四川燃气涡轮研究院], *Chinese Society of Aeronautics and Astronautics,* 12 August 2019, http://www.csaa.org.cn/art/2019/8/12/art_451_52037.html
[238] "China's aero-engine development is blowing up with a new high-altitude simulation base“ [中国航空发动机呈井喷式发展 新建高空模拟基地], *Qingdao News*, 31 July 2013, https://www.qingdaonews.com/content/2013-07/31/content_9893803_all.htm
"Aviation Power Explorer" [航空动力探索者], *Anhui Jingwen Education Technology Equipment Co.* [安徽省京文教育技术装备有限公司], June 2016, https://www.ahszyd.com/home/periodical/articleDetail?articleId=1513576
[239] "Aviation Power Explorer" [航空动力探索者], *Anhui Jingwen Education Technology Equipment* Co.[安徽省京文教育技术装备有限公司], June 2016, https://www.ahszyd.com/home/periodical/articleDetail?articleId=1513576
[240] "One Minute with AECC|Daily Learning: Be grateful to your rivals, improve in competition" [一分钟看懂中国航发|每日一学：感恩对手，在竞争中进步], *Sohu*, 23 August 2018, https://www.sohu.com/a/249627973_673674
[241] "Liu Daxiang Anthology" [刘大响文集], *Aviation Industry Press* [航空工业出版社], 1 March 2016, http://lianmeng.tsxcfw.com/bookshow.asp?id=1028089#
[242] "Teachers from College of Aeronautics and Astronautics went to the Key Laboratory of Aero-engine High Altitude Simulation Technology for research and exchange" [航空学院教师赴航空发动机高空模拟技术重点实验室调研交流], *Chongqing Jiao Tong University*, 14 August 2023, https://news.cqjtu.edu.cn/info/1026/52676.htm
[243] "China's new world-class aero-engine high-altitude simulation laboratory" [我国新建世界水平航空发动机高空模拟试验室], *Sina*, 23 August 2012, http://mil.news.sina.com.cn/2012-08-23/1707698833.html
[244] "AECC 2019 Science and Technology Innovation Platform Program Guidelines" [中国航空发动机集团 2019 年度科技创新平台项目指南], *Aero Engine Corporation of China*, 14 November 2019, https://msc.nuaa.edu.cn/_upload/article/files/e0/a8/650a77be49749953c973ff22c006/e648fb81-04ba-441e-8d97-4fe1838fd77f.pdf
He Peilei [何培垒] et al., "Evaluation of exhaust layout for separate exhaust turbofan engine tests" [分开排气大涵道比涡扇发动机高空模拟试验排气布局评估], *Gas Turbine Testing and Research* [燃气涡轮试验与研究], 2015 (2), http://webcache.googleusercontent.com/search?client=firefox-b-1-d&q=cache%3Awww.jasp.com.cn%2Fjasp_cn%2Farticle%2Fview_reference%3Fjid%3D0213C2506A3B3B1127BE7E0518FFD838%26aid%3DD3314E8F91234B4D6A6658D0B9A8AC53%26yid%3DFFD10F7019FAA9EC%26iid%3D0B39A22176CE99FB

Ma Qianrong [马前容] et al., "Technical research requirements for high bypass-ratio turbofan engine test at the simulated altitude test facility" [大涵道比涡扇发动机高空台试验技术研究需求分析], *Gas Turbine Testing and Research* [燃气涡轮试验与研究], 2015 (1), http://webcache.googleusercontent.com/search?client=firefox-b-1-d&q=cache%3Awww.jasp.com.cn%2Fjasp_cn%2Farticle%2Fview_reference%3Fpcid%3D26FCEE7E0C06EA5863D91553F1CAF79C693AA6D910AD699D%26cid%3DCC2B5CBBB526AA32%26jid%3D0213C2506A3B3B1127BE7E0518FFD838%26aid%3D81234F5C6AFD011BC4DA3A1D01E8E1D1%26yid%3DFFD10F7019FAA9EC%26vid%3D2B25C5E62F83A049%26iid%3DCA4FD0336C81A37A%26sid%3D7C3A4C1EE6A45749%26eid%3D1AE5323881A5ECDC

Zhao Tong [赵涌] et al., "An improved thrust measurement method for aero-engine high-altitude simulation tests" [一种改进的航空发动机高空模拟试验推力测量方法], *Gas Turbine Testing and Research* [燃气涡轮试验与研究], 2020 (2), http://www.cqvip.com/qk/85037x/202002/7101986353.html

"China's new world-class aero-engine high-altitude simulation laboratory" [我国新建世界水平航空发动机高空模拟试验室], *Sina*, 23 August 2012, http://mil.news.sina.com.cn/2012-08-23/1707698833.html

[245] "Turbine Academy Visits Students on Dragon Boat Festival" [端午节中国航发涡轮院慰问课题组同学], *Xi'an Jiao Tong University*, 2 June 2022, https://gr.xjtu.edu.cn/en/web/qiao1224/home?p_p_id=cn_edu_xjtu_news_NewsPortlet&p_p_lifecycle=0

[246] "AECC 2019 Science and Technology Innovation Platform Program Guidelines" [中国航空发动机集团 2019 年度科技创新平台项目指南], *Aero Engine Corporation of China*, 14 November 2019, https://msc.nuaa.edu.cn/_upload/article/files/e0/a8/650a77be49749953c973ff22c006/e648fb81-04ba-441e-8d97-4fe1838fd77f.pdf

[247] "Ma Hongwei" [马宏伟], *x-mol*, Accessed February 2024, https://www.x-mol.com/university/faculty/220986

[248] "CAE Academician Liu Daxiang" [中国工程院院士：刘大响], *Liu Family Online* [刘氏家族], 6 June 2022, https://www.liushijiazu.com/archives/8539

[249] "Teachers from College of Aeronautics and Astronautics went to the Key Laboratory of Aero-engine High Altitude Simulation Technology for research and exchange" [航空学院教师赴航空发动机高空模拟技术重点实验室调研交流], *Chongqing Jiao Tong University*, 14 August 2023, https://news.cqjtu.edu.cn/info/1026/52676.htm

[250] "The Fifth Aero-engine Key Manufacturing Technology Innovation Development Forum" [第五届航空发动机关键制造技术创新发展论坛], *Hangkonghui* [航空汇], 24 Novemebr 2020, http://acaw.com.cn/huodongneirong.php?id=723; http://acaw.com.cn/huodongneirong.php?id=735

[251] "Forum22 Event Sponsors," *GPPS*, Accessed February 2024, https://gpps.global/forum22-event-sponsor/

"Aviation Day," https://gpps.global/gpps-forum22-day-one/

"Speakers," https://gpps.global/forum22-speakers/

[252] "China's new world-class aero-engine high-altitude simulation laboratory" [我国新建世界水平航空发动机高空模拟试验室], *Sina*, 23 August 2012, http://mil.news.sina.com.cn/2012-08-23/1707698833.html

[253] "Sichuan Gas Turbine Research Institute of AECC" [中国航发四川燃气涡轮研究院], *Chinese Society of Aeronautics and Astronautics*, 12 August 2019, http://www.csaa.org.cn/art/2019/8/12/art_451_52037.html

Zhang Song [张松] et al., "Research status of engine air intake pressure control based on ESO" [基于 ESO 的高空台发动机进气压力控制研究进展], *Science and Technology Review* [科技导报], 2021 39(11), http://www.kjdb.org/CN/abstract/abstract16354.shtml

[254] Ma Changyou [马昌友] et al., "CDFS Performance Measurement in Matched Environments Based on Static Leaf Characterization" [基于静叶特性的匹配环境下 CDFS 性能测量方法], *Turbine Test and Research 2018*, *Volume 1* [燃气涡轮试验与研究 2018 年 1 期], 23 March 2018, https://m.fx361.com/news/2018/0323/13032064.html

"China's new world-class aero-engine high-altitude simulation laboratory" [我国新建世界水平航空发动机高空模拟试验室], *Sina*, 23 August 2012, http://mil.news.sina.com.cn/2012-08-23/1707698833.html

[255] "Key Laboratory of Aerospace Plasma Dynamics for National Defense Science and Technology was established" [航空等离子体动力学国防科技重点实验室成立], *Science Net*, 28 May 2011. http://blog.sciencenet.cn/blog-80228-448970.html

[256] "Key Laboratory of Aerospace Plasma Dynamics for National Defense Science and Technology was established" [航空等离子体动力学国防科技重点实验室成立], *Science Net*, 28 May 2011. http://blog.sciencenet.cn/blog-80228-448970.html

"Establishment of national key laboratories" [建立国家级重点实验室], *PLA Air Force Engineering University* [空军工程大学], Accessed 2021, http://www.afeu.cn:2002/tuji/show-231.html

[257] "Key Laboratory of Aerospace Plasma Dynamics for National Defense Science and Technology was established" [航空等离子体动力学国防科技重点实验室成立], *Science Net*, 28 May 2011. http://blog.sciencenet.cn/blog-80228-448970.html

"Establishment of national key laboratories" [建立国家级重点实验室], *PLA Air Force Engineering University* [空军工程大学], Accessed 2021, http://www.afeu.cn:2002/tuji/show-231.html

"Notice on Forwarding the Project Guidelines of China Aerospace Plasma Dynamics Key Laboratory" [关于转发中国航空等离子体动力学重点实验室项目指南的通知], *Jiangxi Normal University* [江西师范大学], 8 October 2019. http://kcb.jsnu.edu.cn/2d/6a/c3442a273770/page.htm

[258] "Notice on Forwarding the Project Guidelines of China Aerospace Plasma Dynamics Key Laboratory" [关于转发中国航空等离子体动力学重点实验室项目指南的通知], *Jiangxi Normal University* [江西师范大学], 8 October 2019. http://kcb.jsnu.edu.cn/2d/6a/c3442a273770/page.htm

[259] "Chinese plasma lab established to lay foundation for advanced warplane development" [中国等离子实验室成立为先进战机研发奠定基础], *Sina*, 14 May 2011. http://mil.news.sina.com.cn/2011-05-14/1112647133.html

[260] "Notice on Forwarding the Project Guidelines of China Aerospace Plasma Dynamics Key Laboratory" [关于转发中国航空等离子体动力学重点实验室项目指南的通知], *Jiangxi Normal University* [江西师范大学], 8 October 2019. http://kcb.jsnu.edu.cn/2d/6a/c3442a273770/page.htm

[261] "Academician Li Yinghong from Air Force Engineering University visited the institute for academic exchange" [空军工程大学李应红院士到所进行学术交流], *CAS Institute of Engineering Thermophysics* [中国科学院工程热物理研究所], 4 December 2014. http://www.iet.cn/xwdt/zhxw/201412/t20141204_4268087.html

[262] "The second in the world! China's plasma technology made public for the first time Flying wing bomber has no bottleneck" [全球第二家！中国等离子技术首次公开 飞翼式轰炸机已无瓶颈], *Sina*, 16 September 2019. https://k.sina.cn/article_1743965223_67f2cc2700100lz3k.html?from=mil

"Heavyweight! Domestic stealth bomber key technology first public appearance: after B2 ranked second in the world" [重磅！国产隐身轰炸机关键技术首次公开亮相：B2 之后排世界第二], *Sohu*, 16 September 2019. https://www.sohu.com/a/341150613_808513

[263] "Heavyweight! Domestic stealth bomber key technology first public appearance: after B2 ranked second in the world" [重磅！国产隐身轰炸机关键技术首次公开亮相：B2 之后排世界第二], *Sohu*, 16 September 2019. https://www.sohu.com/a/341150613_808513

[264] "Heavyweight! Domestic stealth bomber key technology first public appearance: after B2 ranked second in the world" [重磅！国产隐身轰炸机关键技术首次公开亮相：B2 之后排世界第二], *Sohu*, 16 September 2019. https://www.sohu.com/a/341150613_808513

[265] "He Weifeng, Associate Professor of Air Force Engineering University - Arriving at the dream in the silent trek" [空军工程大学副教授何卫锋——在默默跋涉中抵达梦想], *Xinhua*, 11 May 2017. http://www.xinhuanet.com//mil/2017-05/11/c_129601128.htm

[266] "Key Laboratory of Aerospace Plasma Dynamics for National Defense Science and Technology was established" [航空等离子体动力学国防科技重点实验室成立], *Science Net*, 28 May 2011. http://blog.sciencenet.cn/blog-80228-448970.html

"Li Yinghong" [李应红], *Xi'an Jiaotong University* [西安交通大学], 13 August 2020. http://iafe.xjtu.edu.cn/info/1081/6141.htm

"Li Yinghong, a delegate to the 19th National Congress: He makes warplanes soar over the Tibetan plateau" [十九大代表李应红：他让战机在青藏高原上空翱翔], *81.cn*, 15 October 2017. http://www.81.cn/jwgz/2017-10/15/content_7787362.htm

[267] "Heavyweight! Domestic stealth bomber key technology first public appearance: after B2 ranked second in the world" [重磅！国产隐身轰炸机关键技术首次公开亮相：B2 之后排世界第二], *Sohu*, 16 September 2019. https://www.sohu.com/a/341150613_808513

"Professor Wu Yun from Air Force Engineering University visited our university and gave an academic report" [空军工程大学吴云教授访问我校并做学术报告], *NUAA* [南京航空航天大学], 25 February 2018. http://cepe.nuaa.edu.cn/2018/0225/c2405a113479/page.htm

[268] “We have solved a world problem, the world's first technology” [我们解决了一项世界性难题，这技术全球首创], *iXigua* [西瓜视频], 18 August 2018. https://www.ixigua.com/6590617053558735373?wid_try=1
“Xi'an Space Base and Xi'an Jiaotong University signed a contract yesterday for the cooperation project on intelligent manufacturing of air and space energy and power” [西安航天基地与西安交通大学 空天能源动力智能制造产学研合作项目昨签约], *S&T Daily*, 21 August 2017. http://www.stdaily.com/zhuanti01/hangtian/2017-08/21/content_570656.shtml
[269] “Company Profile” [公司简介], *Xi'an Aerospace Purple Discharge Plasma Tech* [空天紫电], Accessed 2021, http://ktzidian.com/c/guanyuzidian.html
[270] Per a search of two academic journal databases.
[271] "PASSKEy," *Plasma-tech.net*, Accessed April 2025, http://www.plasma-tech.net/parser/passkey/
[272] "2023 International Conference on Surface Science Technology and Application (ICSSTA 2023)" [2023 国际表面科学技术与应用大会], *ICCSTA 2023*, Accessed January 2025, https://icssta2023.scimeeting.cn/cn/web/index/16562_
[273] “The 1st International Symposium on Thermal and Fluid Dynamics was held” [第一届热与流体动力学国际研讨会举行, 西安交通大学], *Xi’an Jiaotong University*, 7 August 2019. http://news.xjtu.edu.cn/info/1033/6110.htm
[274] “Professor Wu Yun from Air Force Engineering University visited our university and gave an academic report” [空军工程大学吴云教授访问我校并做学术报告], *NUAA* [南京航空航天大学], 25 February 2018. http://cepe.nuaa.edu.cn/2018/0225/c2405a113479/page.htm
[275] “Tsinghua Institute of Aeronautics and Astronautics hosts the 9th International Symposium on Explosive Propulsion” [清华航院主办第九届国际爆震推进研讨会], *Tsinghua University*, 19 September 2018. https://news.tsinghua.edu.cn/info/1007/53576.htm
[276] “Notice on Forwarding the Project Guidelines of China Aerospace Plasma Dynamics Key Laboratory” [关于转发中国航空等离子体动力学重点实验室项目指南的通知], *Jiangxi Normal University* [江西师范大学], 8 October 2019. http://kcb.jsnu.edu.cn/2d/6a/c3442a273770/page.htm
[277] “China's official exposure of the Key Laboratory of National Defense Science and Technology for Ballistic Missile Technology is informative” [中国官方曝光弹道导弹突防技术国防科技重点实验室，信息量大], kknews, 20 May 2017. https://kknews.cc/zh-my/military/ao8r2ln.html
[278] Wang Li [王莉], Liu Xin [刘馨], "Who says women can't study missiles! She just doesn't believe it" [阳谁说女人不能研究导弹！她还就是不信邪了], 81.cn, 18 January 2019. Accessed June 2021. http://www.81.cn/depb/2019-01/18/content_9383899.htm
[279] "Why is the research capacity here rocketing?" [为啥这里的科研能力像坐了火箭？], People.cn, 5 February 2021. http://scitech.people.com.cn/n1/2021/0205/c1007-32023373.html
[280] “China's official exposure of the Key Laboratory of National Defense Science and Technology for Ballistic Missile Technology is informative” [中国官方曝光弹道导弹突防技术国防科技重点实验室，信息量大], kknews, 20 May 2017. https://kknews.cc/zh-my/military/ao8r2ln.html
[281] Wang Li [王莉], Liu Xin [刘馨], "Who says women can't study missiles! She just doesn't believe it" [阳谁说女人不能研究导弹！她还就是不信邪了], 81.cn, 18 January 2019. Accessed June 2021. http://www.81.cn/depb/2019-01/18/content_9383899.htm
[282] Liu Xuemei [刘雪梅] et al., "Multiobjective Optimization Algorithm of Survivability of Ballistic Missile in Boost Phase" [弹道导弹助推段突防多目标优化设计方法分享到], Journal Of Ballistics, 22, 2010. http://ddxb.paperopen.com/oa/darticle.aspx?type=view&id=100210
Liu Xuemei [刘雪梅] et al., "To penetrate missile defenses, breaching technology can be "three-handed"" [刺破导弹防御系统，突防技术可施“三手”], 21 October 2016. https://kknews.cc/military/9reepb.html
[283] "Second Artillery Researcher Explains U.S. Missile Defense System: Hard to Identify Fake Warheads" [二炮研究员解读美导弹防御系统：难识别假弹头], Sina, 22 July 2013. http://mil.news.sina.com.cn/2013-07-22/0519732220.html
[284] Liu Xuemei [刘雪梅] et al., "Multiobjective Optimization Algorithm of Survivability of Ballistic Missile in Boost Phase" [弹道导弹助推段突防多目标优化设计方法分享到], Journal Of Ballistics, 22, 2010. http://ddxb.paperopen.com/oa/darticle.aspx?type=view&id=100210

[285] Wang Degang [王德港] et al., "Twin neural network-based anomaly detection in hyperspectral images" [基于孪生神经网络的高光谱图像异常检测], Journal of Image and Graphics (8) 2021. http://www.cjig.cn/jig/ch/reader/view_abstract.aspx?edit_id=20210714151252001&flag=2&file_no=202102010000006&journal_id=jig
[286] Liu Xuemei [刘雪梅] et al., "Multiobjective Optimization Algorithm of Survivability of Ballistic Missile in Boost Phase" [弹道导弹助推段突防多目标优化设计方法分享到], Journal Of Ballistics, 22, 2010. http://ddxb.paperopen.com/oa/darticle.aspx?type=view&id=100210
[287] "National Key Laboratory of Transient Physics, Nanjing University of Science and Technology (NUST) Announcement of 2024 Summer Camp for Outstanding Undergraduates" [南京理工大学瞬态物理全国重点实验室 2024 年全国"优秀大学生夏令营"活动公告], *Baoyan 360*, 21 June 2024, https://baoyan360.com/h-nd-24719.html
[288] "Lab Introduction" [实验室简介], *National Key Laboratory of Transient Physics*, Accessed April 2025, https://zdsys.njust.edu.cn/sysjj/list.htm
"Lab Overview, State Key Laboratory of Transient Physics" [实验室简介, 瞬态物理国家重点实验室, Accessed 2021, http://zdsys.njust.edu.cn/sysjj/list.htm
"State Key Laboratory of Transient Physics" [瞬态物理国家重点实验室], *NJUST*, Accessed 2021, http://kyy.njust.edu.cn/8f/1e/c4975a102174/page.htm
[289] "State Key Laboratory of Transient Physics" [瞬态物理国家重点实验室], *NJUST*, Accessed 2021, http://kyy.njust.edu.cn/8f/1e/c4975a102174/page.htm
[290] "December 2-4, 1992, the Key Laboratory of Ballistic Defense Science and Technology was established " [1992 年 12 月 2 日至 4 日，弹道国防科技重点实验室成立], *NJUST* [南京理工大学], 14 October 2020. http://www.njust.edu.cn/_t155/b4/cf/c12762a242895/page.htm
[291] "State Key Laboratory of Transient Physics" [瞬态物理国家重点实验室, *NJUST*, Accessed 2021, kyy.njust.edu.cn/8f/1e/c4975a102174/page.htm
"Lab Overview, State Key Laboratory of Transient Physics" [实验室简介, 瞬态物理国家重点实验室, Accessed 2021, http://zdsys.njust.edu.cn/sysjj/list.htm
"State Key Laboratory of Transient Physics" [瞬态物理国家重点实验室], *NJUST*, Accessed 2021, http://kyy.njust.edu.cn/8f/1e/c4975a102174/page.htm
[292] "National Key Laboratory of Transient Physics, Nanjing University of Science and Technology (NUST) Announcement of 2024 Summer Camp for Outstanding Undergraduates" [南京理工大学瞬态物理全国重点实验室 2024 年全国"优秀大学生夏令营"活动公告], *Baoyan 360*, 21 June 2024, https://baoyan360.com/h-nd-24719.html
[293] "State Key Laboratory of Transient Physics, Nanjing University of Science and Technology Recruitment" [南京理工大学瞬态物理国家重点实验室招聘], *Muchong* [木虫], Accessed 2021, http://muchong.com/html/201909/13671592.html
"Research Achievements, State Key Laboratory of Transient Physics" [科研成果, 瞬态物理国家重点实验室], *State Key Laboratory of Transient Physics*, 28 November 2020. zdsys.njust.edu.cn/kycg/list.htm
[294] "Organization of the State Key Laboratory of Transient Physics" [瞬态物理国家重点实验室组织机构], *State Key Laboratory of Transient Physics* [瞬态物理国家重点实验室], Accessed 2021, http://zdsys.njust.edu.cn/zzjg/list.htm
[295] "State Key Laboratory of Transient Physics" [瞬态物理国家重点实验室], *NJUST*, Accessed 2021, http://kyy.njust.edu.cn/8f/1e/c4975a102174/page.htm
"National Network Management Platform for Scientific Research Facilities and Instruments" [科研设施与仪器国家网络管理平台], *NRII.org*, Accessed 2021, http://webcache.googleusercontent.com/search?q=cache%3Ahttps%3A%2F%2Fnrii.org.cn%2Fsearch%2Fds.do%3FinstruID%3D3640%26instruType%3D%E9%87%8D%E5%A4%A7%E7%A7%91%E7%A0%94%E5%9F%BA%E7%A1%80%E8%AE%BE%E6%96%BD&rlz=1C1CHBD_enUS895US895&oq=cache%3Ahttps%3A%2F%2Fnrii.org.cn%2Fsearch%2Fds.do%3FinstruID%3D3640%26instruType%3D%E9%87%8D%E5%A4%A7%E7%A7%91%E7%A0%94%E5%9F%BA%E7%A1%80%E8%AE%BE%E6%96%BD&aqs=chrome..69i57j69i58.1578j0j4&sourceid=chrome&ie=UTF-8

[296] "Nanjing Zhuangda Intelligent Technology Research Institute Co." [南京壮大智能科技研究院有限公司], *YouUAV*, Accessed April 2025, https://www.youuav.com/shop/4992/about/
[297] "Lab Introduction" [实验室简介], *National Key Laboratory of Transient Physics*, Accessed April 2025, https://zdsys.njust.edu.cn/sysjj/list.htm
[298] "State Key Laboratory of Transient Physics" [瞬态物理国家重点实验室], *NJUST*, Accessed 2021, http://kyy.njust.edu.cn/8f/1e/c4975a102174/page.htm
[299] "China's new concept of weapons surfaced, the value of the actual battle compared to the electromagnetic gun, speed of more than Mach 6" [我国新概念武器浮出水面，实战价值比肩电磁炮，速度超 6 马赫], *Sohu*, 30 July 2019. https://www.sohu.com/a/330308400_120087602
Li Hongzhi [李鸿志], "Progress in the Research of Electrothermal Chemical Launch Technology--Review of the New Concept Research in the China National Defense Key Laboratory of Ballistics in the Past Decade" [电热化学发射技术的研究进展--弹道国防科技重点实验室新概念研究 10 年], *JOURNAL OF NANJING UNIVERSITY OF SCIENCE AND TECHNOLOGY* (27) 2003. http://industry.wanfangdata.com.cn/dl/Detail/Periodical?id=Periodical_njlgdxxb200305001
[300] "The Fifth Academic Committee Meeting of the State Key Laboratory of Transient Physics was held in our university" [瞬态物理国家重点实验室第五届学术委员会会议在我校召开], *NJUST*, 10 December 2018. http://www.njust.edu.cn/d6/af/c3624a186031/page.htm
[301] "The Fifth Academic Committee Meeting of the State Key Laboratory of Transient Physics was held in our university" [瞬态物理国家重点实验室第五届学术委员会会议在我校召开], *NJUST*, 10 December 2018. http://www.njust.edu.cn/d6/af/c3624a186031/page.htm
[302] "Current Leadership" [现任领导], *National Key Laboratory of Transient Physics*, Accessed April 2025, https://zdsys.njust.edu.cn/fzlc/list.htm
"Liu Jiyuan, former general manager of China Aerospace Industry Corporation, Hu Shixiang, former deputy minister of General Armament Department, and Zhang Rui, former deputy commander of the Second Artillery, came to our university for investigation and research" [中国航天工业总公司原总经理刘纪原、总装备部原副部长胡世祥、第二炮兵原副司令员张瑞一行来我校考察调研], *NJUST*, 11 May 2017. http://www.njust.edu.cn/35/f3/c3624a144883/page.htm
"State Key Laboratory of Transient Physics, State Key Laboratory of Transient Physics" [瞬态物理重点实验室现任党政领导, 瞬态物理国家重点实验室], Accessed 2021, http://zdsys.njust.edu.cn/fzlc/list.htm
[303] "Current Leadership" [现任领导], *National Key Laboratory of Transient Physics*, Accessed April 2025, https://zdsys.njust.edu.cn/fzlc/list.htm
[304] "Current Leadership" [现任领导], *National Key Laboratory of Transient Physics*, Accessed April 2025, https://zdsys.njust.edu.cn/fzlc/list.htm
[305] "Current Leadership" [现任领导], *National Key Laboratory of Transient Physics*, Accessed April 2025, https://zdsys.njust.edu.cn/fzlc/list.htm
[306] "The 2016 Ballistics Academic Conference of the Ballistics Professional Committee of the Chinese Society of Military Industry was held in Beijing" [中国兵工学会弹道专业委员会 2016 年弹道学术会议在北京召开], *NJUST*, 31 October 2016. http://www.njust.edu.cn/2016/1101/c3624a132063/page.psp
"Li Hongzhi" [李鸿志], *CKCEST* [中国工程院院士馆], Accessed 2021, https://ysg.ckcest.cn/html/details/1843/index.html
"State Key Laboratory of Transient Physics, Everyone is Elegant" [大家风采, 瞬态物理国家重点实验室], Accessed 2021, zdsys.njust.edu.cn/11768/list.htm
[307] "The inaugural meeting of Water Ballistics Collaborative Innovation Center was held in our university" [我校隆重召开水中弹道协同创新中心成立大会], *NJUST*, 9 January 2017. http://www.njust.edu.cn/16/c8/c3624a136904/page.htm
[308] "The 2016 Ballistics Academic Conference of the Ballistics Professional Committee of the Chinese Society of Military Industry was held in Beijing" [中国兵工学会弹道专业委员会 2016 年弹道学术会议在北京召开], *NJUST*, 31 October 2016. http://www.njust.edu.cn/2016/1101/c3624a132063/page.psp

"The 2017 Ballistics Academic Conference of the Ballistics Professional Committee of the Chinese Society of Military Industry was held in Zhengzhou" [中国兵工学会弹道专业委员会 2017 年弹道学术会议在郑州召开], *NJUST*, 30 October 2017. http://www.njust.edu.cn/6e/eb/c3624a159467/page.htm
"Call for Papers for the 2021 Ballistics Conference of the Ballistics Professional Committee of the Chinese Society of Military Industry" [中国兵工学会弹道专业委员会 2021 年弹道学术会议征文通知], *National Key Lab of Transient Physics*, 27 February 2021. http://zdsys.njust.edu.cn/dd/14/c12476a253204/page.htm
[309] "Research Achievements, State Key Laboratory of Transient Physics" [科研成果, 瞬态物理国家重点实验室], *NJUST*, 28 November 2020. zdsys.njust.edu.cn/kycg/list.htm
[310] "Liu Jiyuan, former general manager of China Aerospace Industry Corporation, Hu Shixiang, former deputy minister of General Armament Department, and Zhang Rui, former deputy commander of the Second Artillery, came to our university for investigation and research" [中国航天工业总公司原总经理刘纪原、总装备部原副部长胡世祥、第二炮兵原副司令员张瑞一行来我校考察调研], *NJUST*, 11 May 2017. http://www.njust.edu.cn/35/f3/c3624a144883/page.htm
[311] "Lab Introduction" [实验室简介], *National Key Laboratory of Transient Physics*, Accessed April 2025, https://zdsys.njust.edu.cn/sysjj/list.htm
[312] "Clive Russell Woodley, President of the International Ballistic Society (IBS), was invited to visit the university" [国际弹道学会（IBS）主席 Clive Russell Woodley 受邀来校访问], *NJUST*, 3 November 2016. http://www.njust.edu.cn/04/ea/c3624a132330/page.htm
[313] "National Network Management Platform for Scientific Research Facilities and Instruments" [科研设施与仪器国家网络管理平台], *NRII.org*, Accessed 2021, http://webcache.googleusercontent.com/search?q=cache%3Ahttps%3A%2F%2Fnrii.org.cn%2Fsearch%2Fds.do%3FinstruID%3D3640%26instruType%3D%E9%87%8D%E5%A4%A7%E7%A7%91%E7%A0%94%E5%9F%BA%E7%A1%80%E8%AE%BE%E6%96%BD&rlz=1C1CHBD_enUS895US895&oq=cache%3Ahttps%3A%2F%2Fnrii.org.cn%2Fsearch%2Fds.do%3FinstruID%3D3640%26instruType%3D%E9%87%8D%E5%A4%A7%E7%A7%91%E7%A0%94%E5%9F%BA%E7%A1%80%E8%AE%BE%E6%96%BD&aqs=chrome..69i57j69i58.1578j0j4&sourceid=chrome&ie=UTF-8
[314] "Lab Introduction" [实验室简介], *National Key Laboratory of Transient Physics*, Accessed April 2025, https://zdsys.njust.edu.cn/sysjj/list.htm
[315] "Lab Introduction" [实验室简介], *National Key Laboratory of Transient Physics*, Accessed April 2025, https://zdsys.njust.edu.cn/sysjj/list.htm
[316] "Lab Introduction" [实验室简介], *National Key Laboratory of Transient Physics*, Accessed April 2025, https://zdsys.njust.edu.cn/sysjj/list.htm
[317] "National Network Management Platform for Scientific Research Facilities and Instruments" [科研设施与仪器国家网络管理平台], *NRII.org*, Accessed 2021, http://webcache.googleusercontent.com/search?q=cache%3Ahttps%3A%2F%2Fnrii.org.cn%2Fsearch%2Fds.do%3FinstruID%3D3640%26instruType%3D%E9%87%8D%E5%A4%A7%E7%A7%91%E7%A0%94%E5%9F%BA%E7%A1%80%E8%AE%BE%E6%96%BD&rlz=1C1CHBD_enUS895US895&oq=cache%3Ahttps%3A%2F%2FnriF.org.cn%2Fsearch%2Fds.do%3FinstruID%3D3640%26instruType%3D%E9%87%8D%E5%A4%A7%E7%A7%91%E7%A0%94%E5%9F%BA%E7%A1%80%E8%AE%BE%E6%96%BD&aqs=chrome..69i57j69i58.1578j0j4&sosource=chrome&ie=UTF-8
"State Key Laboratory of Transient Physics" [瞬态物理国家重点实验室], NJUST, Accessed 2021, http://kyy.njust.edu.cn/8f/1e/c4975a102174/page.htm
[318] "Key Laboratory of Transient Physics" [瞬态物理国家重点实验室], *Baidu Baike*, Accessed 2021, https://baike.baidu.com/item/%E7%9E%AC%E6%80%81%E7%89%A9%E7%90%86%E5%9B%BD%E5%AE%B6%E9%87%8D%E7%82%B9%E5%AE%9E%E9%AA%8C%E5%AE%A4
[319] "National Network Management Platform for Scientific Research Facilities and Instruments" [科研设施与仪器国家网络管理平台], *NRII.org*, Accessed 2021, http://webcache.googleusercontent.com/search?q=cache%3Ahttps%3A%2F%2Fnrii.org.cn%2Fsearch%2Fds.do%3FinstruID%3D3640%26instruType%3D%E9%87%8D%E5%A4%A7%E7%A7%91%E7%A0%94%E5%9F%BA%E7%A1%80%E8%AE%BE%E6%96%BD&rlz=1C1CHBD_enUS895US895&oq=cache%3Ahttps%3A%2F%2Fnrii.org.cn%2Fsearch%2Fds.do%3FinstruID%3D3640%26instruType%3D%E9%87%8D%E5%A4%A7%E7%A7%91

%E7%A0%94%E5%9F%BA%E7%A1%80%E8%AE%BE%E6%96%BD&aqs=chrome..69i57j69i58.1578j0j4&sourceid=chrome&ie=UTF-8

[320] "Introduction to Gui Mingyue, Supervisor of the State Key Laboratory of Transient Physics, Nanjing University of Science and Technology" [南京理工瞬态物理国家重点实验室导师归明月简介], *Sina*, 14 December 2016. http://blog.sina.com.cn/s/blog_14ecc6f470102xtb0.html

[321] "2021 Graduate Admissions Seminar: National Key Laboratory of Communication Anti-Interference Technology, University of Electronic Science and Technology " [2021 年研究生招生宣讲会：电子科技大学通信抗干扰技术国家级重点实验室], *bilibili*, 11 September 2020. https://www.bilibili.com/video/av842033442/

[322] "Lab Introduction" [实验室简介], *National Key Laboratory of Wireless Communications*, Accessed February 2025, https://www.ncl.uestc.edu.cn/sysgk/sysjj.htm

[323] "2021 Graduate Admissions Seminar: National Key Laboratory of Communication Anti-Interference Technology, University of Electronic Science and Technology " [2021 年研究生招生宣讲会：电子科技大学通信抗干扰技术国家级重点实验室], *bilibili*, 11 September 2020. https://www.bilibili.com/video/av842033442/
"National Key Laboratory of Communication Anti-Interference Technology" [通信抗干扰技术国家级重点实验室], *UESTC,* Accessed 2021, https://www.ncl.uestc.edu.cn/index.htm

[324] "Lab Introduction" [实验室简介], *National Key Laboratory of Wireless Communications*, Accessed February 2025, https://www.ncl.uestc.edu.cn/sysgk/sysjj.htm

[325] Wang Haiyang [汪海洋] et al., "Reproducing algorithm of Lempel-Greenberger sequence and improved model in hopping frequency" [重构 L-G 模型及改进模型跳频序列*], Journal of China Institute of Communications* [通信学报] (1) 2003.

[326] "Lab Introduction" [实验室简介], *National Key Laboratory of Wireless Communications*, Accessed February 2025, https://www.ncl.uestc.edu.cn/sysgk/sysjj.htm

[327] "2021 Graduate Admissions Seminar: National Key Laboratory of Communication Anti-Interference Technology, University of Electronic Science and Technology" [2021 年研究生招生宣讲会：电子科技大学通信抗干扰技术国家级重点实验室], *bilibili*, 11 September 2020. https://www.bilibili.com/video/av842033442/
"National Key Laboratory of Communication Anti-Interference Technology" [通信抗干扰技术国家级重点实验室], *UESTC,* Accessed 2021, https://www.ncl.uestc.edu.cn/index.htm

[328] "National Key Laboratory of Communication Anti-Interference Technology" [通信抗干扰技术国家级重点实验室], *UESTC*, Accessed 2021, https://www.ncl.uestc.edu.cn/index.htm

[329] "Six provincial engineering laboratories (research centers) of the University of Electronic Science and Technology were approved for construction" [电子科技大学 6 个省级工程实验室（研究中心）获批建设], *Sohu*, 18 October 2019. https://www.sohu.com/a/347952540_726066
"Postdoctoral Fellowship at the Center for Intelligent Communication and Future Networks, University of Electronic Science and Technology" [电子科技大学"智能通信与未来网络"研究中心诚聘博士后], *Rencai8*, Accessed 2021, https://rencai8.com/web/job_content.php?id=35140

[330] "2021 Graduate Admissions Seminar: National Key Laboratory of Communication Anti-Interference Technology, University of Electronic Science and Technology" [2021 年研究生招生宣讲会：电子科技大学通信抗干扰技术国家级重点实验室], *bilibili*, 11 September 2020. https://www.bilibili.com/video/av842033442/

[331] "2021 Graduate Admissions Seminar: National Key Laboratory of Communication Anti-Interference Technology, University of Electronic Science and Technology " [2021 年研究生招生宣讲会：电子科技大学通信抗干扰技术国家级重点实验室], *bilibili*, 11 September 2020. https://www.bilibili.com/video/av842033442/

[332] "National Key Laboratory of Communication Anti-Interference Technology" [通信抗干扰技术国家级重点实验室], *UESTC*, Accessed 2021, https://www.ncl.uestc.edu.cn/index.htm

[333] Marcus Clay, "The PLA's Pursuit of Terahertz: Facts and Fallacies", *Jamestown Foundation*, 12 November 2020. https://jamestown.org/program/pla-pursuit-terahertz-facts-and-fallacies/
Li Xiaoxiao [李晓骁], "Chinese terahertz radar can counteract F22 fighters?" [中国太赫兹雷达能反制 F22 战机?], *China Science Communication* [科普中国], 10 October 2017. http://www.kepuchina.cn/mil/news/201710/t20171026_236997.shtml

[334] "Key projects of 863 program passed the acceptance" [863 计划重点项目通过验收], *UESTC*, 26 September 2012. https://news.uestc.edu.cn/?n=UestcNews.Front.Document.ArticlePage&Id=48399

[335] "2021 Graduate Admissions Seminar: National Key Laboratory of Communication Anti-Interference Technology, University of Electronic Science and Technology" [2021 年研究生招生宣讲会：电子科技大学通信抗干扰技术国家级重点实验室], *bilibili*, 11 September 2020. https://www.bilibili.com/video/av842033442/
"Sichuan 5G Development Index Blue Book (2020 Edition) Released The province has disclosed 1,966 5G patents, ranking sixth in the country" [四川省 5G 发展指数蓝皮书（2020 版）发布 全省已公开 5G 专利 1966 件，位居全国第六], *NBC* [海经网], 28 August 2020. http://www.nbd.com.cn/articles/2020-08-28/1493564.html
[336] "2023 Sichuan Microwave RF Technology and Application Conference held in Chengdu" [2023 年四川微波射频技术与应用大会在蓉举行], *thepaper.cn*, 21 April 2023, https://www.thepaper.cn/newsDetail_forward_22797325
[337] "Sichuan 5G Development Index Blue Book (2020 Edition) Released The province has disclosed 1,966 5G patents, ranking sixth in the country" [四川省 5G 发展指数蓝皮书（2020 版）发布 全省已公开 5G 专利 1966 件，位居全国第六], *NBC* [海经网], 28 August 2020. http://www.nbd.com.cn/articles/2020-08-28/1493564.html
[338] "Chen Zhi: Terahertz Communication Technology Makes Athletes on the Field Finesse" [陈智：太赫兹通信技术让赛场上的运动员纤毫毕现], *CCTV*, 28 August 2024, https://v.cctv.com/2024/08/28/VIDEGJGxOZI4KAwG51LJIZo1240828.shtml
[339] Li Shaoqian [李少谦], *Chengdu Shude High School* [成都树德中学], 6 May 2020. http://www.sdzx.net/detail?id=12191aea-f92a-47a7-bce3-0478c71dbab7
[340] "Gao Xiang" [高翔], *UESTC*, Accessed 2021, https://yjsjy.uestc.edu.cn/gmis/jcsjgl/dsfc/dsgrjj/12369?yxsh=22
[341] "Congratulation! Prof. Yingkuang Liang of University of Electronic Science and Technology was elected as a foreign member of European Academy of Sciences" [祝贺！电子科技大学梁应敞教授当选欧洲科学院外籍院士], *Inner Mongolia University* [内蒙古大学], 3 July 2019. http://www.liuxuehr.com/m/view.php?aid=37158
[342] "School of Communication leaders talk with selected and introduced talents" [通信学院领导与选留、引进人才座谈], *UESTC*, 30 May 2003. https://news.uestc.edu.cn/?n=UestcNews.Front.Document.ArticlePage&Id=25240
[343] "How good is the national key laboratory of communication anti-interference technology? Just take a look at this recruitment notice to know" [通信抗干扰技术国家级重点实验室有多牛？看看这则招聘启事就知道了], *NetEase*, 15 September 2020. https://www.163.com/dy/article/FMII4I5O05348BNH.html
[344] "National Key Laboratory of Communication Anti-Interference Technology" [通信抗干扰技术国家级重点实验室], *UESTC*, Accessed 2021, https://www.ncl.uestc.edu.cn/index.htm
[345] Wang Haiyang [汪海洋] et al., "Reproducing algorithm of Lempel-Greenberger sequence and improved model in hopping frequency" [重构 L-G 模型及改进模型跳频序列], *Journal of China Institute of Communications* [通信学报] (1) 2003.
[346] "Notice of 2020 Space Electronic Information Academic Exchange Conference" [2020 空间电子信息学术交流大会的通知], *Journal of Radars* [雷达学报], 3 March 2020. http://radars.ie.ac.cn/news/bianjibugonggao/5dc6e637-04a3-477a-9d8a-e96aa086f1c5.htm
[347] "2021 Graduate Admissions Seminar: National Key Laboratory of Communication Anti-Interference Technology, University of Electronic Science and Technology " [2021 年研究生招生宣讲会：电子科技大学通信抗干扰技术国家级重点实验室], *bilibili*, 11 September 2020. https://www.bilibili.com/video/av842033442/
[348] "Chengdian Distinguished Student Qianqian Zhang, under the supervision of Prof. Yingliang Liang, IEEE Fellow and Foreign Member of the European Academy of Sciences!" [成电杰出学生张倩倩，师从欧洲科学院外籍院士、IEEE Fellow 梁应敞教授！], *Sohu*, 11 February 2022, https://www.sohu.com/a/522134560_469837
[349] "National Key Laboratory of Communication Anti-Interference Technology" [通信抗干扰技术国家级重点实验室], *UESTC*, Accessed 2021, https://www.ncl.uestc.edu.cn/index.htm
[350] "How good is the national key laboratory of communication anti-interference technology? Just take a look at this recruitment notice to know" [通信抗干扰技术国家级重点实验室有多牛？看看这则招聘启事就知道了], *NetEase*, 15 September 2020. https://www.163.com/dy/article/FMII4I5O05348BNH.html
[351] "How good is the national key laboratory of communication anti-interference technology? Just take a look at this recruitment notice to know" [通信抗干扰技术国家级重点实验室有多牛？看看这则招聘启事就知道了], *NetEase*, 15 September 2020. https://www.163.com/dy/article/FMII4I5O05348BNH.html

[352] "Third International Academic Conference on Electronic Information Technology (EIT 2024)" [第三届电子信息技术国际学术会议（EIT 2024）], EIT 2024, Accessed February 2025, https://www.ais.cn/attendees/index/VYEEMN
[353] "Tenth International Conference on Computer and Communication Systems 2025 (ICCCS 2025)" [2025 年第十届计算机与通信系统国际会议 (ICCCS 2025)], *ScienceNet*, 23 January 2025, https://meeting.sciencenet.cn/index.php?s=/Category/reading_display&rid=21619
[354] "IEEE ICCT 2024 Call for Papers is in progress!" [IEEE ICCT 2024 征稿火热进行中，诚邀投稿！], *Bendi News*, Accessed February 2025, https://bendi.news/wxnews/clvw35djw001prvmnh1ygedmv
[355] "2021 Graduate Admissions Seminar: National Key Laboratory of Communication Anti-Interference Technology, University of Electronic Science and Technology" [2021 年研究生招生宣讲会：电子科技大学通信抗干扰技术国家级重点实验室], *bilibili*, 11 September 2020. https://www.bilibili.com/video/av842033442/
[356] "Brief Introduction to Sponsors," *ISAPE 2018*, 3 December 2018. http://www.rpsoc.cn/isape2018/index.php/site/singlePage/35
[357] "Company Introduction" [企业简介], *CETC 36th RI*, Accessed February 2025, http://www.cetc36.cn/36/335690/335678/index.html
[358] "National Key Laboratory of Communication System Information Control Technology held a grand opening ceremony" [通信系统信息控制技术国家级重点实验室隆重举行挂牌仪式], *iXueshu*, Accessed 2021, https://www.ixueshu.com/h5/document/a8dadf5b05409484a77e281dd86e666f318947a18e7f9386.html
[359] "Key Laboratory of Communication Information Control and Security Technology" [通信信息控制和安全技术重点实验室], *iXueshu*, Accessed 2021, https://www.ixueshu.com/h5/document/b182fab31af30eb109c6772a49626e03318947a18e7f9386.html
[360] "Key Laboratory of Communication Information Control and Security Technology" [通信信息控制和安全技术重点实验室], *iXueshu*, Accessed 2021, https://www.ixueshu.com/h5/document/b182fab31af30eb109c6772a49626e03318947a18e7f9386.html
[361] "Internet Security Joint Lab" [互联网安全联合实验室], *Wuxi IoT Innovation Center* [无锡物联网创新中心], 25 June 2020. http://www.wiot.tech/html/1680934945.html
[362] "The Working Meeting of the Council of National Key Laboratory for Electromagnetic Space Safety was Successfully Held in Tianjin" [电磁空间安全全国重点实验室理事会工作会议在天津顺利召开], *CETC*, 27 December 2024, https://29.cetc.com.cn/29/335616/335592/1823010/index.html
[363] "Communications Countermeasures" [通信对抗], *China Editology Society of Science Periodicals* [中国科学技术期刊编辑学会], Accessed 2021, http://www.cessp.org.cn/info/73537.jspx
[364] Zhang Jie [张杰] et al., "Simulation Study on Performance of Projectile-Carried Communication Jamming in 'Dual Transmission' Mode" ["双发射"模式下弹载通信干扰性能仿真研究], *Journal of Ordnance Equipment Engineering* [兵器装备工程学报] (41) July 2020.
[365] "Richard A. Poisel," *Artech House*, Accessed 2021, https://us.artechhouse.com/cw_contributorinfo.aspx?ContribID=1024&Name=Richard+A.+Poisel
[366] "Key Laboratory of Communication Information Control and Security Technology" [通信信息控制和安全技术重点实验室], *iXueshu*, Accessed 2021, https://www.ixueshu.com/h5/document/b182fab31af30eb109c6772a49626e03318947a18e7f9386.html
"National Key Laboratory of Information Control Technology for Communication Systems" [通信系统信息控制技术国家级重点实验室], *iXueshu*, Accessed 2021, https://www.ixueshu.com/h5/document/c5951ac9594eeb8eb2dc2e26e2d54318947a18e7f9386.html
[367] "Key Laboratory of Communication Information Control and Security Technology" [通信信息控制和安全技术重点实验室], *iXueshu*, Accessed 2021, https://www.ixueshu.com/h5/document/b182fab31af30eb109c6772a49626e03318947a18e7f9386.html
"Internet Security Joint Lab" [互联网安全联合实验室], *Wuxi IoT Innovation Center* [无锡物联网创新中心], 25 June 2020. http://www.wiot.tech/html/1680934945.html
[368] Yang Xiaoniu [杨小牛], "Cognitive Electronic Warfare and Cognitive Electronic Warfare Systems Research" [认知电子战与认知电子战系统研究], *MWRF* [微波射频网], 27 December 2017. http://www.mwrf.net/tech/radar/2017/22666.html

Zhang Chunlei [张春磊], Yang Xiaoniu [杨小牛], "Research on the Cognitive Electronic Warfare and Cognitive Electronic Warfare System" [认知电子战与认知电子战系统研究], *Journal of China Academy of Electronics and Information Technology* [中国电子科学研究院学报] (6) 2014.

[369] "Three methods for anti-UAV operations" ["反无人机"三大模式], *Xinhua*, 24 October 2017. http://uav.xinhuanet.com/2017-10/24/c_129725771.htm

[370] "CETC wins another defense science and technology industry award Americans repeat an action: China can lock the F-22" [中电科又获国防科技工业大奖美国人重复一动作：中国可锁定 F-22], *Sina*, 21 January 2020. https://k.sina.com.cn/article_7247851055_1b0016e2f00100tg0t.html

[371] "CETC wins another defense science and technology industry award Americans repeat an action: China can lock the F-22" [中电科又获国防科技工业大奖美国人重复一动作：中国可锁定 F-22], *Sina*, 21 January 2020. https://k.sina.com.cn/article_7247851055_1b0016e2f00100tg0t.html

[372] "Key Laboratory of Communication Information Control and Security Technology" [通信信息控制和安全技术重点实验室], *iXueshu*, Accessed 2021, https://www.ixueshu.com/h5/document/b182fab31af30eb109c6772a49626e03318947a18e7f9386.html

[373] "Yang Xiaoniu (Academician)" [杨小牛(院士)], *Geren Jianli* [个人简历], Accessed 2021, http://www.gerenjianli.com/Mingren/47/gt6da19otm.html

[374] "2017 China Electronic Warfare Academic Communication" [2017 全国电子战学术交流大会征文通知], *Chinese Institute of Electronics*, 2017. http://sxjs.cnjournals.cn/config/sxjs/news_category/2017-05-27/2017%E7%94%B5%E5%AD%90%E6%88%98%E5%A4%A7%E4%BC%9A%E5%BE%81%E6%96%87%E9%80%9A%E7%9F%A5.pdf

[375] "The Second Defense Big Data Summit Forum was successfully held" [第二届国防大数据高峰论坛成功举行], Chinese Association of Automation [中国自动化学会], Accessed 2021, https://www.caa.org.cn/index.php?me_id=190&ac_id=3757

[376] "Conference Organization, The 5th Annual National Radio Communication Conference" [大会组织机构, 第五届全国电波传播年会], *RPSOC*, October 2019. http://www.rpsoc.cn/cnsrp2019/index.php/site/singlePage/39

[377] "The 14th International Conference on Antennas, Propagation and Electromagnetic Theory in Hefei" [第十四届天线、传播及电磁理论国际会议在合肥召开], Chinese Journal of Radio Science, 3 November 2024, http://www.cjors.cn/news/217

[378] "Conference Introduction" [大会介绍], *2025 International Conference on UAV Application*, Accessed February 2025, https://www.uav-expo.cn/Home/About/1

"[Conference Update] 2023 International UAV Application and Prevention and Control Conference" [【大会更新】2023 国际无人机应用及防控大会], *Shifair* [世展网], 7 April 2023, https://www.shifair.com/informationDetails/106028.html

[379] "ICCSN 2024 / October 18-20, 2024 / Ningbo, China," *ICCSN*, Accessed February 2025, https://www.iccsn.org/iccsn24.html

"Keynote Speakers of ICCSN2025" https://www.iccsn.org/keynote.html

"Invited Speakers of ICCSN2025" https://www.iccsn.org/is.html

"Conference Committee of 2025 " https://www.iccsn.org/committee.html

[380] "Keynotes," *ISAPE2018*, 3 December 2018. http://www.rpsoc.cn/isape2018/index.php/site/singlePage/23

[381] "The 4th Micro- and Nano-Optics Technology and Application Exchange Conference-Successful Closing" [第四届微纳光学技术与应用交流会—顺利闭幕], *Chinese Society for Optical Engineering* [中国光学工程学会], 15 December 2020. https://csoe.org.cn/html/xhgg/gjjl/3317.html

[382] "Key Laboratory of Communication Information Control and Security Technology" [通信信息控制和安全技术重点实验室], *iXueshu*, Accessed 2021, https://www.ixueshu.com/h5/document/b182fab31af30eb109c6772a49626e03318947a18e7f9386.html

[383] "Key Laboratory of Communication Information Control and Security Technology" [通信信息控制和安全技术重点实验室], *iXueshu*, Accessed 2021, https://www.ixueshu.com/h5/document/b182fab31af30eb109c6772a49626e03318947a18e7f9386.html

[384] "Prof. Xiao Gang's group participated in the 2020 National Avionics Information Technology High-end Forum and won the excellent paper" [肖刚教授课题组参加 2020 年全国航空电子信息技术高端论坛并获优秀论文], *Shanghai Jiao Tong University*, 30 September 2020, https://www.aero.sjtu.edu.cn/en/data/view/3891
Jingshuai Huang et al., "An Interacting-Multiple-Model Method for Tracking a Hypersonic Glide Target," *2020 Chinese Control and Decision Conference (CCDC)*, 22 August 2020, https://ieeexplore.ieee.org/document/9164342/authors#authors
[385] "The Fifth Military Optoelectronics Technology Development Forum Notice of Meeting (First Round)" [第五届军用光电技术发展论坛 会议通知（第一轮)], *Journal of Applied Optics*, 29 July 2024, http://www.yygx.net/news/259
[386] "PLAAF Research Academy Institute of Systems Engineering" [空军研究院系统工程所], *Yingjiesheng*, 14 September 2023, https://www.yingjiesheng.com/job-006-428-163.html
[387] Meng Jie [孟捷], Xiu Haojun [徐浩军], Zhang Jiankang [张建康], "Comparison of type II motor feedback and feed-forward inhibition system" [II型摩辋犗反馈与前馈抑制系统对比], *Acta Aeronautica* [航空学报], September 2010 31(9), http://webcache.googleusercontent.com/search?q=cache%3Ahttps%3A%2F%2Fhkxb.buaa.edu.cn%2FCN%2Farticle%2FdownloadArticleFile.do%3FattachType%3DPDF%26id%3D8382&rlz=1C1SJWC_enUS1059US1059&oq=cache%3Ahttps%3A%2F%2Fhkxb.buaa.edu.cn%2FCN%2Farticle%2FdownloadArticleFile.do%3FattachType%3DPDF%26id%3D8382&gs_lcrp=EgZjaHJvbWUyBggAEEUYOTIGCAEQRRg60gEIMTM5MWowajSoAgCwAgA&sourceid=chrome&ie=UTF-8
Lu Yaobin [陆耀宾] et al., "Research on Operational Effectiveness Analysis Modeling Frame of Air ForceWeapon and Equipment System Based on Task" [基于任务的空军装备体系效能建模框架研究], *Computer Simulation* [计算机仿真], 2011, 3, https://d.wanfangdata.com.cn/periodical/ChpNaW5lclBlcmlvZGljYWxDSEkyMDIzMDgwMhIOanNqZnoyMDExMDMwMjkaCDNwa244eWlh
Cheng Long [程龙], "Overview of foreign military UAVs'equipment and technology development" [2017 年军用无人机装备技术发展回眸], *Science & Technology Review* [科技导报], 2018, 36(4), http://www.kjdb.org/CN/abstract/abstract14789.shtml
[388] Dong Chen [董晨] et al., " Cooperative Detection Task Programming of Multi Sensor for Ballistic Missile Defense" [ 导弹防御多传感器协同探测任务规划], *Modern Defence Technology* [现代防御技术], 2018, 46(6), https://www.xdfyjs.cn/EN/abstract/abstract41.shtml
[389] "PLAAF Research Academy Institute of Systems Engineering" [空军研究院系统工程所], *Yingjiesheng*, 14 September 2023, https://www.yingjiesheng.com/job-006-428-163.html
[390] Yang Manzhong [杨满忠], Yin Jian [尹健], Zhang Jiankang [张建康], "Algorithmic study of the destructiveness of air-to-ground missiles against targets" [空地导弹对目标的毁伤性算法研究], *Tactical Missile Technology* [战术导弹技术], 2005, 2, http://webcache.googleusercontent.com/search?q=cache%3Abitssp.dayainfo.com%2FpublicResWarehouse%2FselectResWarehouseByCs%3Fkeyword%3DresWarehourseMain%26comefrom%3D%26unitId%3D1%26title%3D%26basic_cj_id%3D%26author%3D%26searchType%3Dall%26searchValue%3D%2525u4eff%2525u771f%26timeFlag%3D%26userId%3D%26searchMode%3D0%26flag%3Dabcde%26departmentFlag%3D0%26wareflag%3D0%26typeflag%3D0%26coreflag%3D0%26fundflag%3D0%26currentPage%3D1551&rlz=1C1SJWC_enUS1059US1059&oq=cache%3Abitssp.dayainfo.com%2FpublicResWarehouse%2FselectResWarehouseByCs%3Fkeyword%3DresWarehourseMain%26comefrom%3D%26unitId%3D1%26title%3D%26basic_cj_id%3D%26author%3D%26searchType%3Dall%26searchValue%3D%2525u4eff%2525u771f%26timeFlag%3D%26userId%3D%26searchMode%3D0%26flag%3Dabcde%26departmentFlag%3D0%26wareflag%3D0%26typeflag%3D0%26coreflag%3D0%26fundflag%3D0%26currentPage%3D1551&gs_lcrp=EgZjaHJvbWUyBggAEEUYOTIGCAEQRRg60gEIMTQ5MmowajSoAgCwAgA&sourceid=chrome&ie=UTF-8
[391] "Application of Rough Set and Immunization Algorithms to Distinguish Reconnaissance Tasks" [粗糙集和免疫算法在区分侦察任务中的应用], *Koovin* [库问搜索], Accessed September 2023, http://www.koovin.com/?a=url&id=11906786
[392] Yang Manzhong [杨满忠], Yin Jian [尹健], Zhang Jiankang [张建康], "Algorithmic study of the destructiveness of air-to-ground missiles against targets" [空地导弹对目标的毁伤性算法研究], Tactical Missile Technology [战术

导弹技术], 2005, 2,
http://webcache.googleusercontent.com/search?q=cache%3Abitssp.dayainfo.com%2FpublicResWarehouse%2FselectResWarehouseByCs%3Fkeyword%3DresWarehourseMain%26comefrom%3D%26unitId%3D1%26title%3D%26basic_cj_id%3D%26author%3D%26searchType%3Dall%26searchValue%3D%2525u4eff%2525u771f%26timeFlag%3D%26userId%3D%26searchMode%3D0%26flag%3Dabcde%26departmentFlag%3D0%26wareflag%3D0%26typeflag%3D0%26coreflag%3D0%26fundflag%3D0%26currentPage%3D1551&rlz=1C1SJWC_enUS1059US1059&oq=cache%3Abitssp.dayainfo.com%2FpublicResWarehouse%2FselectResWarehouseByCs%3Fkeyword%3DresWarehourseMain%26comefrom%3D%26unitId%3D1%26title%3D%26basic_cj_id%3D%26author%3D%26searchType%3Dall%26searchValue%3D%2525u4eff%2525u771f%26timeFlag%3D%26userId%3D%26searchMode%3D0%26flag%3Dabcde%26departmentFlag%3D0%26wareflag%3D0%26typeflag%3D0%26coreflag%3D0%26fundflag%3D0%26currentPage%3D1551&gs_lcrp=EgZjaHJvbWUyBggAEEUYOTIGCAEQRRg60gEIMTQ5MmowajSoAgCwAgA&sourceid=chrome&ie=UTF-8

[393] Lu Yaobin [陆耀宾] et al., "Research on Operational Effectiveness Analysis Modeling Frame of Air ForceWeapon and Equipment System Based on Task" [基于任务的空军装备体系效能建模框架研究], *Computer Simulation* [计算机仿真], 2011, 3,
https://d.wanfangdata.com.cn/periodical/ChpNaW5lclBlcmlvZGljYWxDSEkyMDIzMDgwMhIOanNqZnoyMDExMDMwMjkaCDNwa244eWlh

[394] Cheng Long [程龙], "Overview of foreign military UAVs'equipment and technology development" [2017 年军用无人机装备技术发展回眸], *Science & Technology Review* [科技导报], 2018, 36(4),
http://www.kjdb.org/CN/abstract/abstract14789.shtml

[395] Dong Chen [董晨] et al., " Cooperative Detection Task Programming of Multi Sensor for Ballistic Missile Defense" [ 导弹防御多传感器协同探测任务规划], *Modern Defence Technology* [现代防御技术], 2018, 46(6),
https://www.xdfyjs.cn/EN/abstract/abstract41.shtml

[396] Jingshuai Huang et al., "An Interacting-Multiple-Model Method for Tracking a Hypersonic Glide Target," 2020 *Chinese Control and Decision Conference (CCDC)*, 22 August 2020,
https://ieeexplore.ieee.org/document/9164342/authors#authors

[397] Lu Zheng [陆峥] et al., "Fluctuation Feature Extraction and Application of Satellite Telemetry Data" [卫星遥测数据的波动特征提取及应用], *Practice and Understanding of Mathematics* [数学的实践与认识], 2018(04).

[398] "2016 Seminar on Unmanned Aircraft Systems and Mission Payload Technologies and Applications and Annual Meeting of China Unmanned Aircraft Mission Systems and Technology Industry Alliance" [2016 年无人机系统与任务载荷技术及应用研讨会暨中国无人机任务系统及技术产业联盟年会], *YouUAV* [无人机网], 8 October 2016, https://m.youuav.com/news/detail/201610/10249.html

[399] Gao Jinsong [高劲松] et al., "Air-to-air Missile F/A-pole in Single-plane Launch and Cooperative Launch" [空空导弹单机发射和合作发射中的 F/A 极], *Journal of Command and Control* [指挥与控制学报], 2023, 9(2).

[400] An Daoxiang [安道祥], "Research on the Technology of Airborne Multi-channel Wide Angle Staring SAR Ground Moving Target Indication" [机载多通道广角凝视 SAR 地面动目标指示技术研究], *Journal of Radars* [雷达学报], 2023, 12(6).

[401] Zhang Jing [张菁] et al., "Technical features demonstration of the next generation figher" [新一代战斗机技术特征论证], *Systems Engineering and Electronics* [系统工程与电子技术], 2018, 40(8), https://www.sys-ele.com/CN/10.3969/j.issn.1001-506X.2018.08.13

[402] "CSCI Air Intelligence Gaming Countermeasures Technology Development Qingtuo Salon Held" [中科协空中智能博弈对抗技术发展青托沙龙举行], *Sohu*, 20 November 2020,
https://www.sohu.com/a/700491024_121687414

[403] Zhang Jing [张菁] et al., "Technical features demonstration of the next generation figher" [新一代战斗机技术特征论证], *Systems Engineering and Electronics* [系统工程与电子技术], 2018, 40(8), https://www.sys-ele.com/CN/10.3969/j.issn.1001-506X.2018.08.13

[404] "The Second "Target Recognition and Artificial Intelligence Summit Forum" Held in Shenyang" [第二届"目标识别与人工智能高峰论坛"在沈阳召开], *CAS Shenyang Institute of Automation*, 4 September 2019,
http://www.sia.cas.cn/xwzx/zhxw/201909/t20190904_5

[405] "Fault Tolerant Computing Specialized Committee" [容错计算专业委员会], *China Computer Federation*, Accessed January 2024, https://www.ccf.org.cn/Chapters/TC/TC_Listing/TCFTC/
[406] "CSCI Air Intelligence Gaming Countermeasures Technology Development Qingtuo Salon Held" [中科协空中智能博弈对抗技术发展青托沙龙举行], *Sohu*, 20 November 2020, https://www.sohu.com/a/700491024_121687414
[407] "Prof. Xiao Gang's group participated in the 2020 National Avionics Information Technology High-end Forum and won the excellent paper" [肖刚教授课题组参加 2020 年全国航空电子信息技术高端论坛并获优秀论文], *Shanghai Jiao Tong University*, 30 September 2020, https://www.aero.sjtu.edu.cn/en/data/view/3891
[408] "The Second "Target Recognition and Artificial Intelligence Summit Forum" Held in Shenyang" [第二届"目标识别与人工智能高峰论坛"在沈阳召开], *CAS Shenyang Institute of Automation*, 4 September 2019, http://www.sia.cas.cn/xwzx/zhxw/201909/t20190904_5
[409] Lu Yaobin [陆耀宾] et al., "Research on Operational Effectiveness Analysis Modeling Frame of Air ForceWeapon and Equipment System Based on Task" [基于任务的空军装备体系效能建模框架研究], *Computer Simulation* [计算机仿真], 2011, 3, https://d.wanfangdata.com.cn/periodical/ChpNaW5lclBlcmlvZGljYWxDSEkyMDIzMDgwMhIOanNqZnoyMDExMDMwMjkaCDNwa244eWlh
[410] "Key Laboratory of National Defense Science and Technology for Ground Complex System Simulation - Xuemei Tang's Academic Reports" [地面复杂系统仿真国防科技重点实验室唐雪梅研究员学术报告简讯], *Nanching University School of Sciences* [南昌大学理学院], 6 April 2016, http://webcache.googleusercontent.com/search?client=firefox-b-1-d&q=cache%3Awww.magnuselectronics.com%2Fgzdt%2Fxyxw%2F28159.htm
[411] "Remembering Tang Xuemei, Researcher of General Armament Department: Fulfilling Qian Xuesen's Wish" [记总装备部研究员唐雪梅：实现了钱学森的心愿], *China.com*, 3 February 2012. http://military.china.com.cn/txt/2012-02/03/content_24540969.htm
[412] Key Laboratory of National Defense Science and Technology for Ground Complex System Simulation - Xuemei Tang's Academic Reports" [地面复杂系统仿真国防科技重点实验室唐雪梅研究员学术报告简讯], Nanching University School of Sciences [南昌大学理学院], 6 April 2016, http://webcache.googleusercontent.com/search?client=firefox-b-1-d&q=cache%
[413] "Key Laboratory of National Defense Science and Technology for Ground Complex System Simulation - Xuemei Tang's Academic Reports" [地面复杂系统仿真国防科技重点实验室唐雪梅研究员学术报告简讯], *Nanching University School of Sciences* [南昌大学理学院], 6 April 2016, http://webcache.googleusercontent.com/search?client=firefox-b-1-d&q=cache%3Awww.magnuselectronics.com%2Fgzdt%2Fxyxw%2F28159.htm
[414] "Key Laboratory of National Defense Science and Technology for Ground Complex System Simulation - Xuemei Tang's Academic Reports" [地面复杂系统仿真国防科技重点实验室唐雪梅研究员学术报告简讯], *Nanching University School of Sciences* [南昌大学理学院], 6 April 2016, http://webcache.googleusercontent.com/search?client=firefox-b-1-d&q=cache%3Awww.magnuselectronics.com%2Fgzdt%2Fxyxw%2F28159.htm
[415] "Key Laboratory of National Defense Science and Technology for Ground Complex System Simulation - Xuemei Tang's Academic Reports" [地面复杂系统仿真国防科技重点实验室唐雪梅研究员学术报告简讯], *Nanching University School of Sciences* [南昌大学理学院], 6 April 2016, http://webcache.googleusercontent.com/search?client=firefox-b-1-d&q=cache%3Awww.magnuselectronics.com%2Fgzdt%2Fxyxw%2F28159.htm
[416] "Remembering Tang Xuemei, Researcher of General Armament Department: Fulfilling Qian Xuesen's Wish" [记总装备部研究员唐雪梅：实现了钱学森的心愿], *China.com*, 3 February 2012. http://military.china.com.cn/txt/2012-02/03/content_24540969.htm
[417] "Remembering Tang Xuemei, Researcher of General Armament Department: Fulfilling Qian Xuesen's Wish" [记总装备部研究员唐雪梅：实现了钱学森的心愿], *China.com*, 3 February 2012. http://military.china.com.cn/txt/2012-02/03/content_24540969.htm

"Winning the War of the Unseen" [打赢不见硝烟的战争], *Sohu*, 27 September 2011. http://roll.sohu.com/20110927/n320729785.shtml

[418] "Remembering Tang Xuemei, Researcher of General Armament Department: Fulfilling Qian Xuesen's Wish" [记总装备部研究员唐雪梅：实现了钱学森的心愿], *China.com*, 3 February 2012. http://military.china.com.cn/txt/2012-02/03/content_24540969.htm
"Winning the War of the Unseen" [打赢不见硝烟的战争], *Sohu*, 27 September 2011. http://roll.sohu.com/20110927/n320729785.shtml

[419] "Winning the War of the Unseen" [打赢不见硝烟的战争], *Sohu*, 27 September 2011. http://roll.sohu.com/20110927/n320729785.shtml

[420] "Awarded the Fifth Army Science and Technology Innovation Group Award" [获第五届军队科技创新群体奖], *China Daily*, 28 April 2015. http://covid-19.chinadaily.com.cn/hqsj/hqlw/2015-04-28/content_13613947.html

[421] "Key Laboratory of National Defense Science and Technology for Ground Complex System Simulation - Xuemei Tang's Academic Reports" [地面复杂系统仿真国防科技重点实验室唐雪梅研究员学术报告简讯], *Nanching University School of Sciences* [南昌大学理学院], 6 April 2016, http://webcache.googleusercontent.com/search?client=firefox-b-1-d&q=cache%3Awww.magnuselectronics.com%2Fgzdt%2Fxyxw%2F28159.htm

[422] "Remembering Tang Xuemei, Researcher of General Armament Department: Fulfilling Qian Xuesen's Wish" [记总装备部研究员唐雪梅：实现了钱学森的心愿], *China.com*, 3 February 2012. http://military.china.com.cn/txt/2012-02/03/content_24540969.htm

[423] "Profiles of some doctoral alumni of Nanchang No.2 Middle School" [南昌二中部分博士校友简介], *Nanchang 2nd Middle School* [南昌二中], 3 April 2008. http://2z.nceduc.cn/info/1045/5552.htm

[424] "Remembering Tang Xuemei, Researcher of General Armament Department: Fulfilling Qian Xuesen's Wish" [记总装备部研究员唐雪梅：实现了钱学森的心愿], *China.com*, 3 February 2012. http://military.china.com.cn/txt/2012-02/03/content_24540969.htm

[425] Hou Yaming [侯亚铭], "China Navy's Key Laboratory for Weapon and Equipment System Research Passes Acceptance Inspection" [中国海军武器装备体系研究重点实验室通过验收], *China.com*, 16 November 2010. http://www.china.com.cn/military/txt/2010-11/16/content_21353794.htmx

[426] Hou Yaming [侯亚铭], "China Navy's Key Laboratory for Weapon and Equipment System Research Passes Acceptance Inspection" [中国海军武器装备体系研究重点实验室通过验收], *China.com*, 16 November 2010. http://www.china.com.cn/military/txt/2010-11/16/content_21353794.htmx

[427] Hou Yaming [侯亚铭], "China Navy's Key Laboratory for Weapon and Equipment System Research Passes Acceptance Inspection" [中国海军武器装备体系研究重点实验室通过验收], *China.com*, 16 November 2010. http://www.china.com.cn/military/txt/2010-11/16/content_21353794.htmx
Lin Xiang [林翔], Zhou Shaoping [周少平], "Multi-resolution based simulation modeling of maritime joint operations" [基于多分辨率的海上联合作战仿真建模研究], Computer Simulation [计算机仿真], June 2018,35, https://wenku.baidu.com/view/c224528dcbaedd3383c4bb4cf7ec4afe05a1b1c3.html?re=view

[428] Lin Xiang [林翔], Zhou Shaoping [周少平], "Multi-resolution based simulation modeling of maritime joint operations" [基于多分辨率的海上联合作战仿真建模研究], *Computer Simulation* [计算机仿真], June 2018,35, https://wenku.baidu.com/view/c224528dcbaedd3383c4bb4cf7ec4afe05a1b1c3.html?re=view

[429] Chen Ying [陈泱[ et al., "Using Reinforcement Learning Method to Defense Amplification DDoS Attack in Cyberspace Operations" [网络空间作战中利用强化学习方法防御放大式拒绝服务攻击], *Ordnance Industry Automation* [兵工自动化], 2021, 1, http://kns55.zh.eastview.com/KCMS/detail/detail.aspx?filename=BGZD202101003&dbcode=CJFD&dbname=CJFD2021

[430] Cheng Zhiqiang [程志强] et al., "Trajectory optimization and control design for transition of thrust-vectored vertical and/or short take-off and landing aircraft" [推力矢量垂直短距飞机轨迹优化与控制], *Control Theory & Applications* [控制理论与应用], 2020, 1, http://202.106.125.35/KCMS/detail/detail.aspx?filename=KZLY202001005&dbcode=CJFD&dbname=CJFD2020

[431] Yao Fanghua [姚芳华], "Research on Deep-sea Underwater Combat System Based on Underwater Preset System" [基于水下预置系统的深远海水下作战体系], *Digital Ocean & Underwater Warfare* [数字海洋与水下攻防], 2020, 1, http://202.202.215.138/KCMS/detail/detail.aspx?filename=DOUW202001015&dbcode=CJFD&dbname=CJFD2020

[432] Hou Yaming [侯亚铭], "China Navy's Key Laboratory for Weapon and Equipment System Research Passes Acceptance Inspection" [中国海军武器装备体系研究重点实验室通过验收], *China.com*, 16 November 2010. http://www.china.com.cn/military/txt/2010-11/16/content_21353794.htmx

[433] Lin Xiang [林翔], Zhou Shaoping [周少平], "Multi-resolution based simulation modeling of maritime joint operations" [基于多分辨率的海上联合作战仿真建模研究], *Computer Simulation* [计算机仿真], June 2018,35, https://wenku.baidu.com/view/c224528dcbaedd3383c4bb4cf7ec4afe05a1b1c3.html?re=view

[434] Harbin Institute of Technology: A Top-Tier University For Science And Engineering, *Science*, 2020. https://www.sciencemag.org/sites/default/files/HIT_advertorial.pdf

[435] "National Key Lab of Composite Material Technology in Special Environments" [特种环境复合材料技术 国家级重点实验室], *Harbin Institute of Technology*, 25 December 2020. http://sa.hit.edu.cn/2020/1225/c6640a250512/page.htm

[436] "National Key Lab of Composite Material Technology in Special Environments" [特种环境复合材料技术 国家级重点实验室], *Harbin Institute of Technology*, 25 December 2020. http://sa.hit.edu.cn/2020/1225/c6640a250512/page.htm
The establishment of the "National Science and Technology Workers' Day" will stimulate the enthusiasm of science and technology workers for innovation" [设立"全国科技工作者日"将激发科技工作者的创新热情], *Xinhua*, Accessed 2021, http://www.xinhuanet.com/talking/character/2017053101.htm

[437] "Harbin Institute of Technology (Shenzhen) 2022 International Young Scholars Shenzhou Forum Invites Young Talents from Home and Abroad" [哈尔滨工业大学（深圳）2022 年国际青年学者神舟论坛诚邀海内外青年英才参加], *Harbin Institute of Technology*, Accessed April 2025, https://www.hitsz.edu.cn/job/view/95.html

[438] "NEOM2025 Conference Chair Prof. Zhang Shanyong Re-entered the Top 2% of Global Top Scientists List" [NEOM2025 大会主席张善勇教授再次入选全球前 2%顶尖科学家榜单], *PASE*, 25 September 2024, https://www.pasanhu.cn/NewsDetail.aspx?id=d4SEoxRHcrBS1DXGTJq3Rg_0_0

[439] "Defense S&T Key Laboratory of Composite Material Technology in Special Environments" [特种环境复合材料技术国防科技重点实验室], *Cailiao Quan* [材料圈], 1 February 2018. http://www.cailiaoquan.com/portal.php?mod=view&aid=554

[440] "The establishment of the "National Science and Technology Workers' Day" will stimulate the enthusiasm of science and technology workers for innovation" [设立"全国科技工作者日"将激发科技工作者的创新热情], *Xinhua*, Accessed 2021, http://www.xinhuanet.com/talking/character/2017053101.htm

[441] "The winner of "National Innovation Award" of our province: Special Environmental Composite Materials Technology Innovation Team" [我省"全国创新争先奖"获奖者：特种环境复合材料技术创新团队], *iFeng* [凤凰], 12 July 2017. http://hlj.ifeng.com/a/20170712/5814638_0.shtml

[442] "China's "MIT" adds a new engine of science and technology, HIT's key laboratory cluster laid the foundation" [中国"MIT"再添科技新引擎 哈工大重点实验室集群奠基], *Xianji China* [贤集网], 4 June 2020. https://www.xianjichina.com/special/detail_448248.html

[443] "National Key Lab of Composite Material Technology in Special Environments" [特种环境复合材料技术 国家级重点实验室], Harbin Institute of Technology, 25 December 2020. http://sa.hit.edu.cn/2020/1225/c6640a250512/page.htm

[444] "National Key Lab of Composite Material Technology in Special Environments" [特种环境复合材料技术 国家级重点实验室], Harbin Institute of Technology, 25 December 2020. http://sa.hit.edu.cn/2020/1225/c6640a250512/page.htm

[445] "Guidelines of Open Fund for State Key Laboratory of Special Environmental Composites Technology (FY2024)" [特种环境复合材料技术国家级重点实验室开放基金指南（2024 年度）], *Harbin Institute of Technology*, 8 April 2024, https://ccms.hit.edu.cn/2024/0408/c13809a341647/page.htm

[446] Harbin Institute Of Technology: A Top-Tier University For Science and Engineering, *Science*, 2020. https://www.sciencemag.org/sites/default/files/HIT_advertorial.pdf
[447] The establishment of the "National Science and Technology Workers' Day" will stimulate the enthusiasm of science and technology workers for innovation" [设立"全国科技工作者日"将激发科技工作者的创新热情], Xinhua, Accessed 2021, http://www.xinhuanet.com/talking/character/2017053101.htm
19. 复合材料与结构研究所 m 哈尔滨工业大学, 7 January 2015. http://sa.hit.edu.cn/6b/de/c6579a158686/page.psp
[448] National Key Lab of Composite Material Technology in Special Environments" [特种环境复合材料技术 国家级重点实验室], Harbin Institute of Technology, 25 December 2020. http://sa.hit.edu.cn/2020/1225/c6640a250512/page.htm
[449] National Key Lab of Composite Material Technology in Special Environments" [特种环境复合材料技术 国家级重点实验室], Harbin Institute of Technology, 25 December 2020. http://sa.hit.edu.cn/2020/1225/c6640a250512/page.htm
[450] Wang Heping [王和平] et al., "Density and organization of explosively compacted ZrB2-SiC ultra-high temperature ceramics" [爆炸压实 ZrB2-SiC 超高温陶瓷的密度与组织], *Materials Science and Technology* [材料科学与工艺] 19 (2011).
[451] "National Key Laboratory of Special Environmental Composites Technology Passes Operational Evaluation" [特种环境复合材料技术国家级重点实验室通过运行评估], *Antpedia*, 20 September 2010. https://web.archive.org/web/20190517062859/http://www.antpedia.com/news/21/n-98221.html
[452] "The 3rd National Conference on Hypervelocity Collision" [第三届全国超高速碰撞学术会议], *Home of Science and Technology Workers* [科技工作者之家], 13 June 2019. https://www.scimall.org.cn/meet/detail?id=1483
[453] "Harbin Institute of Technology (Shenzhen) 2022 International Young Scholars Shenzhou Forum Invites Young Talents from Home and Abroad" [哈尔滨工业大学（深圳）2022 年国际青年学者神舟论坛诚邀海内外青年英才参加], *Harbin Institute of Technology Shenzhen*, Accessed January 2025, https://www.hitsz.edu.cn/job/view/95.html
[454] "International Center of Applied Mechanics of Harbin Institute of Technology invites outstanding scholars from home and abroad to join us!" [哈尔滨工业大学国际应用力学中心诚邀海内外优秀学者加盟], *ScienceNet*, 12 April 2023, https://talent.sciencenet.cn/index.php?s=Info/index/id/23103
[455] "Prof. Paul M Weaver," *HIT International Center for Applied Mechanics*, 17 December 2023, https://mp.weixin.qq.com/s/fByfSM22rb7v5av6WCZ6zQ
"Normal M Werely, PhD," *HIT International Center for Applied Mechanics*, 6 November 2023, https://mp.weixin.qq.com/s/_FIoCOLTTf_E77lxtNd3mg
[456] "Pavel Utkin Lecture" [PAVEL UTKIN 讲座], *HIT International Center for Applied Mechanics*, 26 April 2023, http://icam.hit.edu.cn/chinese/2023/0426/c15866a303706/page.htm
[457] "Institute of Composite Materials and Structures" [复合材料与结构研究所], *Harbin Institute of Technology*, 7 January 2015. http://sa.hit.edu.cn/6b/de/c6579a158686/page.psp
[458] "Harbin Institute of Technology (HIT) is recruiting several PhDs in materials science, chemistry and chemical engineering in September 2018 for the Changjiang Special Team of Functional Composites Laboratory," [哈工大功能复合材料实验室长江特聘团队 2018 年 9 月招聘材料学、化学、化工相关专业博士数名], *sztspi.com*, 6 September 2018. http://www.sztspi.com/archives/158829.html
[459] "National Key Lab of Composite Material Technology in Special Environments" [特种环境复合材料技术 国家级重点实验室], Harbin Institute of Technology, 25 December 2020. http://sa.hit.edu.cn/2020/1225/c6640a250512/page.htm
[460] "National Key Lab of Composite Material Technology in Special Environments" [特种环境复合材料技术 国家级重点实验室], Harbin Institute of Technology, 25 December 2020. http://sa.hit.edu.cn/2020/1225/c6640a250512/page.htm
[461] "National Lab of Computational Fluid Dynamics" [国家计算流体力学实验室], *Beihang University*, 17 July 2017. http://www.ase.buaa.edu.cn/info/1123/9958.htm
"National Lab of Computational Fluid Dynamics" [国家计算流体力学实验室], *Beihang University*, Accessed 2021, https://web.archive.org/web/20120104203457/http://www.buaa.edu.cn/kxyj/zdsys/1628.htm

[462] "Overview" [概况], National Microgravity Laboratory, Chinese Academy of Sciences [中国科学院国家微重力实验室], Accessed 2021, http://nml.imech.ac.cn/info/detailnewsb.asp?infono=12351
[463] "National Lab of Computational Fluid Dynamics" [国家计算流体力学实验室], *Beihang University*, 17 July 2017. http://www.ase.buaa.edu.cn/info/1123/9958.htm
[464] "National Lab of Computational Fluid Dynamics" [国家计算流体力学实验室], *Beihang University*, Accessed 2021, https://web.archive.org/web/20120104203457/http://www.buaa.edu.cn/kxyj/zdsys/1628.htm
[465] "National Lab of Computational Fluid Dynamics" [国家计算流体力学实验室], *Beihang University*, 17 July 2017. http://www.ase.buaa.edu.cn/info/1123/9958.htm
[466] "National Lab of Computational Fluid Dynamics" [国家计算流体力学实验室], *Beihang University*, 17 July 2017. http://www.ase.buaa.edu.cn/info/1123/9958.htm
"National Lab of Computational Fluid Dynamics" [国家计算流体力学实验室], *Beihang University*, Accessed 2021, https://web.archive.org/web/20120104203457/http://www.buaa.edu.cn/kxyj/zdsys/1628.htm
"Ye Youda" [叶友达], *CARDC*, 17 October 2016. http://www.cardc.cn/yanjiusheng/content/?150.html
"Academic presentation at the Department of Mechanics and Air and Space Technology on October 19 " [10 月 19 日力学与空天技术系学术报告], *Peking University*, Accessed 2021, https://www.coe.pku.edu.cn/xzky/jzxx/899621.htm
[467] "Shineway – TaihuLight" [神威·太湖之光], *Jianshu* [简书], 14 December 2017. https://www.jianshu.com/p/5120b0606c27
"China's supercomputing champion repeatedly makes up for "deficiency "" [屡屡夺冠的中国超算 如何补齐"短板"], *Tsinghua University* [清华大学], 1 August 2017. https://news.tsinghua.edu.cn/info/1013/66546.htm
[468] "China's first trillion times supercomputing simulation prototype test flight helps C919 take off" [中国首台千万亿次超算模拟样机试飞助力 C919 腾空], *China News* [中国新闻网], 10 May 2017. http://www.chinanews.com/gn/2017/05-10/8220292.shtml
[469] "How to make our "face" more secure? Six members suggested strengthening the supervision of face recognition" [如何让我们的"脸"更安全？六位委员建议加强人脸识别监管], *New Today* [今日热点], 4 March 2021. https://newtoday.cc/explore/29450.html
[470] "Expatriates celebrate 90 years of the Communist Party of China: always convinced that China will get better and better" [侨界人士庆中共 90 年：始终坚信中国会越来越好], *Jilin New Media* [吉林新传媒], 1 March 2021. http://webcache.googleusercontent.com/search?q=cache%3Awww.fanghaizhizao.com%2Fnews%2F370738.html&rrl=1C1CHBD_enUS895US895&oq=cache%3Awww.fanghaizhizao.com%2Fnews%2F370738.html&aqs=chrome..69i57j69i58.1186j0j4&sourceid=chrome&ie=UTF-8
"National Lab of Computational Fluid Dynamics" [国家计算流体力学实验室], *Beihang University*, Accessed 2021, https://web.archive.org/web/20120104203457/http://www.buaa.edu.cn/kxyj/zdsys/1628.htm
[471] "National Lab of Computational Fluid Dynamics" [国家计算流体力学实验室], *Beihang University*, Accessed 2021, https://web.archive.org/web/20120104203457/http://www.buaa.edu.cn/kxyj/zdsys/1628.htm
[472] "Ye Youda" [叶友达], *CARDC*, 17 October 2016. http://www.cardc.cn/yanjiusheng/content/?150.html
[473] "CPPCC members visited the governing body of Zinfa Technology and researched the user experience of technological innovation" [全国政协委员走访理事单位津发科技，并调研用户体验科技创新], *China Quality Management Association for Electronics Industr*y [中国电子质量管理协会], 31 August 2023, https://www.cqae.org.cn/details/0/1036
[474] "National Key Laboratory of Computational Fluid Dynamics for National Defense Science and Technology" [国家计算流体力学国防科技重点实验室], *Beihang University*, 17 July 2017. https://web.archive.org/web/20190521025901/http://www.ase.buaa.edu.cn/info/1123/5197.htm
[475] "China's "Shen Wei - TaihuLight" won the world's top 500 supercomputers" [中国"神威·太湖之光"夺世界超级计算机 500 强第一名], *Xinhua* [新华网], 20 June 2016. http://www.xinhuanet.com/politics/2016-06/20/c_129077451.htm
[476] "Notice of the Fifth "Beihang Ningbo Meishan International Young Scholars Academic Forum" to be Held in 2023 at Ningbo Institute of Innovation Research, Beijing University of Aeronautics and Astronautics" [北京航空航天大学宁波创新研究院关于 2023 年召开第五届"北航宁波梅山国际青年学者学术论坛"的通知], *Gaoxiao Job*, 21 September 2023, https://www.gaoxiaojob.com/announcement/detail/145892.html

"The Fifth Beihang Ningbo Meishan International Academic Forum for Young Scholars Successfully Held" [第五届北航宁波梅山国际青年学者学术论坛成功召开], *Beihang University*, 30 October 2023, https://nit.buaa.edu.cn/info/1008/4344.htm

[477] "National Lab of Computational Fluid Dynamics" [国家计算流体力学实验室], *Beihang University*, 17 July 2017. http://www.ase.buaa.edu.cn/info/1123/9958.htm

[478] "National Lab of Computational Fluid Dynamics" [国家计算流体力学实验室], *Beihang University*, 17 July 2017. http://www.ase.buaa.edu.cn/info/1123/9958.htm
"National Key Laboratory of Computational Fluid Dynamics for National Defense Science and Technology" [国家计算流体力学国防科技重点实验室], *Beihang University*, 17 July 2017. https://web.archive.org/web/20190521025901/http://www.ase.buaa.edu.cn/info/1123/5197.htm

[479] "Ye Youda" [叶友达], *CARDC*, 17 October 2016. http://www.cardc.cn/yanjiusheng/content/?150.html

[480] "Ye Youda" [叶友达], *CARDC*, 17 October 2016. http://www.cardc.cn/yanjiusheng/content/?150.html

[481] Zhang Linfeng [张林峰] et al., "Simulating the microscopic world：from the Schrödinger equation to the large atomic model" [模拟微观世界：从薛定谔方程到大原子模型], *Physics* [物理], 2024, 53(7), https://wuli.iphy.ac.cn/article/doi/10.7693/wl20240701

[482] "History" ]历史沿革], *Institute of Applied Physics and Computational Mathematics*, Accessed July 2024, http://www.iapcm.ac.cn/history.html

[483] "2022 International Conference on Defence Technology" [2022 国际防务技术大会], *Scimeeting*, 2022, Accessed July 2024, https://mm.scimeeting.cn/cn/minisite/index/15308

[484] "History" ]历史沿革], *Institute of Applied Physics and Computational Mathematics*, Accessed July 2024, http://www.iapcm.ac.cn/history.html

[485] Shen Longjun [沈隆钧] et al., "Introduction to State Key Laboratory of Computational Physics" [计算物理国家级重点实验室简介], *Physics* [物理], 1998, 27(12), https://www.alljournals.cn/view_abstract.aspx?pcid=6E709DC38FA1D09A4B578DD0906875B5B44D4D294832BB8E&cid=47EA7CFDDEBB28E0&jid=D3DCC9D6F2F39F6E31CD40B3E78928FE&aid=91917C9C576B4C86D5756F9876B37954&yid=8CAA3A429E3EA654

[486] "Institute of Applied Physics and Computational Mathematics (IAPCM)", *Federation of American Scientists*, Accessed July 2024, https://nuke.fas.org/guide/china/contractor/iapcm.htm
"Beijing Institute of Applied Physics and Computational Mathematics 2012 Recruitment" [北京应用物理与计算数学研究所 2012 招聘], *University of Science and Technology of China*, 24 October 2011, https://cs.ustc.edu.cn/2011/1024/c3022a220352/pagem.htm

[487] "Addition of Entities to the Entity List, Revision of Certain Entries on the Entity List", *Bureau of Industry and Security*, 5 June 2020, https://www.federalregister.gov/documents/2020/06/05/2020-10869/addition-of-entities-to-the-entity-list-revision-of-certain-entries-on-the-entity-list

[488] "Computational Mathematics Department - Chen Yibing" [计算数学教研室--陈艺冰], *Institute of Applied Physics and Computational Mathematics*, Accessed July 2024, http://www.iapcm.ac.cn/teams_head_con_228.html
"Up to 1.5 Million, Program Guidelines for National Key Laboratory of Computational Physics Released" [最高 150 万，计算物理全国重点实验室项目指南发布], *ScienceNet*, 9 July 2023, https://news.sciencenet.cn/htmlnews/2023/7/504396.shtm

[489] "2022 International Conference on Defence Technology" [2022 国际防务技术大会], *Scimeeting*, 2022, Accessed July 2024, https://mm.scimeeting.cn/cn/minisite/index/15308

[490] "Notification of Lecture by Prof. Xu Aiguo, Key Laboratory of Computational Physics, Beijing Institute of Applied Physics and Computational Mathematics" [北京应用物理与计算数学研究所计算物理重点实验室许爱国教授讲座通知], *Xi'an Jiaotong University*, 18 july 2018, http://mfpe.xjtu.edu.cn/info/1078/5827.htm

[491] Liu Xu [刘旭] et al., "A Nested Partitioning Load Balancing Algorithm for Tianhe-2" [针对天河 2 号的一种嵌套剖分负载平衡算法], *Journal of Computer Research and Development* [计算机研究与发展], 2018, 55(2), https://crad.ict.ac.cn/cn/article/doi/10.7544/issn1000-1239.2018.20160877?viewType=citedby-info

[492] "Academic Seminar by Prof. Tongxiang Gu, Beijing Institute of Applied Physics and Computational Mathematics, Beijing, China May 26, 2010, AM" [北京应用物理与计算数学研究所谷同祥研究员学术报告 5 月 26 日上午], *Fujian Normal University*, 24 May 2016, https://ccs.fjnu.edu.cn/6d/e4/c15017a290276/page.htm

[493] "Up to 1.5 Million, Program Guidelines for National Key Laboratory of Computational Physics Released" [最高150万，计算物理全国重点实验室项目指南发布], *ScienceNet*, 9 July 2023, https://news.sciencenet.cn/htmlnews/2023/7/504396.shtm
[494] "Zhou Yutiao" [周毓舞], *National Taiwan Ocean University*, Accessed July 2024, http://msvlab.hre.ntou.edu.tw/article/%E4%BA%8C%E5%8D%81%E4%B8%96%E7%B4%80%E4%B8%AD%E5%9C%8B%E7%9F%A5%E5%90%8D%E7%A7%91%E5%AD%B8%E5%AE%B6/%E5%91%A8%E6%AF%93%E9%BA%9F.pdf
[495] "Zhou Yutiao" [周毓舞], *National Taiwan Ocean University*, Accessed July 2024, http://msvlab.hre.ntou.edu.tw/article/%E4%BA%8C%E5%8D%81%E4%B8%96%E7%B4%80%E4%B8%AD%E5%9C%8B%E7%9F%A5%E5%90%8D%E7%A7%91%E5%AD%B8%E5%AE%B6/%E5%91%A8%E6%AF%93%E9%BA%9F.pdf
[496] "Prof. Xijun Wei from Beijing Institute of Applied Physics and Computational Mathematics was invited to give a lecture at the academy" [北京应用物理与计算数学研究所蔚喜军教授应邀来院作学术报告], *Huizhou University*, 17 June 2024, https://www.hzu.edu.cn/2024/0619/c10482a255985/page.htm
[497] "Computational Mathematics Department - Chen Yibing" [计算数学教研室--陈艺冰], *Institute of Applied Physics and Computational Mathematics*, Accessed July 2024, http://www.iapcm.ac.cn/teams_head_con_228.html
[498] "Repost: We--Beijing University Mathematics and Literature Department, Class of 1954" [转贴：我们——北京大学數學力學系一九五四級], *Creaders.net*, 25 October 2014, https://m.creaders.net/bbs/politics/view/1001639
[499] "Chinese Academy of Engineering Physics Dedicated to National Prosperity", *Engineering Science* [中国工程科学], 2001, 3(8), https://www.engineering.org.cn/en/article/24871/detail
[500] Up to 1.5 Million, Program Guidelines for National Key Laboratory of Computational Physics Released" [最高150万，计算物理全国重点实验室项目指南发布], *ScienceNet*, 9 July 2023, https://news.sciencenet.cn/htmlnews/2023/7/504396.shtm
[501] Liu Xu [刘旭] et al., "A Nested Partitioning Load Balancing Algorithm for Tianhe-2" [针对天河2号的一种嵌套剖分负载平衡算法], *Journal of Computer Research and Development* [计算机研究与发展], 2018, 55(2), https://crad.ict.ac.cn/cn/article/doi/10.7544/issn1000-1239.2018.20160877?viewType=citedby-info
Xu Aiguo [许爱国] et al., "PROGRESS IN STUDIES ON DISCRETE BOLTZMANN MODELING OF PHASE SEPARATION PROCESS" [相分离过程的离散Boltzmann方法研究进展], *Mechanics in Engineering* [力学与实践], 2016, 38(4), https://lxsj.cstam.org.cn/cn/article/doi/10.6052/1000-0879-16-006
[502] "Cultivation of Practical Ability of Full-time Professional Degree Graduate Students and University-Enterprise Joint Cultivation Program Introduction to Joint Training Programs" [全日制专业学位研究生实践能力培养及校企联合培养项目介绍], *Shanghai Jiao Tong University*, Accessed March 2024, https://me.sjtu.edu.cn/upload/%E9%99%84%E4%BB%B61%EF%BC%9A%E5%85%A8%E6%97%A5%E5%88%B6%E4%B8%93%E4%B8%9A%E5%AD%A6%E4%BD%8D%E7%A0%94%E7%A9%B6%E7%94%9F%E5%AE%9E%E8%B7%B5%E8%83%BD%E5%8A%9B%E5%9F%B9%E5%85%BB%E5%8F%8A%E8%81%94%E5%9F%B9%E9%A1%B9%E7%9B%AE%E4%BB%8B%E7%BB%8D.pdf
[503] "Wang Zengquan: The "Heart" of Tianjin Manufacturing Speeds Up High-End Manufacturing Industry" [王增全：津产“心”为高端制造业提速], *eNorth*, 31 May 2018, http://news.enorth.com.cn/system/2018/05/31/035611052.shtml
[504] "AVIC's Yang Wei, Sun Cong and Tang Changhong Honored with the First National Innovation and Pioneering Award" [航空工业杨伟孙聪唐长红获颁首届全国创新争先奖], *Sohu*, 28 May 2017, https://www.sohu.com/a/144288701_821269
[505] "Company Profile" [公司简介], *51 Job*, Accessed March 2024, http://campus.51job.com/bffdj/index.html
[506] Wei Mingshan [魏名山] et al., "Thermodynamic Analysis of a Regulated Two-Stage Turbocharging System" [可调二级增压系统涡轮级热力学分析], *Chinese Internal Combustion Engine Engineering* [内燃机工程], 2008 29(1), http://cnjournals.com/view_abstract.aspx?pcid=5B3AB970F71A803DEACDC0559115BFCF0A068CD97DD29835&cid=C4EA1DB2DF23061E&jid=1C7B156A9CA70CBF564678522E399ACA&aid=0A422F001CF8429805A32FDB7214704B&yid=67289AFF6305E306&vid=771469D9D58C34FF&iid=CA4FD0336C81A37A&sid=BE33CC7147FEFCA4&eid=F4B561950EE1D31A&referenced_num=

Guo Zhiqiang [郭志强], "Analysis on Internal Flow Characteristics of Special Vehicle Turbocharger" [特种车辆涡轮增压器内部流动特性分析], *Transactions of Beijing institute of Technology* [北京理工大学学报自然版], 2018 38(S1), https://journal.bit.edu.cn/zr/cn/article/doi/10.15918/j.tbit1001-0645.2018.%E5%A2%9E%E5%88%8A1.013

[507] Zhang Junyue [张俊跃] et al., "Reliability Evaluation Model for Supercharger Turbine Overspeed Damage Failure Mode" [增压器涡轮超速破坏失效模式可靠性评价模型], "Proceedings of the 2009 Academic Conference on Fluid Mechanics of the Chinese Society of Engineering Thermophysics" [中国工程热物理学会流体机械 2009 年学术会议论文集], *Wangfang*, 1 January 2009, https://d.wanfangdata.com.cn/conference/7169236
Wang Zheng [王正], "The Development of Vehicle Engine Reliability Technology" [车用发动机可靠性技术发展研究], *Vehicle Engineer* [车用发动机], 2010 5(1), https://qikan.cqvip.com/Qikan/Article/Detail?id=35630702

[508] "Current state of domestic and foreign high-altitude emissions control and research" [国内外高海拔排放控制及研究现状], *Zhihu*, 11 July 2023, https://zhuanlan.zhihu.com/p/643018407

[509] "Engine Research Institute of the Power Research Institute "specialization, specialization and new" industry cluster development is showing signs of promise" [动力院发动机研究所"专精特新"产业集群发展初露峥嵘], *Sohu*, 23 August 2022, https://www.sohu.com/a/579196709_620823

[510] "Wang Zengquan: The "Heart" of Tianjin Manufacturing Speeds Up High-End Manufacturing Industry" [王增全：津产"心"为高端制造业提速], *eNorth*, 31 May 2018, http://news.enorth.com.cn/system/2018/05/31/035611052.shtml

[511] "BIT hosts 2016 Internal Combustion Engine Supercharger Industry Development Forum" [北理工举办 2016 内燃机增压器行业发展论坛], *Beijing Institute of Technology*, 15 January 2016, http://webcache.googleusercontent.com/search?client=firefox-b-1-d&q=cache%3Akjc.ypgylr.com%2Fxww%2Fxzw%2Fxsjl1%2Fa121601.htm

[512] "Company Profile" [公司简介], *51 Job*, Accessed March 2024, http://campus.51job.com/bffdj/index.html

[513] "Honor Roll! The Party Group of Norinco Industry Group honored a number of advanced collectives and individuals for their labor union work, "five small" activities and Communist Youth League work."" [光荣榜！兵器工业集团党组表彰一批工会工作、"五小"活动和共青团工作先进集体和先进个人], *Norinco*, 15 June 2022, http://www.norincogroup.com.cn/art/2022/6/15/art_84_357330.html

[514] "Cultivation of Practical Ability of Full-time Professional Degree Graduate Students and University-Enterprise Joint Cultivation Program Introduction to Joint Training Programs" [全日制专业学位研究生实践能力培养及校企联合培养项目介绍], *Shanghai Jiao Tong University*, Accessed March 2024, https://me.sjtu.edu.cn/upload/%E9%99%84%E4%BB%B61%EF%BC%9A%E5%85%A8%E6%97%A5%E5%88%B6%E4%B8%93%E4%B8%9A%E5%AD%A6%E4%BD%8D%E7%A0%94%E7%A9%B6%E7%94%9F%E5%AE%9E%E8%B7%B5%E8%83%BD%E5%8A%9B%E5%9F%B9%E5%85%BB%E5%8F%8A%E8%81%94%E5%9F%B9%E9%A1%B9%E7%9B%AE%E4%BB%8B%E7%BB%8D.pdf

[515] "Cultivation of Practical Ability of Full-time Professional Degree Graduate Students and University-Enterprise Joint Cultivation Program Introduction to Joint Training Programs" [全日制专业学位研究生实践能力培养及校企联合培养项目介绍], *Shanghai Jiao Tong University*, Accessed March 2024, https://me.sjtu.edu.cn/upload/%E9%99%84%E4%BB%B61%EF%BC%9A%E5%85%A8%E6%97%A5%E5%88%B6%E4%B8%93%E4%B8%9A%E5%AD%A6%E4%BD%8D%E7%A0%94%E7%A9%B6%E7%94%9F%E5%AE%9E%E8%B7%B5%E8%83%BD%E5%8A%9B%E5%9F%B9%E5%85%BB%E5%8F%8A%E8%81%94%E5%9F%B9%E9%A1%B9%E7%9B%AE%E4%BB%8B%E7%BB%8D.pdf

[516] "State Key Laboratory of Diesel Engine Boosting Technology 2023 First Batch of Open Door Fund to the Public" [柴油机增压技术国家级重点实验室 2023 年第一批对外开放基金], *Weixin* 6 November 2023, https://mp.weixin.qq.com/s/B2UB44pxihvGJkLf-_Gy2Q

[517] "Wang Zengquan: The "Heart" of Tianjin Manufacturing Speeds Up High-End Manufacturing Industry" [王增全：津产"心"为高端制造业提速], *eNorth*, 31 May 2018, http://news.enorth.com.cn/system/2018/05/31/035611052.shtml

[518] "Tianjin University and China National Power Research Institute of Norinco Signed a Strategic Cooperation Agreement" [天津大学与中国兵器工业集团动力研究院有限公司签署战略合作协议], *Education Online* [中国教育在线]. 17 August 2020, https://news.eol.cn/dongtai/202008/t20200817_1751776.shtml

[519] "The Key Laboratory of Diesel Boosting Technology co-organized the International Symposium on "High Efficiency, Low Carbon and Clean Combustion" for Internal Combustion Engines" [柴油机增压技术重点实验室协办内燃机"高效、低碳、清洁燃烧"国际学术研讨会], *Sohu*, 23 August 2022, https://www.sohu.com/a/579198861_620823

[520] "Cultivation of Practical Ability of Full-time Professional Degree Graduate Students and University-Enterprise Joint Cultivation Program Introduction to Joint Training Programs" [全日制专业学位研究生实践能力培养及校企联合培养项目介绍], *Shanghai Jiao Tong University*, Accessed March 2024, https://me.sjtu.edu.cn/upload/%E9%99%84%E4%BB%B61%EF%BC%9A%E5%85%A8%E6%97%A5%E5%88%B6%E4%B8%93%E4%B8%9A%E5%AD%A6%E4%BD%8D%E7%A0%94%E7%A9%B6%E7%94%9F%E5%AE%9E%E8%B7%B5%E8%83%BD%E5%8A%9B%E5%9F%B9%E5%85%BB%E5%8F%8A%E8%81%94%E5%9F%B9%E9%A1%B9%E7%9B%AE%E4%BB%8B%E7%BB%8D.pdf

[521] "Honor Roll! The Party Group of Norinco Industry Group honored a number of advanced collectives and individuals for their labor union work, "five small" activities and Communist Youth League work."" [光荣榜！兵器工业集团党组表彰一批工会工作、“五小”活动和共青团工作先进集体和先进个人], *Norinco*, 15 June 2022, http://www.norincogroup.com.cn/art/2022/6/15/art_84_357330.html

[522] "AVIC's Yang Wei, Sun Cong and Tang Changhong Honored with the First National Innovation and Pioneering Award" [航空工业杨伟孙聪唐长红获颁首届全国创新争先奖], *Sohu*, 28 May 2017, https://www.sohu.com/a/144288701_821269

[523] "Tianjin University and China National Power Research Institute of Norinco Signed a Strategic Cooperation Agreement" [天津大学与中国兵器工业集团动力研究院有限公司签署战略合作协议], *Education Online* [中国教育在线]. 17 August 2020, https://news.eol.cn/dongtai/202008/t20200817_1751776.shtml

[524] "Wang Zengquan: The "Heart" of Tianjin Manufacturing Speeds Up High-End Manufacturing Industry" [王增全：津产“心”为高端制造业提速], *eNorth*, 31 May 2018, http://news.enorth.com.cn/system/2018/05/31/035611052.shtml

[525] “Engine Research Institute of the Power Research Institute "specialization, specialization and new" industry cluster development is showing signs of promise” [动力院发动机研究所“专精特新”产业集群发展初露峥嵘], *Sohu*, 23 August 2022, https://www.sohu.com/a/579196709_620823

[526] "Cultivation of Practical Ability of Full-time Professional Degree Graduate Students and University-Enterprise Joint Cultivation Program Introduction to Joint Training Programs" [全日制专业学位研究生实践能力培养及校企联合培养项目介绍], *Shanghai Jiao Tong University*, Accessed March 2024, https://me.sjtu.edu.cn/upload/%E9%99%84%E4%BB%B61%EF%BC%9A%E5%85%A8%E6%97%A5%E5%88%B6%E4%B8%93%E4%B8%9A%E5%AD%A6%E4%BD%8D%E7%A0%94%E7%A9%B6%E7%94%9F%E5%AE%9E%E8%B7%B5%E8%83%BD%E5%8A%9B%E5%9F%B9%E5%85%BB%E5%8F%8A%E8%81%94%E5%9F%B9%E9%A1%B9%E7%9B%AE%E4%BB%8B%E7%BB%8D.pdf

[527] "About Us" [关于我们], *Shandong Xinde Make Supercharger Co. Ltd.*, Accessed March 2024, http://www.xdmake.com/

[528] "Cooperation Enterprises" [合作企业], *Hunan Province Key Lab of Critical Components for High-End Intelligent Equipment*, Accessed March 2024, http://ccfe.hnu.edu.cn/hzqy/hzqy.htm

[529] "Tianjin University and China National Power Research Institute of Norinco Signed a Strategic Cooperation Agreement" [天津大学与中国兵器工业集团动力研究院有限公司签署战略合作协议], *Education Online* [中国教育在线]. 17 August 2020, https://news.eol.cn/dongtai/202008/t20200817_1751776.shtml

[530] "BIT hosts 2016 Internal Combustion Engine Supercharger Industry Development Forum" [北理工举办 2016 内燃机增压器行业发展论坛], *Beijing Institute of Technology*, 15 January 2016, http://webcache.googleusercontent.com/search?client=firefox-b-1-d&q=cache%3Akjc.ypgylr.com%2Fxww%2Fxzw%2Fxsjl1%2Fa121601.htm

[531] "The Key Laboratory of Diesel Boosting Technology co-organized the International Symposium on "High Efficiency, Low Carbon and Clean Combustion" for Internal Combustion Engines" [柴油机增压技术重点实验室协办内燃机"高效、低碳、清洁燃烧"国际学术研讨会], *Sohu*, 23 August 2022, https://www.sohu.com/a/579198861_620823

[532] "Jin Donghan Attends 2019 Joint Academic Annual Meeting of China Internal Combustion Engine Society" [金东寒出席中国内燃机学会 2019 年联合学术年会], *Tianjin University*, 4 November 2019, http://news.tju.edu.cn/info/1003/48233.htm
[533] "Notice of the 2014 Booster Technology International Forum Meeting" [关于召开 2014 年增压技术国际论坛会议的通知], *China Internal Combustion Engine Industry Association*, 3 September 2014, https://ciceia.org.cn/fenzhijigou/1225.html
[534] "Cultivation of Practical Ability of Full-time Professional Degree Graduate Students and University-Enterprise Joint Cultivation Program Introduction to Joint Training Programs" [全日制专业学位研究生实践能力培养及校企联合培养项目介绍], *Shanghai Jiao Tong University*, Accessed March 2024, https://me.sjtu.edu.cn/upload/%E9%99%84%E4%BB%B61%EF%BC%9A%E5%85%A8%E6%97%A5%E5%88%B6%E4%B8%93%E4%B8%9A%E5%AD%A6%E4%BD%8D%E7%A0%94%E7%A9%B6%E7%94%9F%E5%AE%9E%E8%B7%B5%E8%83%BD%E5%8A%9B%E5%9F%B9%E5%85%BB%E5%8F%8A%E8%81%94%E5%9F%B9%E9%A1%B9%E7%9B%AE%E4%BB%8B%E7%BB%8D.pdf
[535] "State Key Laboratory of Diesel Engine Boosting Technology 2023 First Batch of Open Door Fund to the Public" [柴油机增压技术国家级重点实验室 2023 年第一批对外开放基金], *Weixin*, 6 November 2023, https://mp.weixin.qq.com/s/B2UB44pxihvGJkLf-_Gy2Q
[536] Zhang Junyue [张俊跃] et al., "Reliability Evaluation Model for Supercharger Turbine Overspeed Damage Failure Mode" [增压器涡轮超速破坏失效模式可靠性评价模型], "Proceedings of the 2009 Academic Conference on Fluid Mechanics of the Chinese Society of Engineering Thermophysics" [中国工程热物理学会流体机械 2009 年学术会议论文集], *Wangfang*, 1 January 2009, https://d.wanfangdata.com.cn/conference/7169236
[537] "Dedication and commitment are not regrettable, full of enthusiasm for the fire industry - remember the group company's science and technology leader, 2015 Model Worker Zhang Rui" [奉献担当终不悔 满腔热忱为火工——记集团公司科技带头人，2015 年劳动模范张蕊], *Norinco*, 4 May 2016. http://www.norincogroup.com.cn/art/2016/5/4/art_185_21251.html
[538] "Dedication and commitment are not regrettable, full of enthusiasm for the fire industry - remember the group company's science and technology leader, 2015 Model Worker Zhang Rui" [奉献担当终不悔 满腔热忱为火工——记集团公司科技带头人，2015 年劳动模范张蕊], *Norinco*, 4 May 2016. http://www.norincogroup.com.cn/art/2016/5/4/art_185_21251.html
[539] "Institute of Applied Physical Chemistry 2020 Campus Recruitment" [应用物理化学研究所 2020 校园招聘], *Wutongguo* [梧桐果], 13 September 2019. https://www.wutongguo.com/notice5491D60346.html
[540] "State Key Laboratory of Explosion Science and Technology Invites Researcher Rui Zhang to Give an Academic Report, " [爆炸科学与技术国家重点实验室邀请张蕊研究员做学术报告], State Key Laboratory of Explosion Science and Technology [爆炸科学技术国家重点实验室], 24 December 2015. http://webcache.googleusercontent.com/search?q=cache%3Ahttps%3A%2F%2Fest.bit.edu.cn%2Fkyxzdt%2F79807.htm&rlz=1C1CHBD_enUS949US949&oq=cache%3Ahttps%3A%2F%2Fest.bit.edu.cn%2Fkyxzdt%2F79807.htm&aqs=chrome.0.69i59j69i58j69i60.1529j0j4&sourceid=chrome&ie=UTF-8
[541] "Dedication and commitment are not regrettable, full of enthusiasm for the fire industry - remember the group company's science and technology leader, 2015 Model Worker Zhang Rui" [奉献担当终不悔 满腔热忱为火工——记集团公司科技带头人，2015 年劳动模范张蕊], *Norinco*, 4 May 2016. http://www.norincogroup.com.cn/art/2016/5/4/art_185_21251.html
[542] "Dedication and commitment are not regrettable, full of enthusiasm for the fire industry - remember the group company's science and technology leader, 2015 Model Worker Zhang Rui" [奉献担当终不悔 满腔热忱为火工——记集团公司科技带头人，2015 年劳动模范张蕊], *Norinco*, 4 May 2016. http://www.norincogroup.com.cn/art/2016/5/4/art_185_21251.html
[543] "NORINCO GROUP's initiating explosive devices have helped launch the "one rocket and nine satellites" at sea," *Norinco*, 15 September (no year). http://en.norincogroup.com.cn/art/2020/9/24/art_423_247758.html
[544] "Xi'an University of Technology and Weapon Industry 213 inaugurate "Optoelectronic Testing and Application Innovation Laboratory" [西安工大与兵器工业 213 所共建"光电测试与应用创新实验室"揭牌], *Netease*, 21 November 2020. https://www.163.com/dy/article/FS010D2I05363IFS.html

[545] "Dedication and commitment are not regrettable, full of enthusiasm for the fire industry - remember the group company's science and technology leader, 2015 Model Worker Zhang Rui" [奉献担当终不悔 满腔热忱为火工——记集团公司科技带头人，2015 年劳动模范张蕊], *Norinco*, 4 May 2016. http://www.norincogroup.com.cn/art/2016/5/4/art_185_21251.html
[546] "Xi'an University of Technology and Weapon Industry 213 inaugurate "Optoelectronic Testing and Application Innovation Laboratory" [西安工大与兵器工业 213 所共建"光电测试与应用创新实验室"揭牌], *Netease*, 21 November 2020. https://www.163.com/dy/article/FS010D2I05363IFS.html
[547] "Signing Ceremony of Strategic Cooperation Agreement of Energy-Containing Materials Innovation Alliance Laboratory was successfully held" [含能材料创新联盟实验室战略合作协议签约仪式成功举行], *Beijing Institute of Technology*, 24 October 2019. https://www.bit.edu.cn/xww/zhxw/yljs/a177952.htm
[548] "Norinco Special Energy Group" [北方特种能源集团有限公司], *Norinco*, Accessed 2021, https://nhrdc.cn:8080/campus/company_detail.jsp?code=12
[549] Fu Haihui [付海贤], Zhang Suixue [张岁学], "Three Key Laboratories of National Defense Science and Technology of Xi'an Institute of Electromechanical Information Technology of MEMS Group Signed Joint Innovation Platform Agreement" [微机电集团西安机电信息技术研究所三个国防科技重点实验室签订联合创新平台协议], *Norinco*, 15 October 2013. http://www.norincogroup.com.cn/art/2013/10/15/art_85_7829.html
[550] "The Eleventh National Conference on Explosive Mechanics Second Round Notice" [第十一届全国爆炸力学学术会议 第二轮会议通知], *South China University of Technology* [华南理工大学], 2 September 2016. http://www2.scut.edu.cn/jtxy/2016/0902/c1878a125644/page.htm
[551] "The 4th International Symposium on Nanostructured Energy-Containing Materials and their Application Technologies" was held in Nanjing" [第四届"国际纳米结构含能材料及其应用技术研讨会"在南京召开], *Jiansgu Society of Low-carbon Technology* [江苏省低碳技术学会], 5 November 2018. http://www.lowcarbonchina.org.cn/x2.asp?ID=314&sid=760
[552] "Shaanxi Institute of Applied Physical Chemistry" [陕西应用物理化学研究所], *Research and Recruitment* [研招网], Accessed 2021, https://yz.chsi.com.cn/sch/schoolInfo--schId-368529,categoryId-486742.dhtml
[553] "National Key Laboratory of Electromagnetic Effects and Safety of Marine Equipment inaugurated!" [海洋装备电磁效应及安全全国重点实验室揭牌!], *iMarine*, 24 September 2024, https://www.imarine.cn/160526.html
[554] "Defense S&T Key Laboratory of Electromagnetic Compatibility" [电磁兼容性国防科技重点实验室], *China Ship Research* [中国舰船研究], Accessed 2021, https://www.ixueshu.com/document/ee3f5d1acb12b91a3950c50ec69312cf318947a18e7f9386.html
[555] "Defense S&T Key Laboratory of Electromagnetic Compatibility" [电磁兼容性国防科技重点实验室], *China Ship Research* [中国舰船研究], Accessed 2021, https://www.ixueshu.com/document/ee3f5d1acb12b91a3950c50ec69312cf318947a18e7f9386.html
Key Lab of EMC" [电磁兼容性重点实验室], *Military Engineer Culture* [军工文化] (8) 2015. http://113.31.19.9/Qikan/Article/Detail?id=666204914
[556] "National Key Laboratory of Electromagnetic Effects and Safety of Marine Equipment inaugurated!" [海洋装备电磁效应及安全全国重点实验室揭牌!], *iMarine*, 24 September 2024, https://www.imarine.cn/160526.html
[557] "China Ship Research and Design Center 2021 Fall Recruitment" [中国舰船研究设计中心 2021 届秋季招聘简章], *Xi'an Jiaotong University*, 2 September 2020. http://epe.xjtu.edu.cn/info/1114/13071.htm
Deng Xiaoci, Guo Yuandan, Chinese shipbuilder shows 'mysterious' new carrier, *Global Times*, 20 June 2018. https://www.globaltimes.cn/content/1107638.shtml
[558] 15 CFR Part 744, *Federal Register* Vol. 85, No. 246, 22 December, 2020. https://www.govinfo.gov/content/pkg/FR-2020-12-22/pdf/2020-28031.pdf
[559] "China Shipbuilding Industry Electromagnetic Compatibility Testing Center" [中国船舶工业电磁兼容性检测中心], *@info* [创新信息垂直搜索引擎], 16 July 2012. http://info.360inno.com/Resource/Organ/28b9488c-4c1d-4139-a0f0-e2e439312602
[560] "Defense S&T Key Laboratory of Electromagnetic Compatibility" [电磁兼容性国防科技重点实验室], *Journal of Microwaves* [微波学报], Accessed 2021, https://www.ixueshu.com/document/b182fab31af30eb125651f452d5daba3318947a18e7f9386.html

[561] "Defense S&T Key Laboratory of Electromagnetic Compatibility" [电磁兼容性国防科技重点实验室], *China Ship Research* [中国舰船研究], Accessed 2021, https://www.ixueshu.com/document/ee3f5d1acb12b91a3950c50ec69312cf318947a18e7f9386.html
[562] "China Shipbuilding Industry Electromagnetic Compatibility Testing Center" [中国船舶工业电磁兼容性检测中心], *@info* [创新信息垂直搜索引擎], 16 July 2012. http://info.360inno.com/Resource/Organ/28b9488c-4c1d-4139-a0f0-e2e439312602
"Notice of 2019 Workshop on Complex Electromagnetic Environment Effects Technology" [关于举办 2019 复杂电磁环境效应技术研讨会"的通知], *China Institute of Electronics* [中国电子学会], 22 November 2019. http://www.mwjournal.org/uploadfile/newsfiles/2019-09-2014/2019%E5%A4%8D%E6%9D%82%E7%94%B5%E7%A3%81%E7%8E%AF%E5%A2%83%E6%95%88%E5%BA%94%E7%A0%94%E8%AE%A8%E4%BC%9A%E9%80%9A%E7%9F%A5(cie%EF%BC%89(22).pdf
"Domestic aircraft carrier deputy chief engineer Sun Guangshu made his first public appearance, it turns out that he is also a native of Hubei" [国产航母副总工程师孙光甦首次公开亮相，原来他也是湖北人], *Sina*, 23 March 2017. http://webcache.googleusercontent.com/search?q=cache%3Ahttps%3A%2F%2Fk.sina.cn%2Farticle_6446538128_1803e5d90001007637.html&rlz=1C1CHBD_enUS949US949&oq=cache%3Ahttps%3A%2F%2Fk.sina.cn%2Farticle_6446538128_1803e5d90001007637.html&aqs=chrome..69i57j69i58.1344j0j4&sourceid=chrome&ie=UTF-8
"701 senior engineer Liu Qifeng of CSIC - flicking electromagnetic space, weaving sea Skynet" [中船重工 701 高工刘其凤——弹拨电磁空间，编织海上天网], *Hubei People's Government* [湖北省人民政府], 20 July 2018. http://www.hubei.gov.cn/zhuanti/2018zt/2018xsdfd/201807/t20180720_1319770.shtml
[563] "701 senior engineer Liu Qifeng of CSIC - flicking electromagnetic space, weaving sea Skynet" [中船重工 701 高工刘其凤——弹拨电磁空间，编织海上天网], *Hubei People's Government* [湖北省人民政府], 20 July 2018. http://www.hubei.gov.cn/zhuanti/2018zt/2018xsdfd/201807/t20180720_1319770.shtml
[564] "National Key Laboratory of Electromagnetic Effects and Safety of Marine Equipment inaugurated!" [海洋装备电磁效应及安全全国重点实验室揭牌!], *iMarine*, 24 September 2024, https://www.imarine.cn/160526.html
[565] "Defense S&T Key Laboratory of Electromagnetic Compatibility" [电磁兼容性国防科技重点实验室], China Ship Research [中国舰船研究], Accessed 2021, https://www.ixueshu.com/document/ee3f5d1acb12b91a3950c50ec69312cf318947a18e7f9386.html
[566] "Publication Project of National Weapons Principle of Electromagnetic Compatibility" [国之重器出版工程 电磁兼容性原理], Posts & Telecom Press [人民邮电出版社], Accessed 2021, https://item.jd.com/13082930.html
[567] "Honor | The national upward and good youth selection was announced, Wuhan 8 people were selected" [荣誉 | 全国向上向善好青年评选揭晓，武汉 8 人入选], *Sohu*, 28 April 2019. https://www.sohu.com/a/310844009_100199096
[568] "701 senior engineer Liu Qifeng of CSIC - flicking electromagnetic space, weaving sea Skynet" [中船重工 701 高工刘其凤——弹拨电磁空间，编织海上天网], *Hubei People's Government* [湖北省人民政府], 20 July 2018. http://www.hubei.gov.cn/zhuanti/2018zt/2018xsdfd/201807/t20180720_1319770.shtml
[569] "701 senior engineer Liu Qifeng of CSIC - flicking electromagnetic space, weaving sea Skynet" [中船重工 701 高工刘其凤——弹拨电磁空间，编织海上天网], *Hubei People's Government* [湖北省人民政府], 20 July 2018. http://www.hubei.gov.cn/zhuanti/2018zt/2018xsdfd/201807/t20180720_1319770.shtml
"2016 Annual Academic Conference on Electromagnetic Compatibility Held Successfully " [2016 年度电磁兼容学术会议圆满举行], *Office of the Commission of the CPC Hubei Provincial Committee for the Integration of Military and Civilian Development* [中共湖北省委军民融合发展委员会办公室], 2 September 2016. http://webcache.googleusercontent.com/search?q=cache%3Agfkgb.hubei.gov.cn%2F2019%2Fyw%2Frgdt%2Fqydt%2F20695.htm&rlz=1C1CHBD_enUS949US949&oq=cache%3Agfkgb.hubei.gov.cn%2F2019%2Fyw%2Frgdt%2Fqydt%2F20695.htm&aqs=chrome..69i57j69i58.1180j0j4&sourceid=chrome&ie=UTF-8
[570] "2016 Annual Academic Conference on Electromagnetic Compatibility Held Successfully " [2016 年度电磁兼容学术会议圆满举行], *Office of the Commission of the CPC Hubei Provincial Committee for the Integration of Military and Civilian Development* [中共湖北省委军民融合发展委员会办公室], 2 September 2016. http://www.hbjmrh.gov.cn/xwdt/qydt/11755.htm

[571] "4th National Conference on Complex Electromagnetic Environment Technology and Applications" [第四届全国复杂电磁环境技术及应用学术会议], 27 April 2021. http://ceme2021.hplpb.com.cn/zh-CN/web/page?mid=506&pid=Home
[572] "NNU's Soo Research Institute holds IEEE MTT-S IMWS-AMP 2020 International Academic Conference" [新国大苏研院召开 IEEE MTT-S IMWS-AMP 2020 国际学术会议], *National University of Singapore*, 21 August 2020. http://www.nusri.cn/nusri/news/nusrinews/664.html
[573] "Sixth IEEE Global International Conference on Electromagnetic Compatibility held in Xi'an" [第六届 IEEE 全球电磁兼容国际会议在西安举行], Xi'an Jiaotong University, 28 October 2020. http://news.xjtu.edu.cn/info/1002/123290.htm
[574] "Asia International Conference of Electromagnetics begins in Xi'an" [亚洲电磁学国际会议（ASIAEM 2019）在西安召开], *Xi'an Jiaotong University*, 24 September 2019. http://news.xjtu.edu.cn/info/1033/6574.htm
"IEEE Xplore," IEEE Electromagnetic Compatibility Magazine 10 (3), 2021. https://ieeexplore.ieee.org/document/9614177
[575] Liu Xiaodong [刘晓东] et al., "Introduction of Safety Integrity on Safety-critical Systems" [关键性安全系统安全完整性概述], 安全与电磁兼容 (6) 2011. http://www.safetyandemc.com/backend/pics/files/File/2011/semc20110610.pdf
[576] "China Shipbuilding Industry Electromagnetic Compatibility Testing Center" [中国船舶工业电磁兼容性检测中心], *@info* [创新信息垂直搜索引擎], 16 July 2012. http://info.360inno.com/Resource/Organ/28b9488c-4c1d-4139-a0f0-e2e439312602
[577] "Honor | The national upward and good youth selection was announced, Wuhan 8 people were selected" [荣誉 | 全国向上向善好青年评选揭晓，武汉 8 人入选], *Sohu*, 28 April 2019. https://www.sohu.com/a/310844009_100199096
[578] "Qiu Zhanzhao, Academic Committee of Key Laboratory of Electromagnetic Protection was established" [邱展招, 电磁防护重点实验室学术委员会成立], *Sina*, 12 June 2006. http://jczs.news.sina.com.cn/2006-06-12/0940376467.html
"Yin Xiangdong, Qiu Zhanzhao, China builds key lab for electromagnetic protection to improve weapons combat effectiveness" [尹向东, 邱展招, 中国建成电磁防护重点实验室提高武器作战效能], *Sina*, 24 May 2007. http://mil.news.sina.com.cn/2007-05-24/0631446105.html
[579] "CAE Academician: Liu Shanghe" [中国工程院院士：刘尚合], *Liu Family*, 10 June 2022, https://www.liushijiazu.com/archives/8567
[580] "Qiu Zhanzhao, Academic Committee of Key Laboratory of Electromagnetic Protection was established" [邱展招, 电磁防护重点实验室学术委员会成立], *Sina*, 12 June 2006. http://jczs.news.sina.com.cn/2006-06-12/0940376467.html
[581] "Qiu Zhanzhao, Academic Committee of Key Laboratory of Electromagnetic Protection was established" [邱展招, 电磁防护重点实验室学术委员会成立], *Sina*, 12 June 2006. http://jczs.news.sina.com.cn/2006-06-12/0940376467.html
[582] "Part of China's military vehicles weak anti-magnetic interference ability needs to install a shielding device" [我国部分军车抗电磁干扰能力弱需加装屏蔽装置], *Sina*, 1 April 2010, https://mil.news.sina.com.cn/2010-04-01/0735588879.html
[583] "College of Telecommunications held a special recruitment seminar for civilian staff of Army Engineering University" [电信学院举办陆军工程大学文职人员专场招聘宣讲会], *Beijing Jiaotong University* [北京交通大学], Accessed October 2021, http://eaie.bjtu.edu.cn/cms/item/2209.html
[584] "Electromagnetic Compatiability Branch" [电磁兼容分会], *Chinese Institute of Electronics*, Accessed October 2021, https://www.cie.org/list_150/5242.html
[585] "Part of China's military vehicles weak anti-magnetic interference ability needs to install a shielding device" [我国部分军车抗电磁干扰能力弱需加装屏蔽装置], *Sina*, 1 April 2010, https://mil.news.sina.com.cn/2010-04-01/0735588879.html

[586] "College of Telecommunications held a special recruitment seminar for civilian staff of Army Engineering University" [电信学院举办陆军工程大学文职人员专场招聘宣讲会], Beijing Jiaotong University [北京交通大学], Accessed 2021, http://eaie.bjtu.edu.cn/cms/item/2209.html
[587] Liu Shanghe [刘尚合], Hu Xiaofeng [胡小锋] et al., "Electrostatic discharge test device in the environment of electromagnetic pulse radiation" [电磁脉冲辐射环境下静电放电试验装置], *Google Patents*, 9 January 2015. https://patents.google.com/patent/CN104535868A/zh
[588] "Experiment with yourself for scientific research Academician will 71,000 volts of static electricity into the body" [为科研拿自己实验 院士将 7.1 万伏静电注入身体], *China.com*, 5 May 2017. https://3g.china.com/act/news/945/20170505/30492240.html
[589] Pan Xiaodong [潘晓东] et al., "Experimental study on radiation effect of in-band continuous wave on typical radar equipment" [典型雷达装备带内连续波辐射效应试验研究], *High Power Laser and Particle Beams* [强激光与粒子束] (5) 2020. http://www.hplpb.com.cn/cn/article/doi/10.11884/HPLPB202032.190471
[590] Cheng Erwei [程二威], Chen Yazhou [陈亚洲] et al., "Analysis on the interference effect of electrostatic discharge of GNSS receiver on aircraft" [飞行器 GNSS 接收机静电放电干扰效应分析], *High Power Laser and Particle Beams* [强激光与粒子束] (12) 2019. http://www.hplpb.com.cn/cn/article/doi/10.11884/HPLPB201931.190268
[591] Chen Yazhou [陈亚洲] et al., "Early warning protection integrated mobile lightning protection and monitoring platform and method" [预警防护一体化机动雷电防护与监测平台及方法], *Google Patents*, 24 November 2016. https://patents.google.com/patent/CN106654864A/zh
[592] "Graduate Student Mentorship" [研究生导师风采], *Shijiazhuang University of Railways* [石家庄铁道大学], Accessed 2021, https://yjs.stdu.edu.cn/supervisor?code=40000010
[593] Graduate Student Mentorship" [研究生导师风采], *Shijiazhuang University of Railways* [石家庄铁道大学], Accessed 2021, https://yjs.stdu.edu.cn/supervisor?code=40000010
"Part of China's military vehicles weak anti-magnetic interference ability needs to install a shielding device" [我国部分军车抗电磁干扰能力弱需加装屏蔽装置], *Sina*, 1 April 2010, https://mil.news.sina.com.cn/2010-04-01/0735588879.html
[594] "Part of China's military vehicles weak anti-magnetic interference ability needs to install a shielding device" [我国部分军车抗电磁干扰能力弱需加装屏蔽装置], *Sina*, 1 April 2010, https://mil.news.sina.com.cn/2010-04-01/0735588879.html
[595] "Part of China's military vehicles weak anti-magnetic interference ability needs to install a shielding device" [我国部分军车抗电磁干扰能力弱需加装屏蔽装置], *Sina*, 1 April 2010, https://mil.news.sina.com.cn/2010-04-01/0735588879.html
[596] "Part of China's military vehicles weak anti-magnetic interference ability needs to install a shielding device" [我国部分军车抗电磁干扰能力弱需加装屏蔽装置], *Sina*, 1 April 2010, https://mil.news.sina.com.cn/2010-04-01/0735588879.html
[597] "Director Chen Yazhou of National Key Laboratory of Electromagnetic Environmental Effects visited the university" [电磁环境效应国家级重点实验室陈亚洲主任一行来校参观交流], *EXUESHI* [易学士], 28 April 2018. http://webcache.googleusercontent.com/search?q=cache%3Aszmoander.com%2Fnews%2Fnews-7663&rlz=1C1CHBD_enUS895US895&oq=cache%3Aszmoander.com%2Fnews%2Fnews-7663&aqs=chrome..69i57j69i58.1263j0j4&sourceid=chrome&ie=UTF-8
[598] "Electromagnetic Compatiability Branch" [电磁兼容分会], *Chinese Institute of Electronics*, Accessed October 2021, https://www.cie.org/list_150/5242.html
[599] "Electromagnetic Compatiability Branch" [电磁兼容分会], *Chinese Institute of Electronics*, Accessed October 2021, https://www.cie.org/list_150/5242.html
[600] "Academician Liu Shanghe and Vice President Rongfei visited Colin Electric Company" [刘尚合院士、荣飞副校长到科林电气公司考察], *Shijiazhuang Tiedao University* [石家庄铁道大学], 7 April 2018. https://xcbnew.stdu.edu.cn/news/28013-2018-04-07-02-34-19
[601] "Liu Shanghe" [刘尚合], *CAE* [中国工程院], Accessed 2021, https://ysg.ckcest.cn/html/details/623/index.html
"Graduate Student Mentorship" [研究生导师风采], *Shijiazhuang University of Railways* [石家庄铁道大学], Accessed 2021, https://yjs.stdu.edu.cn/supervisor?code=40000010

"Experiment with yourself for scientific research Academician will 71,000 volts of static electricity into the body" [为科研拿自己实验 院士将 7.1 万伏静电注入身体], *China.com*, 5 May 2017. https://3g.china.com/act/news/945/20170505/30492240.html

[602] "Part of China's military vehicles weak anti-magnetic interference ability needs to install a shielding device" [我国部分军车抗电磁干扰能力弱需加装屏蔽装置], *Sina*, 1 April 2010, https://mil.news.sina.com.cn/2010-04-01/0735588879.html

[603] "Part of China's military vehicles weak anti-magnetic interference ability needs to install a shielding device" [我国部分军车抗电磁干扰能力弱需加装屏蔽装置], *Sina*, 1 April 2010, https://mil.news.sina.com.cn/2010-04-01/0735588879.html

[604] "Graduate Student Mentorship" [研究生导师风采], *Shijiazhuang University of Railways* [石家庄铁道大学], Accessed 2021, https://yjs.stdu.edu.cn/supervisor?code=40000010

"Academician Liu Shanghe and Vice President Rongfei visited Colin Electric Company" [刘尚合院士、荣飞副校长到科林电气公司考察], *Shijiazhuang Tiedao University* [石家庄铁道大学], 7 April 2018. https://xcbnew.stdu.edu.cn/news/28013-2018-04-07-02-34-19

[605] "The Fourth National Conference on Complex Electromagnetic Environment Technology and Applications" [第四届全国复杂电磁环境技术及应用学术会议], *CEME 2021*, ceme2021.hplpb.com.cn/zh-CN/web/article/menudetail?mid=531

[606] "The 4th International Symposium on Static Protection and Standardization was successfully held in Tianjin" [第四届静电防护与标准化国际研讨会在天津成功召开], *CEAIE* [中国新能源人才技术交流服务中心], 11 November 2015. http://www.ceaie.org/news/html/4648.html

"U.S.-China Standards and Conformity Assessment Cooperation Program" [中美标准与合格评定合作项目], *ANSI*, 17 November 2016. https://webcache.googleusercontent.com/search?q=cache:GgYteO84rFgJ:https://share.ansi.org/Shared%2520Documents/Standards%2520Activities/International%2520Standardization/Regional/Staff/LMM/SCCP%2520Materials/Phase%2520IV_U.S._China_SCCP_Flyers/U.S.-China%2520ESDA%2520Workshop_%2520Flyer_CN%2520(2).docx+&cd=30&hl=en&ct=clnk&gl=us

"Notice of the 8th International Symposium on Electrostatic Protection and Standardization" [关于举办第八届静电防护与标准化国际研讨会的通知], *kknews*, 8 October 2019. https://kknews.cc/zh-my/news/8g5ybe4.html

[607] "Asian International Conference on Electromagnetics (ASIAEM 2019) in Xi'an" [亚洲电磁学国际会议（ASIAEM 2019）在西安召开], *Xi'an Jiaotong University*, 24 September 2019. http://news.xjtu.edu.cn/info/1033/6574.htm

[608] "Part of China's military vehicles weak anti-magnetic interference ability needs to install a shielding device" [我国部分军车抗电磁干扰能力弱需加装屏蔽装置], *Sina*, 1 April 2010, https://mil.news.sina.com.cn/2010-04-01/0735588879.html

[609] "College of Telecommunications held a special recruitment seminar for civilian staff of Army Engineering University" [电信学院举办陆军工程大学文职人员专场招聘宣讲会], *Beijing Jiaotong University* [北京交通大学], Accessed 2021, http://eaie.bjtu.edu.cn/cms/item/2209.html

[610] "Bright sword of the electromagnetic space" ["亮剑"电磁空间], *Sina*, 8 June 2011, http://mil.news.sina.com.cn/2011-06-08/0326650897.html?from=wap

[611] "Bright sword of the electromagnetic space" ["亮剑"电磁空间], *Sina*, 8 June 2011, http://mil.news.sina.com.cn/2011-06-08/0326650897.html?from=wap

[612] "Asian International Conference on Electromagnetics (ASIAEM 2019) in Xi'an" [亚洲电磁学国际会议（ASIAEM 2019）在西安召开], *Xi'an Jiaotong University*, 24 September 2019. http://news.xjtu.edu.cn/info/1033/6574.htm

[613] "Conference homepage" [大会首页], *Chinese Society of Engineering*, 27 October 2020, https://b2b.csoe.org.cn/meeting/show-38.html

[614] "Electromagnetic Compatibility Branch" [电磁兼容分会], *Chinese Institute of Electronics*, Accessed June 2024, https://www.cie.org.cn/list_150/5242.html

[615] "Overview of foreign machine lightning test system" [国外整机雷电试验系统综述], *Sohu*, 13 July 2020, https://www.sohu.com/a/407336611_487612

Guo Fei [郭飞] et al., "Analysis for lightning indirect effects of the aircraft by numerical stimulation" [飞机闪电间接效应数值仿真分析], *Chinese Journal of Radio Science* [电波科学学报], 2012, 6, https://it.alljournals.cn/view_abstract.aspx?pcid=5B3AB970F71A803DEACDC0559115BFCF0A068CD97DD29835&cid=1319827C0C74AAE8D654BEA21B7F54D3&jid=A4508D0FD86771945B095FCB44596F64&aid=130C97BF45866C6BBA690AAEE1B3CB80&yid=99E9153A83D4CB11&iid=B31275AF3241DB2D&sid=2C195A225F9C61A0&eid=19C90C44246D149B464B200F61A91F18&referenced_num=%E6%80%BB%E8%A2%AB%E5%BC%95%EF%BC%9A2%EF%BC%8C%E8%87%AA%E5%BC%95%EF%BC%9A0%EF%BC%8C%E4%BB%96%E5%BC%95%EF%BC%9A2

[616] Liu Lei [刘磊] et al., "Review of Terahertz Passive Remote Sensing of Ice Clouds" [太赫兹波被动遥感冰云研究现状及进展], *Advances in Earth Science* [地球科学进展], 2020, 35(12), http://www.adearth.ac.cn/article/2020/1001-8166/1001-8166-2020-35-12-1211.shtml

[617] "Overview of foreign machine lightning test system" [国外整机雷电试验系统综述], *Sohu*, 13 July 2020, https://www.sohu.com/a/407336611_487612

[618] "Bright sword of the electromagnetic space" ["亮剑"电磁空间], *Sina*, 8 June 2011, http://mil.news.sina.com.cn/2011-06-08/0326650897.html?from=wap

[619] "First National Electromagnetic Frontier Crosscutting Technology Conference 2024" [2024 年第一届全国电磁前沿交叉技术大会], *Huiyitong* [会议通], 11 April 2024, https://www.huiyi-123.com/article/2661-179.html

[620] "The Second National Academic Conference on Technology and Application of Complex Electromagnetic Environment" [第二届全国复杂电磁环境技术及应用学术会议], *Aconf*, Accessed June 2024, https://www.aconf.org/conf_94112.html

[621] "Asian International Conference on Electromagnetics (ASIAEM 2019) in Xi'an" [亚洲电磁学国际会议（ASIAEM 2019）在西安召开], *Xi'an Jiaotong University*, 24 September 2019, http://news.xjtu.edu.cn/info/1033/6574.htm

"The First Plenary Session of the International Academic Committee of National International Joint Research Center for Transient Electromagnetic Environment and Applications was Held" [瞬态电磁环境与应用国家级国际联合研究中心国际学术委员会第一次全体会议召开], *Xi'an Jiaotong University*, 19 September 2019, http://news.xjtu.edu.cn/info/1004/76906.htm

[622] Liu Lei [刘磊] et al., "Review of Terahertz Passive Remote Sensing of Ice Clouds" [太赫兹波被动遥感冰云研究现状及进展], *Advances in Earth Science* [地球科学进展], 2020, 35(12), http://www.adearth.ac.cn/article/2020/1001-8166/1001-8166-2020-35-12-1211.shtml

[623] "Brief Introduction to Sponsors," *ISAPE 2018*, Accessed 2021, http://www.rpsoc.cn/isape2018/index.php/site/singlePage/35

[624] "Six Generations of Talents" Building New Successes Again--Note to the First Weapon System Terminal Destruction Technology Discipline Group in New China" [英才辈出 "六代同堂"再建新功——记新中国第一个武器系统终端毁伤技术学科群], *Beijing Institute of Technology*, 29 May 2020. http://80.bit.edu.cn/blqh/xscq80/188796.htm

"Brief Introduction to Sponsors," *ISAPE 2018*, Accessed 2021, http://www.rpsoc.cn/isape2018/index.php/site/singlePage/35

"Key Laboratory of Mechatronic Dynamic Control" [机电动态控制重点实验室], *Huodong Jia* [活动家], Accessed 2021, https://www.huodongjia.com/sponsor-07706806512107908406 5048.html

[625] "Six Generations of Talents" Building New Successes Again--Note to the First Weapon System Terminal Destruction Technology Discipline Group in New China" [英才辈出 "六代同堂"再建新功——记新中国第一个武器系统终端毁伤技术学科群], *Beijing Institute of Technology*, 29 May 2020. http://80.bit.edu.cn/blqh/xscq80/188796.htm

"Brief Introduction to Sponsors," *ISAPE 2018*, Accessed 2021, http://www.rpsoc.cn/isape2018/index.php/site/singlePage/35

"Key Laboratory of Mechatronic Dynamic Control" [机电动态控制重点实验室], *Huodong Jia* [活动家], Accessed 2021, https://www.huodongjia.com/sponsor-07706806512107908406 5048.html

[626] Six Generations of Talents" Building New Successes Again--Note to the First Weapon System Terminal Destruction Technology Discipline Group in New China" [英才辈出 "六代同堂"再建新功——记新中国第一个

武器系统终端毁伤技术学科群], *Beijing Institute of Technology*, 29 May 2020. http://80.bit.edu.cn/blqh/xscq80/188796.htm
"Brief Introduction to Sponsors," *ISAPE 2018*, Accessed 2021, http://www.rpsoc.cn/isape2018/index.php/site/singlePage/35
"Key Laboratory of Mechatronic Dynamic Control" [机电动态控制重点实验室], *Huodong Jia* [活动家], Accessed 2021, https://www.huodongjia.com/sponsor-07706806512107908406 5048.html
"Six Generations of Talents" Building New Successes Again--Note to the First Weapon System Terminal Destruction Technology Discipline Group in New China" [英才辈出 "六代同堂"再建新功——记新中国第一个武器系统终端毁伤技术学科群], *Beijing Institute of Technology*, 29 May 2020. http://80.bit.edu.cn/blqh/xscq80/188796.htm
"Xi'an Institute of Mechatronics and Information Technology (212) Introduction" [西安机电信息技术研究所(212所)简介], *KaoYan.com*, 22 April 2014. http://yz.kaoyan.com/emit/jianjie/
"China National Weapons Industry Corporation 212th Research Institute (Xi'an Institute of Mechanical and Electrical Information)" [中国兵器工业集团公司 第 212 研究所 (西安机电信息研究所)], *TRM* [西安科技大市场], Accessed 2021, https://web.archive.org/web/20190521041554/http://www.xatrm.com/organization/detail.jspx?id=194
"Xi'an Institute of Mechanical and Electrical Information Technology: Innovation ignites the "fuze" of the dream of a strong nation" [西安机电信息技术研究所：创新点燃强国之梦的"引信"]， *kknews*, 2 July 2018. https://kknews.cc/zh-cn/news/8okqyvn.html
[627] "Key Laboratory of Mechatronic Dynamic Control" [机电动态控制重点实验室], *Huodong Jia* [活动家], Accessed 2021, https://www.huodongjia.com/sponsor-07706806512107908406 5048.html
"Detection and Control Development Forum 2018 was successfully held " [2018 年探测与控制发展论坛成功举行], *Beijing Institute of Technology*, 7 December 2018. http://webcache.googleusercontent.com/search?q=cache%3Ahttps%3A%2F%2Fwww.bit.edu.cn%2Fxww%2Fxzw%2Fxsjl1%2Fa163194.htm&rlz=1C1CHBD_enUS949US949&oq=cache%3Ahttps%3A%2F%2Fwww.bit.edu.cn%2Fxww%2Fxzw%2Fxsjl1%2Fa163194.htm&aqs=chrome..69i57j69i58.1376j0j4&sourceid=chrome&ie=UTF-8
Chen Xi [陈曦] et al., "Impact of Training on Long-Range Correlation of Gait Cycle" [训练对于步伐周期长程相关性的影响研究], *Transactions of Beijing Institute of Technology* [北京理工大学学报] (36) 2015. http://journal.bit.edu.cn/zr/ch/reader/view_abstract.aspx?file_no=20160208&st=alljournals
"2015 Cross-Strait Four Wireless Technology Symposium " [2015 海峡两岸四地无线科技研讨会], *Huodong Jia* [活动家], 15 August 2015. https://m.huodongjia.com/event-333026.html
[628] "Key Laboratory of Mechatronic Dynamic Control" [机电动态控制重点实验室], *Huodong Jia* [活动家], Accessed 2021, https://www.huodongjia.com/sponsor-07706806512107908406 5048.html
[629] "Key Laboratory of Mechatronic Dynamic Control" [机电动态控制重点实验室], *Huodong Jia* [活动家], Accessed 2021, https://www.huodongjia.com/sponsor-07706806512107908406 5048.html
[630] "Dang Ruirong" [党瑞荣], *Xi'an Shiyou University* [西安石油大学], 28 November 2014. http://dzgc.xsyu.edu.cn/info/1114/1726.htm
"Xi'an Institute of Mechanical and Electrical Information Technology: Innovation ignites the "fuze" of the dream of a strong nation" [西安机电信息技术研究所：创新点燃强国之梦的"引信"], *kknews*, 2 July 2018. https://kknews.cc/zh-cn/news/8okqyvn.html
Tan Huimin [谭惠民] et al., "Motion model of air-to-air missile far-solving mechanism with gimbaled bracket" [带万向支架的空空导弹远解机构的运动模型], *Journal of Detection and Control* [探测与控制学报] (23) 2001. https://www.ixueshu.com/document/9d920d1b6f5dbe6f318947a18e7f9386.html. Tan Huimin is associated with this Lab.
Tan Huimin [谭惠民], "Virtual Test Techniques of Fuze Arming Distance" [引信解除保险距离的虚拟试验技术], *Acta Armamentarii* [兵工学报] (3) 2005.
Dang Ruirong [党瑞荣] et al., "A Theory for the Identification of Fuze Environmental Information" [引信环境信息识别理论], *Acta Armamentarii* [工兵学报] (3) 2000. http://113.31.20.151/articles/article_detail.aspx?id=1001110276

Tan Huimin [谭惠民], "High reliability design of fuze safety system controller" [引信安全系统控制器高可靠性设计], *Modern Fuze* [现代引信] (4) 1993. https://d.wanfangdata.com.cn/periodical/QK000003339315

[631] "Detection and Control Development Forum 2018 was successfully held" [2018 年探测与控制发展论坛成功举行], *Beijing Institute of Technology*, 7 December 2018. http://webcache.googleusercontent.com/search?q=cache%3Ahttps%3A%2F%2Fwww.bit.edu.cn%2Fxww%2Fxzw%2Fxsjl1%2Fa163194.htm&rlz=1C1CHBD_enUS949US949&oq=cache%3Ahttps%3A%2F%2Fwww.bit.edu.cn%2Fxww%2Fxzw%2Fxsjl1%2Fa163194.htm&aqs=chrome..69i57j69i58.1376j0j4&sourceid=chrome&ie=UTF-8

[632] "Six Generations of Talents" Building New Successes Again--Note to the First Weapon System Terminal Destruction Technology Discipline Group in New China" [英才辈出 "六代同堂"再建新功——记新中国第一个武器系统终端毁伤技术学科群], *Beijing Institute of Technology*, 29 May 2020. http://80.bit.edu.cn/blqh/xscq80/188796.htm

[633] "Six Generations of Talents" Building New Successes Again--Note to the First Weapon System Terminal Destruction Technology Discipline Group in New China" [英才辈出 "六代同堂"再建新功——记新中国第一个武器系统终端毁伤技术学科群], *Beijing Institute of Technology*, 29 May 2020. http://80.bit.edu.cn/blqh/xscq80/188796.htm

[634] Dang Ruirong" [党瑞荣], *Xi'an Shiyou University* [西安石油大学], 28 November 2014. http://dzgc.xsyu.edu.cn/info/1114/1726.htm

[635] "Journal Introduction" [学报简介], *Journal of Detection and Control* [探测与控制学报], Accessed 2021, http://www.tcykz.com/

[636] "China National Weapons Industry Corporation 212th Research Institute (Xi'an Institute of Mechanical and Electrical Information)" [中国兵器工业集团公司 第 212 研究所 (西安机电信息研究所)], *TRM* [西安科技大市场], Accessed 2021, https://web.archive.org/web/20190521041554/http://www.xatrm.com/organization/detail.jspx?id=194

[637] "The 2nd IEEE International Conference on Unmanned Systems (IEEE ICUS 2019) was successfully held" [第二届 IEEE 国际无人系统大会（IEEE ICUS 2019）顺利召开], *IEEE ICUS 2019*, Accessed February 2025, https://icus.c2.org.cn/2020/en/web/article/menudetail-571.html

[638] "Keynotes", *ISAPE 2024*, Accessed February 2025, https://www.rpsoc.cn/isape2024/index.php/site/singlePage/23

[639] "The 25th Annual Conference and 14th International Conference of the Chinese Society of Micro and Nanotechnology" [中国微米纳米技术学会第二十五届学术年会暨第十四届国际会议], *CSMNT 2023*, Accessed February 2025, https://cloud.yiyum.com/data/public/upload/file/20230801/1690880548885344.pdf

[640] "Brief Introduction to Sponsors," *ISAPE 2018*, Accessed 2021, http://www.rpsoc.cn/isape2018/index.php/site/singlePage/35

[641] "Brief Introduction to Sponsors," *ISAPE 2018*, Accessed 2021, http://www.rpsoc.cn/isape2018/index.php/site/singlePage/35

[642] "Xi'an Institute of Mechanical and Electrical Information Technology: Innovation ignites the "fuze" of the dream of a strong nation" [西安机电信息技术研究所：创新点燃强国之梦的"引信"], *kknews*, 2 July 2018. https://kknews.cc/zh-cn/news/8okqyvn.html

[643] "Introduction to the Key Laboratory of Electronic Countermeasures for National Defense Science and Technology" [电子对抗国防科技重点实验室简介], *Electronic Warfare Technology* [电子对抗技术], 1995 年 4 期. https://archive.ph/cxoLw

[644] "Airborne passive positioning principle based on Doppler frequency measurement" [基于多普勒频率测量的机载无源定位原理*], Paper Collection of the 2007 Annual Conference of the Sichuan Institute of Electronics* [四川省电子学会 2007 年学术年会论文汇编, 28 June 2007 (meeting date – publication date not listed). https://d.wanfangdata.com.cn/conference/6460380

"A New Passive Location Method Based on Synthetic Aperture" [一种新的机载单站无源定位方法], *Electronic Warfare Technology* [电子对抗技术], 2007, 22(5). https://archive.ph/o96pT

"Research on Fuzzy Comprehensive Evaluation of Radar Signal Recognition Effect" [雷达信号识别效果的模糊综合评价研究], *Radar Science and Technology* [雷达科学与技术], 2012(4). https://web.archive.org/web/20210601132908/http://www.alljournals.cn/view_abstract.aspx?pcid=5B3AB970F71A

803DEACDC0559115BFCF0A068CD97DD29835&cid=1319827C0C74AAE8D654BEA21B7F54D3&jid=5AD7B396DDC3401C79FC563E2B18BE24&aid=2A63442CBCED510836F7AF3464F4019F&yid=99E9153A83D4CB11&from_type=1

[645] "Company Introduction" [企业简介], CETC 29th RI [中国电子科技集团公司第二十九研究所], Accessed 2021, https://web.archive.org/web/20190428012346/http://29.cetc.com.cn/29/335603/335591/index.html (alternate: https://web.archive.org/web/20170420221303/http://www.swiee.com/29/335603/335591/index.html)

[646] Supplement No. 4 to Part 744 -ENTITY LIST," *Bureau of Industry and Security*, 8 April 2021. https://www.bis.doc.gov/index.php/documents/regulation-docs/691-supplement-no-4-to-part-744-entity-list/file

[647] "Electronic Information Technology" [电子信息对抗技术], *Wanfang Data* [万方数据], Accessed 2021, https://www.wanfangdata.com.cn/sns/perio/dzdkjs/; "Electronic Information Warfare Technology" [电子信息对抗技术], accessed May 2021.

[648] "International Electronic Warfare" [国际电子战], *Changfeng County Library* [长丰县图书馆], Accessed 2021, https://archive.ph/3CRPw

[649] "Introduction to the Key Laboratory of Electronic Countermeasures for National Defense Science and Technology" [电子对抗国防科技重点实验室简介], *Electronic Warfare Technology* [电子对抗技术], 1995 年 4 期. https://archive.ph/cxoLw

[650] "Introduction to the Key Laboratory of Electronic Countermeasures for National Defense Science and Technology" [电子对抗国防科技重点实验室简介], *Electronic Warfare Technology* [电子对抗技术], 1995 年 4 期. https://archive.ph/cxoLw
Also, per a survey of the Lab's research in two scientific databases

[651] "Introduction to the Key Laboratory of Electronic Countermeasures for National Defense Science and Technology" [电子对抗国防科技重点实验室简介], *Electronic Warfare Technology* [电子对抗技术], 1995 年 4 期. https://archive.ph/cxoLw
Also, per a survey of the Lab's research in two scientific databases

[652] "Xidian held the 27th Annual Conference of the Three New Academics of Electronic Warfare" [西电举办第二十七届电子战三新学术年会], *Xidian News Network* [西电新闻网], 12 September 2020. https://web.archive.org/web/20210603145329/https://news.xidian.edu.cn/info/2106/205687.htm

[653] "Xidian held the 27th Annual Conference of the Three New Academics of Electronic Warfare" [西电举办第二十七届电子战三新学术年会], *Xidian News Network* [西电新闻网], 12 September 2020. https://web.archive.org/web/20210603145329/https://news.xidian.edu.cn/info/2106/205687.htm

[654] "Introduction to the Key Laboratory of Electronic Countermeasures for National Defense Science and Technology" [电子对抗国防科技重点实验室简介], *Electronic Warfare Technology* [电子对抗技术], 1995 年 4 期. https://archive.ph/cxoLw

[655] "Company Introduction" [企业简介], CETC 29th RI [中国电子科技集团公司第二十九研究所], Accessed 2021, https://web.archive.org/web/20190428012346/http://29.cetc.com.cn/29/335603/335591/index.html (alternate: https://web.archive.org/web/20170420221303/http://www.swiee.com/29/335603/335591/index.html)

[656] Pei Zhongmin [裴忠民], "Network Information System Mechanisms and Methods" [网络信息体系机理与方法], *Defense Industry Press,* 2020, www.duozhuayu.com/books/57143636356870933

[657] Li Xinming [李新明] et al., "Methodology Analysis of Cognitive Computing System for Equipment System of Systems Based on Big Data," [基于大数据的装备体系认知计算系统分析], *Journal of Command and Control* [指挥与控制学报], March 2016, 2, http://webcache.googleusercontent.com/search?q=cache:vujrNf9WxaIJ:jc2.org.cn/CN/article/downloadArticleFile.do%3FattachType%3DPDF%26id%3D92+&cd=13&hl=en&ct=clnk&gl=us

[658] "Solving Beijing Hukou! Pre-announcement of Recruitment of Civilian Personnel for Key Laboratory of Complex Electronic System Simulation" [解决北京户口！复杂电子系统仿真重点实验室招聘文职人员预公告！], *Sohu*, 3 March 2021. https://www.sohu.com/a/453714039_100080725

[659] Yang Chenkai [杨晨凯], "Content Delivery in Wireless Mesh Network Based Military Information System" [军事信息系统中基于无线 Mesh 网络的内容分发方法], *Journal of China Academy of Electronics and Information Technology* [中国电子科学研究院学报], 2017, 6, http://webcache.googleusercontent.com/search?q=cache%3Acnki.hcnu.edu.cn%2FKCMS%2Fdetail%2Fdetail.aspx

%3Ffilename%3DKJPL201706016%26dbcode%3DCJFD%26dbname%3DCJFD2017&rlz=1C1CHBD_enUS949US949&oq=cache%3Acnki.hcnu.edu.cn%2FKCMS%2Fdetail%2Fdetail.aspx%3Ffilename%3DKJPL201706016%26dbcode%3DCJFD%26dbname%3DCJFD2017&aqs=chrome..69i57j69i58.1351j0j4&sourceid=chrome&ie=UTF-8

[660] Lin Qi [林琪], Li Zhi [李智], "Modeling and Simulation Analysis of Antenna Orientation on Inter-Satellite Link" [星间链路天线指向建模与仿真分析], *Computer Simulation* [计算机仿真], 2008, 7, http://ksuxk.cqvip.com/asset/detail/0/20337888625

[661] Ren Haoli [任昊利] et al., "Research on Simulation Framework of Spatial Information System" [空间信息系统仿真框架研究], Journal of Systems Simulation [系统仿真学报], 2006, 2, http://www.mbtsg.com/qikan/6a9cce42c8a58e5d4f511989d9adc866.html

[662] Pei Zhongmin [裴忠民], "Network Information System Mechanisms and Methods" [网络信息体系机理与方法], *Defense Industry Press,* 2020, www.duozhuayu.com/books/57143636356870933

[663] Li Xinming [李新明] et al., "Methodology Analysis of Cognitive Computing System for Equipment System of Systems Based on Big Data," [基于大数据的装备体系认知计算系统分析], *Journal of Command and Control* [指挥与控制学报], March 2016, 2, http://webcache.googleusercontent.com/search?q=cache:vujrNf9WxaIJ:jc2.org.cn/CN/article/downloadArticleFile.do%3FattachType%3DPDF%26id%3D92+&cd=13&hl=en&ct=clnk&gl=us

[664] Wang Shoubiao [王寿彪] et al., "Research on Key Issues of Datamation Aided Decision-making for Strategic Warning" [面向战略预警数据化辅助决策关键问题研究], *Journal of Equipment Academy* [装备学院学报], February 2015, 26, http://www.paper.edu.cn/journal/showPdf/OUTGAF1QNRzVYI2eQ

[665] Pei Zhongmin [裴忠民] et al., "Method of On-board Target Localization and Recognition for Rapid Response Productions" [面向快速响应产品的星上目标定位及识别方法], *Journal of Nanjing University of Aeronautics and Astronautics* [南京航空航天大学学报]2018, 50, http://jnuaa.nuaa.edu.cn/ch/reader/view_abstract.aspx?file_no=2018S104&st=alljournals

[666] Li Xinming [李新明] et al., "Heterogeneous Data Integration Research History" 异构数据集成研究发展历程, *Xuehua*, 11 July 2018. https://www.xuehua.us/a/5ebf990290152a2a3941864e

[667] "Li Xinming" [李新明], *University of Chinese Academy of Sciences* [中国科学院], Accessed August 2021. http://people.ucas.edu.cn/~0058618

[668] Lin Qi [林琪], Li Zhi [李智], "Modeling and Simulation Analysis of Antenna Orientation on Inter-Satellite Link" [星间链路天线指向建模与仿真分析], *Computer Simulation* [计算机仿真], 2008, 7, http://ksuxk.cqvip.com/asset/detail/0/20337888625
"Famous Experts Forum--Professor Li Zhi's visit to the Famous Experts Forum of School of Biological and Medical Engineering" [名家论坛——李智教授做客生物与医学工程学院名家论坛], , Beihang University [北京航空航天大学生物与医学工程学院], 13 April 2012, https://bme.buaa.edu.cn/English/teacherInfo.aspx?catID=332&subcatID=84&curID=1354

[669] "Tianhe Defense hosts "Silk Road Source Cities" Open and Innovative Development and Digital Silk Road Forum on Civil-Military Integration" [天和防务承办"丝路源点城市"开放与创新发展暨军民融合数字丝路论坛], *iFeng*, 13 May 2018, https://isn.ifeng.com/6571476/news.shtml?&back&back

[670] "Solving Beijing Hukou! Pre-announcement of Recruitment of Civilian Personnel for Key Laboratory of Complex Electronic System Simulation" [解决北京户口！复杂电子系统仿真重点实验室招聘文职人员预公告！], *Sohu*, 3 March 2021, https://www.sohu.com/a/453714039_100080725

[671] "Research Achievements" [研究成果], *Shenyang Ligong University*, Accessed August 2021, http://sise.sylu.edu.cn/xsky/yjcg.htm

[672] "Chengdu Calabar Information Technology Co., Ltd" [成都卡莱博尔信息技术股份有限公司], 国开证券有限责任公司, *Qichacha*, December 2015, http://qccdata.qichacha.com/ReportData/PDF/bb9f9299291952be6ad9bbb377e51947.pdf

[673] "Joint Laboratory for Trustworthy Networks (Computing)" [可信网络（计算）联合实验室], *Shudun Technology* [数盾科技], 21 October 2015, http://www.shudun.com/atlas/15.html

[674] Wang Shoubiao [王寿彪] et al., "Research on Key Issues of Datamation Aided Decision-making for Strategic Warning" [面向战略预警数据化辅助决策关键问题研究], *Journal of Equipment Academy* [装备学院学报], February 2015, 26, http://www.paper.edu.cn/journal/showPdf/OUTGAF1QNRzVYI2eQ
"Solving Beijing Hukou! Pre-announcement of Recruitment of Civilian Personnel for Key Laboratory of Complex Electronic System Simulation" [解决北京户口！复杂电子系统仿真重点实验室招聘文职人员预公告！], *Sohu*, 3 March 2021, https://www.sohu.com/a/453714039_100080725
[675] "Organizational Structure" [组织机构], *Electromagnetic Compatibility and Electromagnetic Environmental Effects Technology and Industry Innovation Conference in China 2024* [2024 年中国电磁兼容及电磁环境效应技术及产业创新大会], Accessed January 2024, https://b2b.csoe.org.cn/meeting/CEMEE2024.html
[676] "41st RI State Key Laboratory of Electronic Testing" [41 所电子测试国家重点实验室], *CETC* [中国电子科技集团公司], 17 July 2009.
http://ectc.51rich.net/?action=newshow%7Cectc%7C2197%7Ccn%7C2327,4429%7C4401 / https://archive.is/uLjJu
"******National Defense Science and Technology Key Laboratory" [******国防科技重点实验室], *Institute of Science and Technology, North University of China* [中北大学科学技术研究院], 6 July 2018.
https://web.archive.org/web/20200130230651/http://std.nuc.edu.cn/info/1046/1603.htm
[677] "National Defense Science and Technology Key Laboratory" [国防科技重点实验室], *School of Instrument and Electronics, North University of China* [中北大学仪器与电子学院], Accessed 2021,
https://web.archive.org/web/20190402225600/http://6y.nuc.edu.cn/xsyyj/pthjd/gfkjzdsys.htm
[678] "41st RI Introduction" [四十一所简介], *CETC 41st Research Institute* [中国电子科技集团公司第四十一研究所], accessed March 2021,
https://web.archive.org/web/20170226045108/http://www.ei41.com/ei41webcn/asp/about.asp?id=68
"East China Electronic Measuring Instruments Research Institute (41st RI)" [华东电子测量仪器研究所（41 所）], *Military Industry Talent Network* [军工人才网], accessed March 2021, https://archive.is/fdJBW
[679] "41st RI Introduction" [四十一所简介], "CETC 41st Research Institute" [中国电子科技集团公司第四十一研究所], Accessed 2021,
https://web.archive.org/web/20170226045108/http://www.ei41.com/ei41webcn/asp/about.asp?id=68
"Enterprise Introduction" [企业简介], China Electronics Technology Instruments Co., Ltd [中电科仪器仪表有限公司] , Accessed 2021,
https://web.archive.org/web/20210316183734/https://webcache.googleusercontent.com/search?q=cache%3Ahttp%3A%2F%2Fei.cetc.com.cn%2Fyqyb%2F334191%2F334179%2Findex.html&strip=0&vwsrc=0 /
http://qdrc.people.cn/web/project/c/content_108.shtml
[680] "******National Defense Science and Technology Key Laboratory" [******国防科技重点实验室], Institute of Science and Technology, North University of China [中北大学科学技术研究院], 6 July 2018.
https://web.archive.org/web/20200130230651/http://std.nuc.edu.cn/info/1046/1603.htm
[681] "******National Defense Science and Technology Key Laboratory" [******国防科技重点实验室], Institute of Science and Technology, North University of China [中北大学科学技术研究院], 6 July 2018.
https://web.archive.org/web/20200130230651/http://std.nuc.edu.cn/info/1046/1603.htm
"National Defense Science and Technology Key Laboratory" [国防科技重点实验室], School of Instrument and Electronics, *North University of China* [中北大学仪器与电子学院], Accessed 2021,
https://web.archive.org/web/20190402225600/http://6y.nuc.edu.cn/xsyyj/pthjd/gfkjzdsys.htm
[682] "******National Defense Science and Technology Key Laboratory" [******国防科技重点实验室], *Institute of Science and Technology, North University of China* [中北大学科学技术研究院], 6 July 2018.
https://web.archive.org/web/20200130230651/http://std.nuc.edu.cn/info/1046/1603.htm
[683] "******National Defense Science and Technology Key Laboratory" [******国防科技重点实验室], *Institute of Science and Technology, North University of China* [中北大学科学技术研究院], 6 July 2018.
https://web.archive.org/web/20200130230651/http://std.nuc.edu.cn/info/1046/1603.htm
[684] "National Defense Science and Technology Key Laboratory" [国防科技重点实验室], *School of Instrument and Electronics, North University of China* [中北大学仪器与电子学院], Accessed 2021,
https://web.archive.org/web/20190402225600/http://6y.nuc.edu.cn/xsyyj/pthjd/gfkjzdsys.htm

[685] "******National Defense Science and Technology Key Laboratory" [******国防科技重点实验室], *Institute of Science and Technology, North University of China* [中北大学科学技术研究院], 6 July 2018. https://web.archive.org/web/20200130230651/http://std.nuc.edu.cn/info/1046/1603.htm
[686] "******National Defense Science and Technology Key Laboratory" [******国防科技重点实验室], *Institute of Science and Technology, North University of China* [中北大学科学技术研究院], 6 July 2018. https://web.archive.org/web/20200130230651/http://std.nuc.edu.cn/info/1046/1603.htm
"Chang'e 4" sent a letter of thanks to North University of China" ["嫦娥四号"为中北大学发来感谢信], *Taiyuan Evening News* [太原晚报], 4 March 2019. https://web.archive.org/web/20190312123256/http://www.nuc.edu.cn/info/1355/9901.htm
[687] "[Alumni's demeanor of meritorious demeanor] Nian Fushun: the forerunner who guarded the original heart" [【校友建功立业风采】年夫顺：守护初心的前行者], *China Electronics Technology Instruments Co., Ltd (CETI)* [中电科仪器仪表有限公司], 16 December 2020. https://web.archive.org/web/20210319210137/http://news.xjtu.edu.cn/info/1032/127233.htm
[688] "******National Defense Science and Technology Key Laboratory" [******国防科技重点实验室], *Institute of Science and Technology, North University of China* [中北大学科学技术研究院], 6 July 2018. https://web.archive.org/web/20200130230651/http://std.nuc.edu.cn/info/1046/1603.htm
"From a small inventor to a Changjiang scholar Xue Chenyang "perceives the world with a core"" [从小发明家到长江学者 薛晨阳"用芯感知"世界], *China News Service* [中国新闻网], 14 October 2017. https://www.chinanews.com/gn/2017/10-14/8352488.shtml
"Xue Chenyang: Invest in scientific research with more enthusiasm" [薛晨阳：以更饱满的热情投入到科研中去], *Xinhua*, 27 December 2017. http://www.xinhuanet.com/politics/2017-12/27/c_1122173254.htm
[689] "They are the pride of Qingdao! These people were shortlisted as National Model Workers and National Advanced Workers" [他们是青岛骄傲！这些人入围全国劳模、入选全国先进工作者], *Qingdao News Net* [青岛新闻网], 19 October 2020. https://news.qingdaonews.com/wap/2020-10/19/content_22399749.htm
[690] "Recruitment information for the post-doctoral mobile station of instrument science and technology of North University of China" [中北大学仪器科学与技术博士后流动站招收信息], *Human Resources Management Office* [人力资源管理处], 8 June 2011. https://web.archive.org/web/20200128090654/http://rlzyglc.nuc.edu.cn/info/1014/1353.htm
[691] "New system radar research and test base established in Qingdao Development Zone" [新体制雷达研究试验基地在青岛开发区建立] *People's Daily Online*, 19 April 2005. https://news.sina.com.cn/o/2005-04-19/14475693428s.shtml
"Calibration of mutual coupling for bi/multi-static synthetic impulse and aperture ground wave radar" [双／多基地综合脉冲孔径地波雷达的互耦校正], *Chinese Journal of Radio Science* [电波科学学报], 2008 年第 1 期 134-140. http://60.171.75.82:82/article/detail.aspx?id=26732128 / http://www.zutsg.com/qikan/f87e1e0122e0030ede413261d981f54e.html
[692] "Institute of Dynamic Measurement and Control and Intelligent Instruments"[动态测控与智能仪器研究所], *School of Electrical and Control Engineering* [中北大学电气与控制工程学院], Accessed 2021, https://web.archive.org/web/20200804074825/https://ece.nuc.edu.cn/ky/kypt/dtckyznyqyjs.htm
[693] "Chang'e 4" sent a letter of thanks to North University of China" ["嫦娥四号"为中北大学发来感谢信*], Taiyuan Evening News* [太原晚报], 4 March 2019. https://web.archive.org/web/20190312123256/http://www.nuc.edu.cn/info/1355/9901.htm
[694] "Intelligent Equipment and Superstructure/Metamaterials Reliability Team of National University of Defense Technology (NUDT) Admits PhD Students and Probationary Master's Degree Students" [ 国防科技大学智能装备与超结构/超材料可靠性团队招收博士生、推免硕士生], *Sohu*, 2 September 2024, https://www.sohu.com/a/805573970_121124292
[695] Bai Guanghan [白光晗], "Improved resilience measure for component recovery priority in power grids", *Frontiers of Engineering Management*, 15 December 2021, https://zhuanlan.zhihu.com/p/454196936

"National University of Defense Technology (NUDT) made significant progress in the research of nonlinear acoustic vibration damping metamaterials" [国防科大在非线性声学减振超材料研究上取得重要进展], *Audio160*, 30 November 2017, http://www.audio160.com/news/2017/11/2017_1_45858.htm

[696] Qiu Jing [邱静] et al., "Equipment Test Modeling and Design Technology" [装备测试性建模与设计技术], *Scientific Publishing House* [科学出版社], 2012, http://www.ecsponline.com/yz/B3DAD98F81A6F417280D756CC773A052F000.pdf

[697] Qiu Jing [邱静] et al., "Equipment Test Modeling and Design Technology" [装备测试性建模与设计技术], *Scientific Publishing House* [科学出版社], 2012, http://www.ecsponline.com/yz/B3DAD98F81A6F417280D756CC773A052F000.pdf

[698] "Provide technical support for the reliable operation of the Open Guide for Stabilization Support Project of the State-level Key Laboratory of Integrated Equipment Guarantee Technology" [装备综合保障技术国家级重点实验室稳定支持项目开放指南可靠运 行提供技术支], *Zhihu*, Accessed January 2024, https://zhuanlan.zhihu.com/p/649105722

[699] "Defense Science and Technology Key Laboratory Fund Public Guidelines Summary" [国防科技重点实验室基金公开指南汇总], *University of Electronic Science and Technology of China*, Accessed January 2024, https://www.sre.uestc.edu.cn/__local/3/89/3E/6A5DE1ECF8C0A7D6B4FEF7962E8_58840CEB_C03FC.pdf?e=.pdf

[700] "Principles and methods of laser detection of aero-engine blade vibration" [航空发动机叶片振动激光探测原理与方法], *Xiamen University*, 30 October 2020, https://phys.xmu.edu.cn/info/1022/1141.htm

[701] Zhu Wenjin [朱文金], "One-stop Maintenance Strategy for UAV Swarm with Successive Missions" [一种考虑多任务的无人机集群"一站式"维修策略], *Mechanical Science and Technology* [机械科学与技术], 2023, 002, https://coaa.istic.ac.cn/openJournal/periodicalArticle/0120230403146323

"Ph.D. Admission in National Key Laboratory of National Defense Science University" [国防科大全国重点实验室博士招生], *eshukan*, 6 September 2023, https://www.eshukan.com/academic/show.aspx?id=139185&cid=23

"Provide technical support for the reliable operation of the Open Guide for Stabilization Support Project of the State-level Key Laboratory of Integrated Equipment Guarantee Technology" [装备综合保障技术国家级重点实验室稳定支持项目开放指南可靠运 行提供技术支], *Zhihu*, Accessed January 2024, https://zhuanlan.zhihu.com/p/649105722

[702] "Provide technical support for the reliable operation of the Open Guide for Stabilization Support Project of the State-level Key Laboratory of Integrated Equipment Guarantee Technology" [装备综合保障技术国家级重点实验室稳定支持项目开放指南可靠运 行提供技术支], *Zhihu*, Accessed January 2024, https://zhuanlan.zhihu.com/p/649105722

[703] "Xu Yongcheng" [徐永成], *Hunan International Economics University*, 25 August 2022, http://www.hieu.edu.cn/info/1039/5813.htm

"Ph.D. Admission in National Key Laboratory of National Defense Science University" [国防科大全国重点实验室博士招生], *eshukan*, 6 September 2023, https://www.eshukan.com/academic/show.aspx?id=139185&cid=23

[704] "Xu Yongcheng" [徐永成], *Hunan International Economics University*, 25 August 2022, http://www.hieu.edu.cn/info/1039/5813.htm

"Key Laboratory Fund-61420030103-New Technology for Modeling and Simulation of Equipment Protection System" [重点实验室基金-61420030103-装备保障系统建模与仿真新技术], *Equipment Procurement Information Service Center* [装备采购信息服务中心], 19 May 2017, http://www.staroceans.org/weain/550528.html

[705] Bai Guanghan [白光晗], "Improved resilience measure for component recovery priority in power grids", *Frontiers of Engineering Management*, 15 December 2021, https://zhuanlan.zhihu.com/p/454196936

"National University of Defense Technology (NUDT) made significant progress in the research of nonlinear acoustic vibration damping metamaterials" [国防科大在非线性声学减振超材料研究上取得重要进展], *Audio160*, 30 November 2017, http://www.audio160.com/news/2017/11/2017_1_45858.htm

[706] Qiu Jing [邱静] et al., "Equipment Test Modeling and Design Technology" [装备测试性建模与设计技术], *Scientific Publishing House* [科学出版社], 2012, http://www.ecsponline.com/yz/B3DAD98F81A6F417280D756CC773A052F000.pdf

[707] "Chen Zhongsheng" [陈仲生], *Hunan University of Technology*, 9 September 2019, https://eeit.hut.edu.cn/info/1151/1919.htm
[708] Dong Dongni [董冬妮], "PBL Analysis and Implications of a Generic Auxiliary Power System for U.S. Navy Shipboard Aircraft" [美国海军舰载机通用型辅助动力系统的 PBL 分析及启示], *fx361*, 8 April 2020, https://m.fx361.com/news/2020/0408/8079981.html
[709] "The Translator's Preface to The Journey to Software-Defined Networking: Building Smarter, Faster, and More Flexible Networks of the Future" [带你读《软件定义网络之旅：构建更智能、更快速、更灵活的未来网络》译者序], *Aliyun* [阿里云], 18 October 2021, https://developer.aliyun.com/article/794716
[710] Dong Dongni [董冬妮], "PBL Analysis and Implications of a Generic Auxiliary Power System for U.S. Navy Shipboard Aircraft" [美国海军舰载机通用型辅助动力系统的 PBL 分析及启示], *fx361*, 8 April 2020, https://m.fx361.com/news/2020/0408/8079981.html
[711] Bai Guanghan [白光晗], "Improved resilience measure for component recovery priority in power grids", *Frontiers of Engineering Management*, 15 December 2021, https://zhuanlan.zhihu.com/p/454196936
[712] "Principles and methods of laser detection of aero-engine blade vibration" [航空发动机叶片振动激光探测原理与方法], *Xiamen University*, 30 October 2020, https://phys.xmu.edu.cn/info/1022/1141.htm
[713] Hu Jiao [胡蛟], "Modeling and Simulation of Failure Dynamics of Typical Components of Helicopter Main Deceleration" [直升机主减典型部件故障动力学建模与仿真], *Journal of Northeastern University*, 2022, 43(12), https://d.wanfangdata.com.cn/periodical/dbdxxb202212009
[714] Zhu Wenjin [朱文金], "One-stop Maintenance Strategy for UAV Swarm with Successive Missions" [一种考虑多任务的无人机集群"一站式"维修策略], *Mechanical Science and Technology* [机械科学与技术], 2023, 002, https://coaa.istic.ac.cn/openJournal/periodicalArticle/0120230403146323
[715] "Ph.D. Admission in National Key Laboratory of National Defense Science University" [国防科大全国重点实验室博士招生], *eshukan*, 6 September 2023, https://www.eshukan.com/academic/show.aspx?id=139185&cid=23
[716] "Ph.D. Admission in National Key Laboratory of National Defense Science University" [国防科大全国重点实验室博士招生], *eshukan*, 6 September 2023, https://www.eshukan.com/academic/show.aspx?id=139185&cid=23
[717] "Ph.D. Admission in National Key Laboratory of National Defense Science University" [国防科大全国重点实验室博士招生], *eshukan*, 6 September 2023, https://www.eshukan.com/academic/show.aspx?id=139185&cid=23
[718] Qiu Jing [邱静] et al., "Equipment Test Modeling and Design Technology" [装备测试性建模与设计技术], *Scientific Publishing House* [科学出版社], 2012, http://www.ecsponline.com/yz/B3DAD98F81A6F417280D756CC773A052F000.pdf
[719] "Defense Science and Technology Key Laboratory Fund Public Guidelines Summary" [国防科技重点实验室基金公开指南汇总], *University of Electronic Science and Technology of China*, Accessed January 2024, https://www.sre.uestc.edu.cn/__local/3/89/3E/6A5DE1ECF8C0A7D6B4FEF7962E8_58840CEB_C03FC.pdf?e=.pdf
[720] "Defense Science and Technology Key Laboratory Fund Public Guidelines Summary" [国防科技重点实验室基金公开指南汇总], *University of Electronic Science and Technology of China*, Accessed January 2024, https://www.sre.uestc.edu.cn/__local/3/89/3E/6A5DE1ECF8C0A7D6B4FEF7962E8_58840CEB_C03FC.pdf?e=.pdf
[721] "Provide technical support for the reliable operation of the Open Guide for Stabilization Support Project of the State-level Key Laboratory of Integrated Equipment Guarantee Technology" [装备综合保障技术国家级重点实验室稳定支持项目开放指南可靠运 行提供技术支], *Zhihu*, Accessed January 2024, https://zhuanlan.zhihu.com/p/649105722
[722] "Provide technical support for the reliable operation of the Open Guide for Stabilization Support Project of the State-level Key Laboratory of Integrated Equipment Guarantee Technology" [装备综合保障技术国家级重点实验室稳定支持项目开放指南可靠运 行提供技术支], *Zhihu*, Accessed January 2024, https://zhuanlan.zhihu.com/p/649105722
[723] "Provide technical support for the reliable operation of the Open Guide for Stabilization Support Project of the State-level Key Laboratory of Integrated Equipment Guarantee Technology" [装备综合保障技术国家级重点实验

室稳定支持项目开放指南可靠运 行提供技术支], *Zhihu*, Accessed January 2024, https://zhuanlan.zhihu.com/p/649105722

[724] "Provide technical support for the reliable operation of the Open Guide for Stabilization Support Project of the State-level Key Laboratory of Integrated Equipment Guarantee Technology" [装备综合保障技术国家级重点实验室稳定支持项目开放指南可靠运 行提供技术支], *Zhihu*, Accessed January 2024, https://zhuanlan.zhihu.com/p/649105722

[725] "Casting Era Expanding Ambitions: China Cast Group Marries 23 Enterprises at a Time" ["铸鼎纪元"拓宏图：中铸集团一次联姻 23 家企业], *Sohu*, 1 April 2019, https://www.sohu.com/a/305221489_381580

[726] "Principles and methods of laser detection of aero-engine blade vibration" [航空发动机叶片振动激光探测原理与方法], *Xiamen University*, 30 October 2020, https://phys.xmu.edu.cn/info/1022/1141.htm

[727] "Homepage", Hunan Provincial Key Laboratory of Ultra-Precision Machining Technology" [超精密加工技术湖南省重点实验室], Accessed January 2024, http://upmlab.com/

5. "Xu Yongcheng" [徐永成], *Hunan International Economics University*, 25 August 2022, http://www.hieu.edu.cn/info/1039/5813.htm

[728] Qiu Jing [邱静] et al., "Equipment Test Modeling and Design Technology" [装备测试性建模与设计技术], *Scientific Publishing House* [科学出版社], 2012, http://www.ecsponline.com/yz/B3DAD98F81A6F417280D756CC773A052F000.pdf

[729] Qiu Jing [邱静] et al., "Equipment Test Modeling and Design Technology" [装备测试性建模与设计技术], *Scientific Publishing House* [科学出版社], 2012, http://www.ecsponline.com/yz/B3DAD98F81A6F417280D756CC773A052F000.pdf

[730] "Chen Zhongsheng" [陈仲生], *Hunan University of Technology*, 9 September 2019, https://eeit.hut.edu.cn/info/1151/1919.htm

[731] "Liu Peng" [刘鹏], *Qingdao University of Technology*, 1 August 2020, https://mae.qut.edu.cn/info/1043/3745.htm

[732] "Chen Xun" [陈循], *iCourse* [爱课程], Accessed January 2024, https://www.icourses.cn/web/sword/portal/teacherDetails?userId=ff8080814117fc0401411c97d9b7080f

[733] "Xu Yongcheng" [徐永成], *Hunan International Economics University*, 25 August 2022, http://www.hieu.edu.cn/info/1039/5813.htm

[734] "National University of Defense Technology (NUDT) made significant progress in the research of nonlinear acoustic vibration damping metamaterials" [国防科大在非线性声学减振超材料研究上取得重要进展], *Audio160*, 30 November 2017, http://www.audio160.com/news/2017/11/2017_1_45858.htm

[735] "Chen Zhongsheng" [陈仲生], *Hunan University of Technology*, 9 September 2019, https://eeit.hut.edu.cn/info/1151/1919.htm

[736] "Chen Xun" [陈循], *iCourse* [爱课程], Accessed January 2024, https://www.icourses.cn/web/sword/portal/teacherDetails?userId=ff8080814117fc0401411c97d9b7080f

[737] "Xu Yongcheng" [徐永成], *Hunan International Economics University*, 25 August 2022, http://www.hieu.edu.cn/info/1039/5813.htm

[738] "Provide technical support for the reliable operation of the Open Guide for Stabilization Support Project of the State-level Key Laboratory of Integrated Equipment Guarantee Technology" [装备综合保障技术国家级重点实验室稳定支持项目开放指南可靠运 行提供技术支], *Zhihu*, Accessed January 2024, https://zhuanlan.zhihu.com/p/649105722

[739] "Northern Special Energy Group Co." [北方特种能源集团有限公司], *Norinco*, Accessed 2021, https://nhrdc.cn:8080/campus/company_detail.jsp?code=12

[740] "Recruitment Announcement for 2025 College Graduates of China National Research Institute of Hydrocarbons Industry No.204" [中国兵器工业第二〇四研究所 2025 年高校毕业生招聘公告], *Xiamen University Career Education Digital Intelligent Platform*, 31 October 2024, https://jy.xmu.edu.cn/campus/view/id/996295

[741] Zhao Qifeng [赵凤起], "Introduction to the key lab of explosive combustion" [火炸药燃烧国防科技重点实验室功能介绍], *Journal of Explosives* [火炸药学报] (4) 1996.

[742] "Xi'an Modern Chemistry Institute" [西安近代化学研究所], *Norinco*, Accessed 2021, https://www.nhrdc.cn:8080/campus/company_detail.jsp?code=09

"Xi'an Institute of Modern Chemistry (Institute 204) Introduction to Graduate Training" [西安近代化学研究所(204所)研究生培养介绍], *Kaoyan.com*, 28 January 2007, https://yz.kaoyan.com/mcri204/zhaosheng/28/208401/

[743] "Recruitment Announcement for 2025 College Graduates of China National Research Institute of Hydrocarbons Industry No.204" [中国兵器工业第二〇四研究所 2025 年高校毕业生招聘公告], *Xiamen University Career Education Digital Intelligent Platform*, 31 October 2024, https://jy.xmu.edu.cn/campus/view/id/996295
"Lead 44! 2025 Jiangsu Province National Key Laboratory Inventory" [牵头 44 家！2025 年江苏省全国重点实验室大盘点], *Netease*, 26 February 2025, https://www.163.com/dy/article/JPB8IQDE0536A3D8.html

[744] Zhao Qifeng [赵凤起], "Introduction to the key lab of explosive combustion" [火炸药燃烧国防科技重点实验室功能介绍], *Journal of Explosives* [火炸药学报] (4) 1996.

[745] Zhao Qifeng [赵凤起], "Introduction to the key lab of explosive combustion" [火炸药燃烧国防科技重点实验室功能介绍], Journal of Explosives [火炸药学报] (4) 1996.

[746] "Liu Zijia: A Selfless Contributor to National Defense" [刘子如：为国防事业无私奉献的学科奠基者], *kkNews*, 23 July 2019. https://kknews.cc/zh-cn/media/y3nqqba.html

[747] Zhao Fengqi [赵凤起] et al., "Monograph Series on Explosives Technology: Solid Rocket Propellant Technology with Boron Rich Fuel" [火炸药技术系列专著：含硼富燃料固体火箭推进剂技术], *Amazon*, Accessed 2021, https://www.amazon.com/%E7%81%AB%E7%82%B8%E8%8D%AF%E6%8A%80%E6%9C%AF%E7%B3%BB%E5%88%97%E4%B8%93%E8%91%97%EF%BC%9A%E5%90%AB%E7%A1%BC%E5%AF%8C%E7%87%83%E6%96%99%E5%9B%BA%E4%BD%93%E7%81%AB%E7%AE%AD%E6%8E%A8%E8%BF%9B%E5%89%82%E6%8A%80%E6%9C%AF-%E5%BA%9E%E7%BB%B4%E5%BC%BA%EF%BC%8C%E6%A8%8A%E5%AD%A6%E5%BF%A0%EF%BC%8C%E8%B5%B5%E5%87%A4%E8%B5%B7/dp/B01N7A2J33
Zhao Fengqi [赵凤起], "Monograph Series on Explosives Technology: Solid Propellant Combustion Catalysts" [火炸药技术系列专著：固体推进剂燃烧催化剂], *JD.com*, Accessed 2021, https://item.jd.com/11969972.html

[748] "Zhao Fengqi, director of a key laboratory of Xi'an Institute of Modern Chemistry, and Wang Shumao of Beijing General Research Institute of Nonferrous Metals visited our college for academic exchange" [西安近代化学研究所某重点实验室主任赵凤起、北京有色金属研究总院王树茂一行莅临我学院进行学术交流], *Xi'an Jiaotong University*, 13 March 2017. http://clet.xjtu.edu.cn/info/1016/2943.htm

[749] NORINCO Group Plays a Role in China's Mars Exploration, *SASAC*, 30 July 2020. http://en.sasac.gov.cn/2020/07/30/c_5308.htm

[750] "Zhao Fengqi" [赵凤起], *Hebei University of Science and Technology* [河北科技大学], 23 November 2018. https://hgxy.web.hebust.edu.cn/jygz/xyfc/102154.htm

[751] "Liu Zijia: A Selfless Contributor to National Defense" [刘子如：为国防事业无私奉献的学科奠基者], kkNews, 23 July 2019. https://kknews.cc/zh-cn/media/y3nqqba.html

[752] "Opening Ceremony of Xi'an Key Laboratory of Special Energy Materials and" [西安市特种能源材料重点实验室揭牌仪式暨], *NWPU*, Accessed 2021, https://chin.nwu.edu.cn/info/1056/1751.htm

[753] "The Eighth National Symposium on "Chemistry in Public Safety" of the Chinese Chemical Society" [中国化学会第八届全国"公共安全领域中的化学问题"研讨会], Chinese Chemical Society [中国化学会], 21 October 2021. https://www.chemsoc.org.cn/meeting/8thNSCAFPS/

[754] "Xi'an Institute of Modern Chemistry (Institute 204) Introduction to Graduate Training" [西安近代化学研究所(204 所)研究生培养介绍], *Kaoyan.com*, 28 January 2007.

[755] Zhao Qifeng [赵凤起], "Introduction to the key lab of explosive combustion" [火炸药燃烧国防科技重点实验室功能介绍], *Journal of Explosives* [火炸药学报] (4) 1996.

[756] Zhao Qifeng [赵凤起], "Introduction to the key lab of explosive combustion" [火炸药燃烧国防科技重点实验室功能介绍], *Journal of Explosives* [火炸药学报] (4) 1996.

[757] "These sections of Xi'an have new names, come and see if there is a road in front of our home" [西安的这些路段有新名字啦，快来看看有没有咱家门口的路], *Tencent*, 14 April 2020. https://new.qq.com/omn/20200414/20200414A0N2DS00.html

[758] "Key Laboratory of National Defense Science and Technology for Fire Control Technology" [火力控制技术国防科技重点实验室], *iXueshu*, Accessed 2021, https://www.ixueshu.com/h5/document/cbdda1caac6215c211c0c0117f1e020b318947a18e7f9386.html

[759] Peter Wood, David Yang, Roger Cliff, "Air-to-Air Missiles Capabilities and Development in China," *China Aerospace Studies Institute*, 2020. https://www.airuniversity.af.edu/Portals/10/CASI/Books/2020-11-%2030%20Air-to-Air%20Missiles%20and%20Guidance%20Systems.pdf?ver=C8qY98R8IETgcweqak0tqA%3D%3D
"College Tour: About 613 Institute of AVIC" [院校巡礼：航空工业总公司 613 所简介], *Kaoyan.com* [考研帮], 21 June 2011. https://m.kaoyan.com/yanzhao/ly613s/zixun/23/207762/
[760] College Tour：About 613 Institute of AVIC" [院校巡礼：航空工业总公司 613 所简介], *Kaoyan.com* [考研帮], 21 June 2011. https://m.kaoyan.com/yanzhao/ly613s/zixun/23/207762/
[761] "Academic Committee of Key Laboratory of Fire Control Technology for National Defense Science and Technology was established and the first meeting was held" [火力控制技术国防科技重点实验室学术委员会成立暨第一次会议召开], *iXueshu*, 1 January 2006. https://www.ixueshu.com/h5/document/df587df9d5dafac7a1d9872c4b49b9c6318947a18e7f9386.html
[762] "Key Laboratory of National Defense Science and Technology for Fire Control Technology" [火力控制技术国防科技重点实验室], *iXueshu*, Accessed 2021, https://www.ixueshu.com/h5/document/cbdda1caac6215c211c0c0117f1e020b318947a18e7f9386.html
[763] Zhou Yue [周锐] et al., "Distributed coordinated heterogeneous task allocation for unmanned aerial vehicles" [多无人机分布式协同异构任务分配], *Control and Decision* [控制与决策] (28) 2013.
"Xing Sen Technology - AVIC Optoelectronics Institute Electronic Assembly Technology Joint Laboratory" ["兴森科技-中航工业光电所电子装联技术联合实验室"成功揭牌], *Guangzhou Baibanbi Jiege community* [广州白板笔价格社区], 18 March 2021. http://www.yhsdgy.com/xinwen/7/20356621.htm
[764] "Key Laboratory of National Defense Science and Technology for Fire Control Technology" [火力控制技术国防科技重点实验室], *iXueshu*, Accessed 2021, https://www.ixueshu.com/h5/document/cbdda1caac6215c211c0c0117f1e020b318947a18e7f9386.html
[765] "Key Laboratory of National Defense Science and Technology for Fire Control Technology" [火力控制技术国防科技重点实验室], *iXueshu*, Accessed 2021, https://www.ixueshu.com/h5/document/cbdda1caac6215c211c0c0117f1e020b318947a18e7f9386.html
[766] "Luoyang new batch of municipal top talent list is out, look who are!" [洛阳新一批市级拔尖人才名单出炉，看看都是谁!], *kkNews*, 24 April 2019. https://kknews.cc/other/4j83klv.html
[767] "Elite wings" [尖兵之翼], *History Online* [历史网], 1 July 2020. http://www.hxbi97.com/sjs/21956.html
[768] "The first national academic conference on information fusion was held" [首届全国信息融合学术年会召开], *China Society of Aeronautics and Astronautics* [中国航空学会], 18 June 2011. http://www.csaa.org.cn/art/2011/6/18/art_410_15268.html
[769] "AVIC I Group builds a base for cutting-edge aviation technology" [中航一集团打造尖端航空技术的基地], *Sina*, 17 June 2004. http://mil.news.sina.com.cn/2004-06-17/1036204751.html
[770] Found on homepage at http://m.avic-optronics.com/
[771] "Xi'an Institute of Electromechanical Information Technology: Innovation to ignite the "fuze" of the dream of a strong nation" [西安机电信息技术研究所：创新点燃强国之梦的'引信"], *kknews*, 2 July 2018, https://kknews.cc/zh-cn/news/8okqyvn.html
[772] Niu Shaohua [牛少华] et al., "Analysis of the error caused by the frequency response of the fire explosive pressure measuring apparatus" [火炸药压力测量仪器频率响应所引起的误差分析], J*ournal of Test and Measurement Technology* [测试技术学报], 2002 16(z2), https://d.wanfangdata.com.cn/periodical/ChlQZXJpb2RpY2FsQ0hJTmV3UzIwMjMxMjI2EhRoYmd4eWNzanN4YjIwMDJ6MjE1NRoIY2h2b3Q3ZG4%253D
[773] "Microelectromechanical Group Xi'an Institute of Electromechanical Information Technology three key laboratories of national defense science and technology signed a joint innovation platform agreement" ["微机电集团西安机电信息技术研究所三个国防科技重点实验室签订联合创新平台协议], *Norinco*, 15 October 2013, www.norincogroup.com.cn/art/2013/10/15/art_85_7829.html
[774] "BIT Schol of Mechatronical Engineering" [北京理工大学机电学院], *CMEE Bulletin* [机电简报], Volume 12, https://mech.buct.edu.cn/_upload/article/files/76/e2/8d11c7404fa4a3985d9a239f5366/cb668a5a-2b28-41d4-af83-5e8e9e764aee.pdf

[775] "Recruitment Announcement for Master and Doctoral Degree at Norinco 212 RI" [中国兵器工业集团第二一二研究所博硕士人才招聘公告], *Sohu*, 3 July 2020, https://www.sohu.com/a/405781616_690342
[776] "Xi'an Institute of Electromechanical Information Technology: Innovation to ignite the "fuze" of the dream of a strong nation" [西安机电信息技术研究所：创新点燃强国之梦的'引信"], *kknews*, 2 July 2018, https://kknews.cc/zh-cn/news/8okqyvn.html
[777] "Xi'an Institute of Electromechanical Information Technology: Innovation to ignite the "fuze" of the dream of a strong nation" [西安机电信息技术研究所：创新点燃强国之梦的'引信"], *kknews*, 2 July 2018, https://kknews.cc/zh-cn/news/8okqyvn.html
[778] "Xi'an Institute of Electromechanical Information Technology: Innovation to ignite the "fuze" of the dream of a strong nation" [西安机电信息技术研究所：创新点燃强国之梦的'引信"], *kknews*, 2 July 2018, https://kknews.cc/zh-cn/news/8okqyvn.html
[779] "Xi'an Institute of Electromechanical Information Technology: Innovation to ignite the "fuze" of the dream of a strong nation" [西安机电信息技术研究所：创新点燃强国之梦的'引信"], *kknews*, 2 July 2018, https://kknews.cc/zh-cn/news/8okqyvn.html
[780] Elsa B. Kania, "Chinese Military Innovation in Artificial Intelligence," *Center for a New American Security*, https://www.uscc.gov/sites/default/files/June%207%20Hearing_Panel%201_Elsa%20Kania_Chinese%20Military%20Innovation%20in%20Artificial%20Intelligence.pdf
[781] "Spring in the Key Laboratory | Sprint to open the floodgates" [重点实验室里“春意”浓 | 全力冲刺开门红], *CETC*, 12 March 2024, https://www.cetc.com.cn/zgdk/1592960/1592965/1802042/index.html
[782] "What Is Gallium Nitride (GaN)? What Is Gallium Nitride Semiconductor?," *Efficient Power Conversion*, Accessed September 2023, https://epc-co.com/epc/gallium-nitride/what-is-gan#:~:text=Gallium%20nitride%20(GaN)%20is%20a,significantly%20outperform%20silicon%2Dbased%20devices.
[783] "The ninth session of the Frontier Academic Forum of the Department of Electronics was successfully held" [电子学系前沿学术论坛第九期成功举办], *Peking University* [北京大学], 7 June 2021, https://ele.pku.edu.cn/info/1235/1845.htm
[784] "Notice of Special Lecture in Information College of Nanjing Electronic Device Research Institute (CECT 55) of CLP Group" [中电集团南京电子器件研究所（CECT 55 所）信息学院专场宣讲会通知], Southeast University, 20 August 2018,
"THAAD, F-35 may be hit hard! Leaked information on core components of China's military radar" [萨德、F-35 或受重创！中国军工雷达核心元器件资料泄露], *ESM China*, 17 April 2017, https://www.esmchina.com/news/201704171527.html
[785] "California-Based Company, Company President and Employee Indicted in Alleged Scheme to Violate the Export Control Reform Act," *US Attorney's Office District of Rhode Island*, 20 July 2020, https://www.justice.gov/usao-ri/pr/california-based-company-company-president-and-employee-indicted-alleged-scheme-violate
[786] Liu Qingbin [刘庆彬] et al., "Influence of polycrystalline diamond on silicon-based GaN material" [多晶金刚石对硅基氮化镓材料的影响], *Physics* [物理学报], 2023, 72(9), https://wulixb.iphy.ac.cn/cn/article/doi/10.7498/aps.72.20221942
[787] "Spring in the Key Laboratory | Sprint to open the floodgates" [重点实验室里“春意”浓 | 全力冲刺开门红], *CETC*, 12 March 2024, https://www.cetc.com.cn/zgdk/1592960/1592965/1802042/index.html
[788] Liu Qingbin [刘庆彬] et al., "Influence of polycrystalline diamond on silicon-based GaN material" [多晶金刚石对硅基氮化镓材料的影响], *Physics* [物理学报], 2023, 72(9), https://wulixb.iphy.ac.cn/cn/article/doi/10.7498/aps.72.20221942
"Diamond Substrate Heterogeneous Integrated GaNHEMT--New Generation of Solid-State Microwave Power Devices--An Interview with Chen Tangsheng, Chief Scientist of Manufacturing Processes at CEC Corporation" [金刚石衬底异质集成 GaNHEMT——新一代固态微波功率器件——专访中国电科集团有限公司制造工艺领域首席科学家陈堂胜], *EET China*, 25 March 2024, https://www.eet-china.com/mp/a300854.html
[789] "Nanjing Institute of Electronic Devices (China Electronics Technology Group Corporation 55th Research Institute) Recruitment of RF Chip Circuit Designer" [南京电子器件研究所（中国电子科技集团公司第五十五研

究所）招聘射频芯片电路设计师], *CN Xincai*, 18 September 2023, https://daohang.cnxincai.com/zhaokao/show-7347254.html

[790] "Frontier Academic Forum, Department of Electronics, Peking University, Issue 9“ [北京大学电子学系前沿学术论坛第 9 期], *Peking University*, 31 May 2021, https://news.pku.edu.cn/wyyd/xxyg/69c7cb7d514c4f55ab36d90ba73be326.htm

[791] "The ninth session of the Frontier Academic Forum of the Department of Electronics was successfully held" [电子学系前沿学术论坛第九期成功举办], *Peking University* [北京大学], 7 June 2021, https://ele.pku.edu.cn/info/1235/1845.htm

[792] "The ninth session of the Frontier Academic Forum of the Department of Electronics was successfully held" [电子学系前沿学术论坛第九期成功举办], *Peking University* [北京大学], 7 June 2021, https://ele.pku.edu.cn/info/1235/1845.htm

"[CASICON 2021] Chen Tangsheng, Chief Scientist of CEC: Low Temperature Bonded Diamond GaN HEMT Microwave Power Devices" [【CASICON 2021】中国电科首席科学家陈堂胜：低温键合金刚石 GaN HEMT 微波功率器件], casmita.com, 14 September 2021, http://www.casmita.com/news/202109/14/6155.html

[793] "THAAD, F-35 may be hit hard! Leaked information on core components of China's military radar" [萨德、F-35 或受重创！中国军工雷达核心元器件资料泄露], *ESM China*, 17 April 2017, https://www.esmchina.com/news/201704171527.html

[794] "Innovation breakthroughs, being in the key laboratory, they are very confident" [创新突破，身在重点实验室的他们很有信心], *Sohu*, 15 August 2019, https://www.sohu.com/a/333996317_779538

[795] "THAAD, F-35 may be hit hard! Leaked information on core components of China's military radar" [萨德、F-35 或受重创！中国军工雷达核心元器件资料泄露], *ESM China*, 17 April 2017, https://www.esmchina.com/news/201704171527.html

[796] "The ninth session of the Frontier Academic Forum of the Department of Electronics was successfully held" [电子学系前沿学术论坛第九期成功举办], *Peking University* [北京大学], 7 June 2021, https://ele.pku.edu.cn/info/1235/1845.htm

[797] "Frontier Academic Forum, Department of Electronics, Peking University, Issue 9” [北京大学电子学系前沿学术论坛第 9 期], *Peking University*, 31 May 2021, https://news.pku.edu.cn/wyyd/xxyg/69c7cb7d514c4f55ab36d90ba73be326.htm

[798] "Innovation breakthroughs, being in the key laboratory, they are very confident" [创新突破，身在重点实验室的他们很有信心], *Sohu*, 15 August 2019, https://www.sohu.com/a/333996317_779538

[799] Qian Guang [钱广] et al., "Microwave Photonic Transmitter/Receiver (T/R," [微波光子收/发模块技术], *Opto-electronics Technology* [光电子技术], 2022, 42(4), https://www.opticsjournal.net/Articles/OJfd87ef0ea687d66b/FullText

[800] "Nanjing Guobao Electronics Co. Ltd." [南京国博电子股份有限公司], *Sina*, 12 April 2023, https://finance.sina.cn/2023-04-12/detail-imyqafvu7245446.d.html

[801] "High-frequency Device Industry Technology Research Institute jointly established by Institute 55 and Nanjing Municipality" [五十五所与南京市共同打造的高频器件产业技术研究院正式组建], *Microwave and High Frequency Online* [微波射频王], 27 June 2018, https://www.mwrf.net/news/suppliers/2018/23815.html

[802] "Tapping into the Alumni Economy Nanjing's New R&D Institutions Create Highlights" [挖掘校友经济 南京新型研发机构打造亮点], *Our Jiangsu* [我苏网], 2 September 2018, http://www.ourjiangsu.com/a/20180909/15364641372.shtml

[803] "International third-generation semiconductor event in the beginning of the year! Nobel Prize winners + academicians lead 300+ expert lineup, gathering efforts to start a new journey!" [开年国际第三代半导体盛会！诺奖得主+院士领衔 300+专家阵容，凝心聚力再启新征程], *China LED*, 1 February 2023, http://www.china-led.net/news/202302/01/51625.html

[804] "Contact Us" [联系我们], *CETC 55*, Accessed September 2023, http://www.cetc55.com/intro/12.html

[805] "School Overview" [学院概况], *NUAA School of Aviation*, Accessed February 2025, https://aero.nuaa.edu.cn/3843/list.htm

[806] "National Key Laboratory of Helicopter Rotor Dynamics" [直升机旋翼动力学国家级重点实验室], *NUAA*, 7 May 2018. https://aero.nuaa.edu.cn/2017/0224/c9601a78296/page.htm
"Helicopter Department" [直升机系], *NUAA*, Accessed 2021, https://hti.nuaa.edu.cn/1126/list.htm
[807] "Open school doors to show off aircraft, NUAA's six helicopter labs open to the public" [敞开校门炫飞机，南航 6 大直升机实验室向公众开放], *S&T Daily*, 19 May 2019, http://stdaily.com/02/jiangsu/2019-05/19/content_767221.shtml
"This "double-class", happy to receive a helicopter and two civil aircraft!" [这所"双一流"，喜提一架直升机和两架民航飞机!], *NetEase*, 29 December 2020, https://www.163.com/dy/article/FV1UGT1I0536A3D8.html
"Institute Overview, " *AVIC Helicopter Design Institute* [中航工业直升机设计研究所], Accessed 2021, https://web.archive.org/web/20140716214052/http://www.chrdi.com/NodePage.aspx?NodeID=2
[808] "Nanjing University of Aeronautics and Astronautics, Professor Lu Yang's group full-time research staff (B class) recruitment" [南京航空航天大学航空学院陆洋教授课题组专职科研人员（B 类）招聘启事], *Jiangsu 168 examination information network* [江苏 168 考试信息网], 7 November 2019. http://www.jsrsksw.com/nanjing/2073.html
[809] "Nanjing University of Aeronautics and Astronautics, College of Aeronautics and Astronautics, Helicopter Research Group, Associate Professor Zhu Qinghua's group June 2020 recruitment of full-time research staff B" [南京航空航天大学航空学院直升机课题组朱清华副教授课题组 2020 年 6 月招聘专职科研人员 B 类], *Gaoxiao Job* [高校人才网], 23 June 2020. http://m.gaoxiaojob.com/view.php?aid=451344
[810] "National Key Laboratory of Helicopter Rotor Dynamics, Nanjing University of Aeronautics and Astronautics Recruitment of Full-time Research Staff" [南京航空航天大学直升机旋翼动力学国家级重点实验室招聘专职科研人员启事], *High Level Talent Net* [高层次人才网], 11 July 2018. http://www.gccrcw.com/tpjsjob/201807/1128913.html
[811] "National Key Laboratory of Helicopter Rotor Dynamics" [直升机旋翼动力学国家级重点实验室], *NUAA*, 7 May 2018. https://aero.nuaa.edu.cn/2017/0224/c9601a78296/page.htm
[812] "National Key Laboratory of Helicopter Dynamics 2023 Fund Program Guidelines" [直升机动力学全国重点实验室 2023 年基金项目指南], *Chinese Helicopter Society* [中国旋翼飞行器网], 13 November 2023, http://www.rotorcraft.org.cn/nd.jsp?id=87
[813] "Nanjing University of Aeronautics and Astronautics, Professor Lu Yang's group full-time research staff (B class) recruitment" [南京航空航天大学航空学院陆洋教授课题组专职科研人员（B 类）招聘启事], *Jiangsu 168 examination information network* [江苏 168 考试信息网], 7 November 2019. http://www.jsrsksw.com/nanjing/2073.html
"Nanjing University of Aeronautics and Astronautics, College of Aeronautics and Astronautics, Helicopter Research Group, Associate Professor Zhu Qinghua's group June 2020 recruitment of full-time research staff B" [南京航空航天大学航空学院直升机课题组朱清华副教授课题组 2020 年 6 月招聘专职科研人员 B 类], *Gaoxiao Job* [高校人才网], 23 June 2020. http://m.gaoxiaojob.com/view.php?aid=451344
"National Key Laboratory of Helicopter Rotor Dynamics, Nanjing University of Aeronautics and Astronautics Recruitment of Full-time Research Staff" [南京航空航天大学直升机旋翼动力学国家级重点实验室招聘专职科研人员启事], *High Level Talent Net* [高层次人才网], 11 July 2018. http://www.gccrcw.com/tpjsjob/201807/1128913.html
[814] "National Key Laboratory of Helicopter Dynamics 2023 Fund Program Guidelines" [直升机动力学全国重点实验室 2023 年基金项目指南], *Chinese Helicopter Society* [中国旋翼飞行器网], 13 November 2023, http://www.rotorcraft.org.cn/nd.jsp?id=87
[815] "Helicopter Department" [直升机系], *NUAA*, Accessed 2021, https://hti.nuaa.edu.cn/1126/list.htm
"The most mysterious laboratory of NUAA: a number of helicopter technology breakthroughs here" [揭秘南航最神秘实验室：多项直升机技术在这里实现突破], *JSTV* [江苏网], 19 May 2019. http://news.jstv.com/a/20190519/e475e347a58841d3b0784b328a55b0a0.shtml
[816] "China's Helicopter Leader: Wang Shicun, Northwestern Polytechnic University" [中国直升机泰斗：王适存, 西北工业大学], *NWPU*, Accessed 2021, https://z.nwpu.edu.cn/info/1569/13584.htm

[817] "NUAA applies for patent for deformed stealth fighter, as a transition, J-20 or use external duck wing droop tail" [南航申请变形隐身战机专利，作为过渡，歼 20 或使用外挂式鸭翼垂尾], *NetEase*, 29 October 2020. https://www.163.com/dy/article/FQ511Q450515DMHK.html
[818] "Read China 2024 | Experts on Low Altitude Economy: Future development of this sector depends on China" [2024 年"读懂中国" | 专家解读低空经济：这个领域未来发展要看中国], *21 Jingji* [经济网], 3 December 2024, https://www.21jingji.com/article/20241203/herald/a6899fa20bdf0627123975f205205178.html
[819] "The Seventh "Cultivation Forum"-China Helicopter Report Series" [第七期"适存讲坛"——中国直升机系列报告], *Rotocraft.org* [中国旋翼飞行器网], 3 July 2020. http://webcache.googleusercontent.com/search?q=cache%3Awww.rotorcraft.org.cn%2Fplus%2Fview.php%3Faid%3D1392&rlz=1C1CHBD_enUS895US895&oq=cache%3Awww.rotorcraft.org.cn%2Fplus%2Fview.php%3Faid%3D1392&aqs=chrome..69i57j69i58.1146j0j4&sourceid=chrome&ie=UTF-8
[820] "China's Helicopter Leader: Wang Shicun, Northwestern Polytechnic University" [中国直升机泰斗：王适存, 西北工业大学], *NWPU*, Accessed 2021, https://z.nwpu.edu.cn/info/1569/13584.htm
[821] "Taoxun Aviation Ge Xun: co-axial twin-rotor drones, pry the drone market" [韬讯航空葛讯：共轴双旋翼无人机，撬动无人机市场], *Sohu*, 17 March 2017. https://www.sohu.com/a/129232238_537890
[822] "From the introduction to independent research and development to promote the "made in Chongqing" helicopter from scratch" [从引入到自主研发 推动"重庆造"直升机从无到有], *Chongqing Daily* [重庆日报], 20 October 2019. https://epaper.cqrb.cn/html/cqrb/2019-10/20/002/content_244706.htm
[823] "This "double-class", happy to receive a helicopter and two civil aircraft!" [这所"双一流"，喜提一架直升机和两架民航飞机!], *NetEase*, 29 December 2020. https://www.163.com/dy/article/FV1UGT1I0536A3D8.html
[824] "National Key Laboratory of Helicopter Rotor Dynamics" [直升机旋翼动力学国家级重点实验室], *NUAA*, 7 May 2018. https://aero.nuaa.edu.cn/2017/0224/c9601a78296/page.htm
[825] "Collaborative Innovation, Integration and Win-Win | The 38th China Helicopter Academic Exchange Conference (Online) and the 6th International Forum on Civil Helicopter Industry in 2022 were successfully concluded in Xi'an" [协同创新，融合共赢 | 第 38 届中国直升机学术交流会（线上）暨 2022 第 6 届民用直升机产业国际论坛于西安圆满落幕], *China Rotorcraft Website* [中国旋翼飞行器网], 29 August 2022, http://rotorcraft.org.cn/nd.jsp?id=76
[826] "National Key Laboratory of Helicopter Rotor Dynamics" [直升机旋翼动力学国家级重点实验室], *NUAA*, 7 May 2018. https://aero.nuaa.edu.cn/2017/0224/c9601a78296/page.htm
[827] "Helicopter Department" [直升机系], *NUAA*, Accessed 2021, https://hti.nuaa.edu.cn/1126/list.htm
[828] "Helicopter Department" [直升机系], *NUAA*, Accessed 2021, https://hti.nuaa.edu.cn/1126/list.htm
[829] "Open school doors to show off aircraft, NUAA's six helicopter labs open to the public" [敞开校门炫飞机，南航 6 大直升机实验室向公众开放], *S&T Daily*, 19 May 2019, http://stdaily.com/02/jiangsu/2019-05/19/content_767221.shtml
"National Key Laboratory of Helicopter Rotor Dynamics" [直升机旋翼动力学国家级重点实验室], *NUAA*, 7 May 2018. https://aero.nuaa.edu.cn/2017/0224/c9601a78296/page.htm
"The most mysterious laboratory of NUAA: a number of helicopter technology breakthroughs here" [揭秘南航最神秘实验室：多项直升机技术在这里实现突破], *JSTV*, 19 May 2019. http://news.jstv.com/a/20190519/e475e347a58841d3b0784b328a55b0a0.shtml
"Laboratory Open Day | National Key Laboratory of Helicopter Rotor Dynamics" [实验室开放日 | 直升机旋翼动力学国家级重点实验室], *Sohu*, 17 May 2019. https://www.sohu.com/a/314744396_120068684
[830] "Helicopter Rotor Dynamics at Nanjing Aerospace University Minggu Palace Campus" [南京航天航空大学明故宫校区直升机旋翼动力学], *Dianping*, 27 July 2019. https://www.dianping.com/shop/laW6sZOsFzi4ufzL
[831] "National Key Laboratory of Helicopter Transmission Technology" [直升机传动技术国家级重点实验室], *NUAA*, 20 December 2019. http://cmee.nuaa.edu.cn/2019/1220/c11625a190575/page.htm
[832] "National Key Laboratory of Helicopter Transmission Technology" [直升机传动技术国家级重点实验室], *NUAA*, 20 December 2019. http://cmee.nuaa.edu.cn/2019/1220/c11625a190575/page.htm
[833] Peter Wood, Alden Wahlstrom, Roger Cliff, "China's Aeroengine Industry", *China Aerospace Studies Institute*, March 2020.

https://www.airuniversity.af.edu/Portals/10/CASI/documents/Research/Infrastructure/CASI_Aeroengines%20041520.pdf?ver=2020-04-22-133912-480
"2018 Jiangsu Nanjing University of Aeronautics and Astronautics, School of Mechanical and Electrical Helicopter Drive Technology National Key Laboratory Recruitment Announcement " [2018 江苏南京航空航天大学机电学院直升机传动技术国家级重点实验室招聘公告], *Offcn* [中共事业单位], Accessed 2021, http://www.zgsydw.com/jiangsu/20180710/421342_2.html
"Open school doors to show off aircraft, NUAA's six helicopter labs open to the public" [敞开校门炫飞机，南航 6 大直升机实验室向公众开放], *S&T Daily*, 19 May 2019. http://stdaily.com/02/jiangsu/2019-05/19/content_767221.shtml
"This "double-class", happy to receive a helicopter and two civil aircraft!" [这所"双一流"，喜提一架直升机和两架民航飞机!], *NetEase*, 29 December 2020. https://www.163.com/dy/article/FV1UGT1I0536A3D8.html
[834] "National Key Laboratory of Helicopter Transmission Technology held an open day" [直升机传动技术国家级重点实验室举办开放日活动], *NUAA*, 30 May 2019. http://cmee.nuaa.edu.cn/2019/0530/c2735a158953/page.htm
[835] "Standing high in the ChangZhuTan metropolitan area, Zhuzhou can be on par with Changzhou" [站在长株潭都市圈高位，株洲可向常州看齐 ], *Sohu*, 9 December 2022, https://www.sohu.com/a/615418212_121221352
[836] "National Key Laboratory of Helicopter Transmission Technology held an open day" [直升机传动技术国家级重点实验室举办开放日活动], *NUAA*, 30 May 2019. http://cmee.nuaa.edu.cn/2019/0530/c2735a158953/page.htm
[837] "The Third Meeting of the First Academic Committee of the National Key Laboratory of Helicopter Transmission Technology" [直升机传动技术国家级重点实验室召开第一届学术委员会第三次会议], *Free Kaoyan*, 20 February 2021. http://school.freekaoyan.com/js/nuaa/dongtai/2021/02-20/16138161111356478.shtml
[838] "The Third Meeting of the First Academic Committee of the National Key Laboratory of Helicopter Transmission Technology" [直升机传动技术国家级重点实验室召开第一届学术委员会第三次会议], *Free Kaoyan*, 20 February 2021. http://school.freekaoyan.com/js/nuaa/dongtai/2021/02-20/16138161111356478.shtml
[839] "The Third Meeting of the First Academic Committee of the National Key Laboratory of Helicopter Transmission Technology" [直升机传动技术国家级重点实验室召开第一届学术委员会第三次会议], *Free Kaoyan*, 20 February 2021. http://school.freekaoyan.com/js/nuaa/dongtai/2021/02-20/16138161111356478.shtml
[840] "National Key Laboratory of Helicopter Transmission Technology held an open day" [直升机传动技术国家级重点实验室举办开放日活动], *NUAA*, 30 May 2019. http://cmee.nuaa.edu.cn/2019/0530/c2735a158953/page.htm
"2018 Jiangsu Nanjing University of Aeronautics and Astronautics, School of Mechanical and Electrical Helicopter Drive Technology National Key Laboratory Recruitment Announcement " [2018 江苏南京航空航天大学机电学院直升机传动技术国家级重点实验室招聘公告], *Offcn* [中共事业单位], Accessed 2021, http://www.zgsydw.com/jiangsu/20180710/421342_2.html
[841] "Laboratory for High Energy Density Beam Processing Technology - High-energy beam processing equipment" [高能束流加工技术研究室 - 高能束流加工设备], *AVIC Beijing Aeronautical Manufacturing Technology Research Institute* [中航工业北京航空制造工程研究所], Accessed 2021, https://www.yangben001.com/m/open/open7337.html
[842] "Laboratory for High Energy Density Beam Processing Technology - High-energy beam processing equipment" [高能束流加工技术研究室 - 高能束流加工设备], *AVIC Beijing Aeronautical Manufacturing Technology Research Institute* [中航工业北京航空制造工程研究所], Accessed 2021, https://www.yangben001.com/m/open/open7337.html
[843] "Laboratory for High Energy Density Beam Processing Technology - High-energy beam processing equipment" [高能束流加工技术研究室 - 高能束流加工设备], *AVIC Beijing Aeronautical Manufacturing Technology Research Institute* [中航工业北京航空制造工程研究所], Accessed 2021, https://www.yangben001.com/m/open/open7337.html
[844] "Application of Power Beam Processing in Aviation Manufacturing" [瞄准航空制造需求 聚焦高能束流加工——走进高能束流加工技术国家级重点实验室] *Aeronautical Manufacturing Technology* [航空制造技术], 2019, Issue (14). http://www.amte.net.cn/CN/abstract/abstract3802.shtml (full-text also here: https://www.tspweb.com/key/%E9%AB%98%E8%83%BD%E6%9D%9F%E6%B5%81%E5%8A%A0%E5%B7%A5%E6%8A%80%E6%9C%AF.html)
[845] 激光焊接技术在航空领域的应用, *Sohu*, 6 July 2021, https://www.sohu.com/a/475759503_121124374

[846] "Introduction of Manufacturing Institute" [制造院简介], AVIC Manufacturing Technology Institute [中国航空制造技术研究院], Accessed 2021, https://web.archive.org/web/20190115172831/http://www.avicmti.avic.com/gxwm/zcyjg/index.shtml
[847] "Supplement No. 4 to Part 744 -ENTITY LIST," *Bureau of Industry and Security*, 8 April 2021. https://www.bis.doc.gov/index.php/documents/regulation-docs/691-supplement-no-4-to-part-744-entity-list/file
[848] "Pioneering and Innovating, Leading Technology Development-Entering the Key Laboratory of High-Energy Beam Processing Technology" [开拓创新 引领技术发展——走进高能束流加工技术重点实验室] *Aeronautical Manufacturing Technology* [航空制造技术], 2014, Vol. 463 Issue (19). https://www.ixueshu.com/document/02fbff2e7db9f898318947a18e7f9386.html
[849] "Pioneering and Innovating, Leading Technology Development-Entering the Key Laboratory of High-Energy Beam Processing Technology" [开拓创新 引领技术发展——走进高能束流加工技术重点实验室] *Aeronautical Manufacturing Technology* [航空制造技术], 2014, Vol. 463 Issue (19). https://www.ixueshu.com/document/02fbff2e7db9f898318947a18e7f9386.html
[850] "Pioneering and Innovating, Leading Technology Development-Entering the Key Laboratory of High-Energy Beam Processing Technology" [开拓创新 引领技术发展——走进高能束流加工技术重点实验室] *Aeronautical Manufacturing Technology* [航空制造技术], 2014, Vol. 463 Issue (19). https://www.ixueshu.com/document/02fbff2e7db9f898318947a18e7f9386.html
"Laboratory for High Energy Density Beam Processing Technology - High-energy beam processing equipment" [高能束流加工技术研究室 - 高能束流加工设备], *AVIC Beijing Aeronautical Manufacturing Technology Research Institute* [中航工业北京航空制造工程研究所], Accessed 2021, https://www.yangben001.com/m/open/open7337.html
[851] "Application of Power Beam Processing in Aviation Manufacturing" [瞄准航空制造需求 聚焦高能束流加工——走进高能束流加工技术国家级重点实验室] *Aeronautical Manufacturing Technology* [航空制造技术], 2019, Issue (14). http://www.amte.net.cn/CN/abstract/abstract3802.shtml (full-text also here: https://www.tspweb.com/key/%E9%AB%98%E8%83%BD%E6%9D%9F%E6%B5%81%E5%8A%A0%E5%B7%A5%E6%8A%80%E6%9C%AF.html)
[852] "Application of Power Beam Processing in Aviation Manufacturing" [瞄准航空制造需求 聚焦高能束流加工——走进高能束流加工技术国家级重点实验室] *Aeronautical Manufacturing Technology* [航空制造技术], 2019, Issue (14). http://www.amte.net.cn/CN/abstract/abstract3802.shtml (full-text also here: https://www.tspweb.com/key/%E9%AB%98%E8%83%BD%E6%9D%9F%E6%B5%81%E5%8A%A0%E5%B7%A5%E6%8A%80%E6%9C%AF.html)
[853] "Application of Power Beam Processing in Aviation Manufacturing" [瞄准航空制造需求 聚焦高能束流加工——走进高能束流加工技术国家级重点实验室] *Aeronautical Manufacturing Technology* [航空制造技术], 2019, Issue (14). http://www.amte.net.cn/CN/abstract/abstract3802.shtml (full-text also here: https://www.tspweb.com/key/%E9%AB%98%E8%83%BD%E6%9D%9F%E6%B5%81%E5%8A%A0%E5%B7%A5%E6%8A%80%E6%9C%AF.html)
[854] "The 6th International Conference on High-Energy Beam Processing Technology (ICPBPT2016)" [第六届高能束流加工技术国际学术会议(ICPBPT2016)], *Beijing Aeronautical Manufacturing Technology Research Institute* [北京航空制造工程研究所], accessed May 2021. http://www.csaa.org.cn/uploads/soft/160318/1_0139258831.pdf; "The 7th International Conference on High-Energy Beam Processing Technology (ICPBPT2018)" [第七届高能束流加工技术国际学术会议(ICPBPT2018)], AVIC Manufacturing Technology Institute [中国航空制造技术研究院], accessed May 2021. http://talent.sciencenet.cn/upload/2018/20180502154154236.pdf
[855] "The 6th International Conference on High-Energy Beam Processing Technology (ICPBPT2016)" [第六届高能束流加工技术国际学术会议(ICPBPT2016)], *Beijing Aeronautical Manufacturing Technology Research Institute* [北京航空制造工程研究所], accessed May 2021. http://www.csaa.org.cn/uploads/soft/160318/1_0139258831.pdf; "The 7th International Conference on High-Energy Beam Processing Technology (ICPBPT2018)" [第七届高能束流加工技术国际学术会议(ICPBPT2018)], AVIC Manufacturing Technology Institute [中国航空制造技术研究院], accessed May 2021. http://talent.sciencenet.cn/upload/2018/20180502154154236.pdf

[856] "The 6th International Conference on High-Energy Beam Processing Technology (ICPBPT2016)" [第六届高能束流加工技术国际学术会议(ICPBPT2016)], *Beijing Aeronautical Manufacturing Technology Research Institute* [北京航空制造工程研究所], accessed May 2021. http://www.csaa.org.cn/uploads/soft/160318/1_0139258831.pdf; "The 7th International Conference on High-Energy Beam Processing Technology (ICPBPT2018)" [第七届高能束流加工技术国际学术会议(ICPBPT2018)], AVIC Manufacturing Technology Institute [中国航空制造技术研究院], accessed May 2021. http://talent.sciencenet.cn/upload/2018/20180502154154236.pdf

[857] "Laboratory for High Energy Density Beam Processing Technology - High-energy beam processing equipment" [高能束流加工技术研究室 - 高能束流加工设备], *AVIC Beijing Aeronautical Manufacturing Technology Research Institute* [中航工业北京航空制造工程研究所], Accessed 2021, https://www.yangben001.com/m/open/open7337.html

[858] See the following sources:

1. "Pioneering and Innovating, Leading Technology Development-Entering the Key Laboratory of High-Energy Beam Processing Technology" [开拓创新 引领技术发展——走进高能束流加工技术重点实验室] *Aeronautical Manufacturing Technology* [航空制造技术], 2014, Vol. 463 Issue (19). https://www.ixueshu.com/document/02fbff2e7db9f898318947a18e7f9386.html
2. "The 6th International Conference on High-Energy Beam Processing Technology (ICPBPT2016)" [第六届高能束流加工技术国际学术会议(ICPBPT2016)], *Beijing Aeronautical Manufacturing Technology Research Institute* [北京航空制造工程研究所], Accessed 2021, http://www.csaa.org.cn/uploads/soft/160318/1_0139258831.pdf; "The 7th International Conference on High-Energy Beam Processing Technology (ICPBPT2018)" [第七届高能束流加工技术国际学术会议(ICPBPT2018)], *AVIC Manufacturing Technology Institute* [中国航空制造技术研究院], Accessed 2021, http://talent.sciencenet.cn/upload/2018/20180502154154236.pdf

[859] "2023 International Conference on Lightweight Materials and Lightweight Manufacturing Technology in Futian" [2023 轻质材料与轻量化制造技术国际会议亮相福田], *Sohu*, 24 October 2023, https://www.sohu.com/a/730891707_161795

[860] "Laboratory for High Energy Density Beam Processing Technology - High-energy beam processing equipment" [高能束流加工技术研究室 - 高能束流加工设备], *AVIC Beijing Aeronautical Manufacturing Technology Research Institute* [中航工业北京航空制造工程研究所], Accessed 2021, https://www.yangben001.com/m/open/open7337.html

[861] "Pioneering and Innovating, Leading Technology Development-Entering the Key Laboratory of High-Energy Beam Processing Technology" [开拓创新 引领技术发展——走进高能束流加工技术重点实验室] *Aeronautical Manufacturing Technology* [航空制造技术], 2014, Vol. 463 Issue (19). https://www.ixueshu.com/document/02fbff2e7db9f898318947a18e7f9386.html
"Application of Power Beam Processing in Aviation Manufacturing" [瞄准航空制造需求 聚焦高能束流加工——走进高能束流加工技术国家级重点实验室] *Aeronautical Manufacturing Technology* [航空制造技术], 2019, Issue (14). http://www.amte.net.cn/CN/abstract/abstract3802.shtml (full-text also here: https://www.tspweb.com/key/%E9%AB%98%E8%83%BD%E6%9D%9F%E6%B5%81%E5%8A%A0%E5%B7%A5%E6%8A%80%E6%9C%AF.html)

[862] "Contact Us" [联系我们], *AVIC Manufacturing Technology Institute* [中国航空制造技术研究院], accessed May 2021. https://web.archive.org/web/20210121083543/http://www.avicmti.avic.com/gxwz/ljwm/index.shtml

[863] "College Introduction" [研究院简介], *UESTC Institute of Advanced Millimeter-Wave Technology*, Accessed February 2025, https://mmw.uestc.edu.cn/yjygk/yjyjj.htm

[864] "Bite the bullet and never relax" [咬定青山不放松], *UESTC*, 27 May 2010. https://news.uestc.edu.cn/?n=UestcNews.Front.Document.ArticlePage&Id=40433
"National Key Laboratory of Microwave Electric Vacuum Devices" [微波电真空器件国家级重点实验室], *University of Electronic Science and Engineering* [电子科技大学], 27 January 2018. https://www.ese.uestc.edu.cn/info/1029/1513.htm

[865] "National Key Laboratory of Microwave Electric Vacuum Devices" [微波电真空器件国家级重点实验室], *University of Electronic Science and Engineering* [电子科技大学], 27 January 2018. https://www.ese.uestc.edu.cn/info/1029/1513.htm

[866] "A decade of hard work to turn into a butterfly --The research team of high-power microwave electric vacuum device technology in College of Physics and Electricity" [孤独前行 十年苦修待化蝶 ——记物电学院大功率微波电真空器件技术科研团队], *UESTC*, 19 February 2012. https://news.uestc.edu.cn/?n=UestcNews.Front.Document.ArticlePage&Id=46347
[867] "Feng Jinjun: Chivalry and Boldness in Scientific Research" [冯进军：科学研究的侠气与胆魄], *Tsinghua University*, 20 August 2022, https://www.tsinghua.org.cn/1014, 37645.htm
[868] "Bite the bullet and never relax" [咬定青山不放松], *UESTC*, 27 May 2010. https://news.uestc.edu.cn/?n=UestcNews.Front.Document.ArticlePage&Id=40433
"The annual academic meeting of National Key Laboratory of Microwave Electric Vacuum Devices was held in our university" [微波电真空器件国家级重点实验室学术年会在我校召开], *UESTC*, 13 December 2016. https://news.uestc.edu.cn/?n=UestcNews.Front.Document.ArticlePage&Id=56983#:~:text=%E5%88%98%E7%9B%9B%E7%BA%B2%E9%99%A2%E5%A3%AB%EF%BC%8C%E5%89%AF%E6%A0%A1%E9%95%BF%E6%9D%A8%E6%99%93%E6%B3%A2,%E9%95%BF%E8%92%99%E6%9E%97%E5%87%BA%E5%B8%AD%E4%BC%9A%E8%AE%AE%E3%80%82
[869] "A decade of hard work to turn into a butterfly --The research team of high-power microwave electric vacuum device technology in College of Physics and Electricity" [孤独前行 十年苦修待化蝶 ——记物电学院大功率微波电真空器件技术科研团队], *UESTC*, 19 February 2012. https://news.uestc.edu.cn/?n=UestcNews.Front.Document.ArticlePage&Id=46347
"National Key Laboratory of Microwave Electric Vacuum Devices" [微波电真空器件国家级重点实验室], *UESTC* [电子科技大学], 27 January 2018. https://www.ese.uestc.edu.cn/info/1029/1513.htm
[870] "Effective design "interacts" with thinking" [高效的设计要与思维"互动"], *Sohu*, 19 September 2019. https://www.sohu.com/a/341889263_99936506?spm=smpc.author.fd-d.7.1570924800060XoZw5NO
[871] "Effective design "interacts" with thinking" [高效的设计要与思维"互动"], *Sohu*, 19 September 2019. https://www.sohu.com/a/341889263_99936506?spm=smpc.author.fd-d.7.1570924800060XoZw5NO
"A decade of hard work to turn into a butterfly --The research team of high-power microwave electric vacuum device technology in College of Physics and Electricity" [孤独前行 十年苦修待化蝶 ——记物电学院大功率微波电真空器件技术科研团队], UESTC, 19 February 2012. https://news.uestc.edu.cn/?n=UestcNews.Front.Document.ArticlePage&Id=46347
[872] "A decade of hard work to turn into a butterfly --The research team of high-power microwave electric vacuum device technology in College of Physics and Electricity" [孤独前行 十年苦修待化蝶 ——记物电学院大功率微波电真空器件技术科研团队], UESTC, 19 February 2012. https://news.uestc.edu.cn/?n=UestcNews.Front.Document.ArticlePage&Id=46347
[873] "Microwave and Millimeter Wave Devices and Applications Team" [微波毫米波器件及应用团队], *UESTC*, Accessed April 2025, https://www.ese.uestc.edu.cn/kxyj/kytd2/wbhmbqjjyytd.htm
[874] "Key Laboratory of National Defense Technology for High Power Microwave Electric Vacuum Device Technology" [大功率微波电真空器件技术国防科技重点实验室], *iXueshu*, Accessed 2021, https://www.ixueshu.com/h5/document/b182fab31af30eb150647127a3d91864318947a18e7f9386.html
[875] "Key Laboratory of National Defense Technology for High Power Microwave Electric Vacuum Device Technology" [大功率微波电真空器件技术国防科技重点实验室], *iXueshu*, Accessed 2021, https://www.ixueshu.com/h5/document/b182fab31af30eb150647127a3d91864318947a18e7f9386.html
"The annual academic meeting of National Key Laboratory of Microwave Electric Vacuum Devices was held in our university" [微波电真空器件国家级重点实验室学术年会在我校召开], *UESTC*, 13 December 2016. https://news.uestc.edu.cn/?n=UestcNews.Front.Document.ArticlePage&Id=56983#:~:text=%E5%88%98%E7%9B%9B%E7%BA%B2%E9%99%A2%E5%A3%AB%EF%BC%8C%E5%89%AF%E6%A0%A1%E9%95%BF%E6%9D%A8%E6%99%93%E6%B3%A2,%E9%95%BF%E8%92%99%E6%9E%97%E5%87%BA%E5%B8%AD%E4%BC%9A%E8%AE%AE%E3%80%82
[876] "China's "killer" millimeter-wave radar was introduced, can ignore strong electromagnetic interference, five years ahead of the world" [中国"杀手锏"毫米波雷达问世，可无视强电磁干扰，领先世界五年], *Sina*, 31 December 2019. https://k.sina.com.cn/article_6242886630_1741ae3e600101qx7c.html
"China has developed another anti-stealth radar technology 5 years ahead of the world" [中国又研制出一款反隐身雷达 技术领先全球 5 年], *Sina*, 1 April 2019. https://mil.sina.cn/sd/2019-04-01/detail-ihtxyzsm2326100.d.html

"F35 has no escape at all, domestic radar in the Middle East, successful detection only to launch a fatal attack" [F35 根本没得逃，国产雷达中东发威，成功探测只待发动致命一击], *Tencent*, 9 June 2020. https://new.qq.com/omn/20200609/20200609A0OPTG00.html

[877] "The annual academic meeting of National Key Laboratory of Microwave Electric Vacuum Devices was held in our university" [微波电真空器件国家级重点实验室学术年会在我校召开], *UESTC*, 13 December 2016. https://news.uestc.edu.cn/?n=UestcNews.Front.Document.ArticlePage&Id=56983#:~:text=%E5%88%98%E7%9B%9B%E7%BA%B2%E9%99%A2%E5%A3%AB%EF%BC%8C%E5%89%AF%E6%A0%A1%E9%95%BF%E6%9D%A8%E6%99%93%E6%B3%A2,%E9%95%BF%E8%92%99%E6%9E%97%E5%87%BA%E5%B8%AD%E4%BC%9A%E8%AE%AE%E3%80%82

Gong Yubin [宫玉彬] et al., "High-power millimeter-wave and terahertz-wave signal multiplication device" [大功率毫米波与太赫兹波信号倍频装置], Google Patents, 4 January 2013. https://patents.google.com/patent/CN103050356A/zh

"Chinese Claims of Terahertz Radar?," *Monch Publishing Group*, 26 July 2018. https://www.monch.com/mpg/news/ew-c4i-channel/3881-chinesewhispers.html#:~:text=Put%20simply%2C%20Terahertz%20(THz),fashion%20to%20an%20X%2Dray

Marcus Clay, "The PLA's Pursuit of Terahertz: Facts and Fallacies", *Jamestown Foundation*, 12 November 2020. https://jamestown.org/program/pla-pursuit-terahertz-facts-and-fallacies/

[878] "Key Laboratory of National Defense Technology for High Power Microwave Electric Vacuum Device Technology" [大功率微波电真空器件技术国防科技重点实验室], *iXueshu*, Accessed 2021, https://www.ixueshu.com/h5/document/b182fab31af30eb150647127a3d91864318947a18e7f9386.html

[879] "The annual academic meeting of National Key Laboratory of Microwave Electric Vacuum Devices was held in our university" [微波电真空器件国家级重点实验室学术年会在我校召开], *UESTC*, 13 December 2016. https://news.uestc.edu.cn/?n=UestcNews.Front.Document.ArticlePage&Id=56983#:~:text=%E5%88%98%E7%9B%9B%E7%BA%B2%E9%99%A2%E5%A3%AB%EF%BC%8C%E5%89%AF%E6%A0%A1%E9%95%BF%E6%9D%A8%E6%99%93%E6%B3%A2,%E9%95%BF%E8%92%99%E6%9E%97%E5%87%BA%E5%B8%AD%E4%BC%9A%E8%AE%AE%E3%80%82

[880] "The annual academic meeting of National Key Laboratory of Microwave Electric Vacuum Devices was held in our university" [微波电真空器件国家级重点实验室学术年会在我校召开], *UESTC*, 13 December 2016. https://news.uestc.edu.cn/?n=UestcNews.Front.Document.ArticlePage&Id=56983#:~:text=%E5%88%98%E7%9B%9B%E7%BA%B2%E9%99%A2%E5%A3%AB%EF%BC%8C%E5%89%AF%E6%A0%A1%E9%95%BF%E6%9D%A8%E6%99%93%E6%B3%A2,%E9%95%BF%E8%92%99%E6%9E%97%E5%87%BA%E5%B8%AD%E4%BC%9A%E8%AE%AE%E3%80%82

[881] "Group News | Innovation breakthrough, they are very confident in the key laboratory" [集团动态 | 创新突破，身在重点实验室的他们很有信心], *Sohu*, 15 August 2019, https://www.sohu.com/a/333996317_779538

[882] "Feng Jinjun: Chivalry and Boldness in Scientific Research" [冯进军：科学研究的侠气与胆魄], *Tsinghua University*, 20 August 2022, https://www.tsinghua.org.cn/1014, 37645.htm

[883] "Jinjun Feng," *Vacuum Electronics.org*, Accessed January 2024, https://vacuumelectronics.org/ivec_award/jinjun_feng.html

[884] "Bite the bullet and never relax" [咬定青山不放松], *UESTC*, 27 May 2010. https://news.uestc.edu.cn/?n=UestcNews.Front.Document.ArticlePage&Id=40433

"China's "killer" millimeter-wave radar was introduced, can ignore strong electromagnetic interference, five years ahead of the world" [中国"杀手锏"毫米波雷达问世，可无视强电磁干扰，领先世界五年], *Sina*, 31 December 2019. https://k.sina.com.cn/article_6242886630_1741ae3e600101qx7c.html

"China has developed another anti-stealth radar technology 5 years ahead of the world" [中国又研制出一款反隐身雷达 技术领先全球 5 年], *Sina*, 1 April 2019. https://mil.sina.cn/sd/2019-04-01/detail-ihtxyzsm2326100.d.html

[885] "The annual academic meeting of National Key Laboratory of Microwave Electric Vacuum Devices was held in our university" [微波电真空器件国家级重点实验室学术年会在我校召开], *UESTC*, 13 December 2016. https://news.uestc.edu.cn/?n=UestcNews.Front.Document.ArticlePage&Id=56983#:~:text=%E5%88%98%E7%9B%9B%E7%BA%B2%E9%99%A2%E5%A3%AB%EF%BC%8C%E5%89%AF%E6%A0%A1%E9%95%BF%E6%9D%A8%E6%99%93%E6%B3%A2,%E9%95%BF%E8%92%99%E6%9E%97%E5%87%BA%E5%B8%AD%E4%BC%9A%E8%AE%AE%E3%80%82

[886] "Effective design "interacts" with thinking" [高效的设计要与思维"互动"], *Sohu*, 19 September 2019. https://www.sohu.com/a/341889263_99936506?spm=smpc.author.fd-d.7.1570924800060XoZw5NO
"Gao Tao led a team to vacuum company to carry out special research" [高涛带队赴真空公司开展专题调研], *thepaper,cn*, 3 July 2020. https://www.thepaper.cn/newsDetail_forward_8120247
Beijing Vacuum Electronic Technology Co. LTD., Accessed 2021, https://www.vetec.com.cn/Home/index.html#
[887] "Feng Jinjun: Chivalry and Boldness in Scientific Research" [冯进军：科学研究的侠气与胆魄], *Tsinghua University*, 20 August 2022, https://www.tsinghua.org.cn/1014, 37645.htm
[888] "Feng Jinjun: Chivalry and Boldness in Scientific Research" [冯进军：科学研究的侠气与胆魄], *Tsinghua University*, 20 August 2022, https://www.tsinghua.org.cn/1014, 37645.htm
[889] "Jinjun Feng," *Vacuum Electronics.org*, Accessed January 2024, https://vacuumelectronics.org/ivec_award/jinjun_feng.html
[890] "National Key Laboratory of Microwave Electric Vacuum Devices" [微波电真空器件国家级重点实验室], *UESTC* [电子科技大学], 27 January 2018. https://www.ese.uestc.edu.cn/info/1029/1513.htm
[891] "Domestic CLP 12 18-40G power amplifier-RS103,200V/m test" [国产中电 12 所 18-40G 功率放大器-RS103,200V/m 测试], *Sohu*, 5 July 2020. https://www.sohu.com/a/405894631_120583365
[892] "China Academy of Engineering Physics" [中国工程物理研究院], *Research Recruitment Web* [研招网], Accessed 2021, https://yz.chsi.com.cn/sch/schoolInfo--schId-367848,categoryId-438815.dhtml
[893] "Institute of Applied Electronics, China Institute of Physics" [中物院应用电子学研究所], *Yingjiesheng* [应届生], 9 October 2018. https://www.yingjiesheng.com/job-003-960-701.html
[894] "Gu Zhenfang, College of Aeronautics and Astronautics visited the Twenty-first Experimental Training Base Research Institute" [顾振芳, 航天学院赴第二十一试验训练基地研究所访问交流], *NWPU*, 13 March 2012. https://news.nwpu.edu.cn/info/1003/37277.htm
Yuan Huan [袁欢] et al., "Impact on Phase of Relativistic Klystron Amplifier by Intense Current Pulse Electron Beam Property" [强流脉冲电子束特性对相对论速调管相位的影响分析], *Acta Electronica Sinica* [电子学报] (45) 2017. http://www.alljournals.cn/view_abstract.aspx?pcid=5B3AB970F71A803DEACDC055911
Yuan Huan [袁欢] et al., "Impact on Phase of Relativistic Klystron Amplifier by Intense Current Pulse Electron Beam Property" [强流脉冲电子束特性对相对论速调管相位的影响分析], *Acta Electronica Sinica* [电子学报] (45) 2017. http://www.alljournals.cn/view_abstract.aspx?pcid=5B3AB970F71A803DEACDC055911
[895] "Chinese Academy of Engineering Physics Dedicated to National Prosperity," *Engineering Science* [中国工程科学], 2001, 3(8), https://www.engineering.org.cn/en/article/24871/detail
"China Academy of Engineering Physics Mianyang ninth academy again choose Hongzhan high temperature test equipment" [中国工程物理研究院绵阳九院再次选用宏展高温试验设备], *Izzcloud*, 17 November 2021, http://webcache.googleusercontent.com/search?client=firefox-b-1-d&q=cache%3Ahttps%3A%2F%2Fkuaibao.lzzcloud.com%2Fnews_info%2F780717.html
[896] "CAEP" [中国工程物理研究院], *Research Recruitment Web* [研招网], Accessed October 2021, https://yz.chsi.com.cn/sch/schoolInfo--schId-367848,categoryId-438815.dhtml
[897] "J-20 electromagnetic pulse weapon first exposure: the second atomic bomb that can instantly hit the aircraft carrier" [歼 20 电磁脉冲武器首次曝光：可瞬间命中航母的第二原子弹], *NetEase*, 2 October 2020. https://www.163.com/dy/article/FNTOQMAL0511DV4H.html
[898] "China again exposed sci-fi high-powered weapons performance has exceeded Europe and the United States, will first equip J-20" [中国再曝科幻高能武器 性能已超欧美或率先装备歼 20], *Sina*, 18 July 2018. http://mil.news.sina.com.cn/jssd/2018-07-18/doc-ihfnsvza1592027.shtml
[899] "The 11th National High Power Microwave Symposium held" [第十一届全国高功率微波学术研讨会举行], *Science Net* [科学网], 7 November 2017. http://news.sciencenet.cn/htmlnews/2017/11/393243.shtm
[900] "The 5th National Pulse Power Conference was successfully concluded" [第五届全国脉冲功率会议圆满结束], *Chinese Pulsed Power Society* [中国核学会脉冲功率技术及其应用分会], August 2017. www.cppsociety.org/pptas/ch/reader/view_news.aspx?id=20170904045823328
[901] "The "Thirteenth Five-Year Plan" equipment pre-research defense science and technology key laboratory fund 2017 annual guide (public part) " ["十三五"装备预研国防科技重点实验室基金 2017 年度指南(公开部分)], *Northeast Normal University* [东北师范大学], Accessed 2021,

http://webcache.googleusercontent.com/search?q=cache:mWMiY-yY-FoJ:www.nenu.edu.cn/_upload/article/files/97/37/64ac72c24d8cb91d7bea77508222/da98dedc-7f06-4f67-bb83-6387f0d7999a.doc+&cd=33&hl=en&ct=clnk&gl=us

[902] "Homepage", *State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology*, Accessed January2025, https://hpld.cust.edu.cn/

[903] "State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology Introduction"[高功率半导体激光国家重点实验室简介], *State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology* [长春理工大学高功率半导体激光国家重点实验室], 7 May 2019. https://web.archive.org/web/20210328165927/http://hpld.cust.edu.cn/sysgk/sysjj/index.htm
"State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology Introduction" [高功率半导体激光国家重点实验室简介], *State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology* [长春理工大学高功率半导体激光国家重点实验室], accessed March 2021.
https://web.archive.org/web/20190908010145/http://hpld.cust.edu.cn/NewsPage.aspx?mid=101

[904] "Organization Chart of Key Laboratory" [重点实验室组织机构图], *State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology* [长春理工大学高功率半导体激光国家重点实验室], 7 May 2019.
https://web.archive.org/web/20210401152546/http://hpld.cust.edu.cn/sysgk/zzjg/index.htm

[905] "Academic Committee" [学术委员会], *State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology* [长春理工大学高功率半导体激光国家重点实验室], 6 May 2019.
https://web.archive.org/web/20210401195656/http://hpld.cust.edu.cn/sysgk/xzwyk/index.htm

[906] "Research directions" [研究方向], *State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology* [长春理工大学高功率半导体激光国家重点实验室], 13 May 2019.
https://web.archive.org/web/20210401154137/http://hpld.cust.edu.cn/kxyj/yjfx/53638.htm

[907] "State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology Introduction"[高功率半导体激光国家重点实验室简介], *State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology* [长春理工大学高功率半导体激光国家重点实验室], 7 May 2019. https://web.archive.org/web/20210328165927/http://hpld.cust.edu.cn/sysgk/sysjj/index.htm

[908] "State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology Introduction" [高功率半导体激光国家重点实验室简介], *State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology* [长春理工大学高功率半导体激光国家重点实验室], 7 May 2019. https://web.archive.org/web/20210328165927/http://hpld.cust.edu.cn/sysgk/sysjj/index.htm

[909] "State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology Introduction" [高功率半导体激光国家重点实验室简介], *State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology* [长春理工大学高功率半导体激光国家重点实验室], 7 May 2019. https://web.archive.org/web/20210328165927/http://hpld.cust.edu.cn/sysgk/sysjj/index.htm

[910] "State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology Introduction" [高功率半导体激光国家重点实验室简介], *State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology* [长春理工大学高功率半导体激光国家重点实验室], 7 May 2019. https://web.archive.org/web/20210328165927/http://hpld.cust.edu.cn/sysgk/sysjj/index.htm

[911] "Ma Xiaohui" [马晓辉], *CUST School of Opto-Electronic Engineering* [长春理工大学光电工程学院], Accessed 2021,
https://web.archive.org/web/20201028061925/http://gd.cust.edu.cn/szdw/jszy/ggsbdtjgzdsys/70016.htm

[912] "Academician Wang Lijun, director of the academic committee, was hired as a double-appointed academician of our school" [学术委员会主任王立军院士受聘我校双聘院士], *State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology* [长春理工大学高功率半导体激光国家重点实验室], 23 May 2015. https://web.archive.org/web/20210402142126/http://hpld.cust.edu.cn/sysxw/53784.htm

[913] "Wei Zhipeng" [魏志鹏], *State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology* [长春理工大学高功率半导体激光国家重点实验室], 16 May 2019.
https://web.archive.org/web/20210401003852/http://hpld.cust.edu.cn/kytd/rc/53681.htm

"Zou Yonggang" [邹永刚], *CUST School of Opto-Electronic Engineering* [长春理工大学光电工程学院], Accessed 2021, https://web.archive.org/web/20201028233415/http://gd.cust.edu.cn/szdw/jszy/ggsbdtjgzdsys/70026.htm

[914] "State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology Introduction" [高功率半导体激光国家重点实验室简介], State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology [长春理工大学高功率半导体激光国家重点实验室], 7 May 2019. https://web.archive.org/web/20210328165927/http://hpld.cust.edu.cn/sysgk/sysjj/index.htm

[915] "State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology Introduction" [高功率半导体激光国家重点实验室简介], State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology [长春理工大学高功率半导体激光国家重点实验室], 7 May 2019. https://web.archive.org/web/20210328165927/http://hpld.cust.edu.cn/sysgk/sysjj/index.htm

[916] "State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology Introduction" [高功率半导体激光国家重点实验室简介], State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology [长春理工大学高功率半导体激光国家重点实验室], 7 May 2019. https://web.archive.org/web/20210328165927/http://hpld.cust.edu.cn/sysgk/sysjj/index.htm

[917] "State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology Introduction" [高功率半导体激光国家重点实验室简介], State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology [长春理工大学高功率半导体激光国家重点实验室], 7 May 2019. https://web.archive.org/web/20210328165927/http://hpld.cust.edu.cn/sysgk/sysjj/index.htm

[918] "State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology Introduction" [高功率半导体激光国家重点实验室简介], State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology [长春理工大学高功率半导体激光国家重点实验室], 7 May 2019. https://web.archive.org/web/20210328165927/http://hpld.cust.edu.cn/sysgk/sysjj/index.htm

[919] "State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology Introduction" [高功率半导体激光国家重点实验室简介], State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology [长春理工大学高功率半导体激光国家重点实验室], 7 May 2019. https://web.archive.org/web/20210328165927/http://hpld.cust.edu.cn/sysgk/sysjj/index.htm

[920] "State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology Introduction" [高功率半导体激光国家重点实验室简介], State Key Laboratory of High Power Semiconductor Laser of Changchun University of Science and Technology [长春理工大学高功率半导体激光国家重点实验室], 7 May 2019. https://web.archive.org/web/20210328165927/http://hpld.cust.edu.cn/sysgk/sysjj/index.htm

[921] "Institute of Human Factors Engineering and Intelligent Interaction" [人因工程与智能交互研究所], *Tsinghua University*, Accessed July 2024, https://www.ie.tsinghua.edu.cn/kxyj/yjs/rygcyznjhyjs.htm

[922] Zheng Xinyu [郑新钰], "Human Factors Engineering Opens a New Paradigm for Human-Computer Interaction" [人因工程开启人机交互新范式], *People's Daily*, 9 December 2024, http://paper.people.com.cn/zgcsb/pc/content/202412/09/content_30033846.html

[923] "Institute of Human Factors Engineering and Intelligent Interaction" [人因工程与智能交互研究所], *Tsinghua University*, Accessed July 2024, https://www.ie.tsinghua.edu.cn/kxyj/yjs/rygcyznjhyjs.htm

[924] "State Key Laboratory of Human Factors Engineering Established at Astronaut Center" [人因工程国家重点实验室在航天员中心成立], *China Manned Space* [中国载人航天], 30 March 2011, https://www.cmse.gov.cn/xwzx/zhxw/201103/t20110330_22303.html

[925] "Chen Shanguang, Director of National Key Laboratory of Human Factors Engineering, visited the university" [人因工程全国重点实验室主任陈善广来校访问], *Central South University*, 26 September 2023, https://news.csu.edu.cn/info/1003/156998.htm

[926] "The 6th Human Factors Engineering Summit Forum and Human Factors Technology and Equipment Exhibition held in Qingdao" [第六届人因工程高峰论坛暨人因科技装备展在青岛举行], *Dashi Zhongguo* [大市中国], 13 September 2021, https://www.dashizg.com/guoji/20210913164591.html

[927] "State Key Laboratory of Human Factors Engineering Established at Astronaut Center" [人因工程国家重点实验室在航天员中心成立], *China Manned Space* [中国载人航天], 30 March 2011, https://www.cmse.gov.cn/xwzx/zhxw/201103/t20110330_22303.html

[928] "Institute of Human Factors Engineering and Intelligent Interaction" [人因工程与智能交互研究所*], Tsinghua University*, Accessed July 2024, https://www.ie.tsinghua.edu.cn/kxyj/yjs/rygcyznjhyjs.htm
[929] "Initiative for Developing Human Factors Engineering and Promoting "Made in China 2025" Campaign" [ 发展人因工程助推“中国制造 2025” 行动倡议书], *Sohu*, 17 July 2018, https://www.sohu.com/a/241705806_280422
[930] "Astronaut Systems" [航天员系统], *China Manned Space*, Accessed July 2024, https://www.cmse.gov.cn/gygc/xtzc/htyxt/
[931] "Graduate students of School of Biological and Medical Engineering went to China Astronaut Training Center for study tour" [生物与医学工程学院研究生赴中国航天员训练中心学习参观], *Beihang University*, Accessed July 2024, https://bme.buaa.edu.cn/studentInfo.aspx?catID=14&curID=1291&subcatID=56
[932] "Cool! Shaoguan Shixing made a special space pen 4 months after the flying sky" [牛！韶关始兴造专用太空笔 4 个月后再“飞天”], *Southcn.com*, 16 October 2021, https://pc.nfnews.com/90/5842493.html
"Chinese scientists conduct research on space robotics and its on-orbit assembly technology" [我国科学家对太空机器人技术及其在轨组装技术进行研究], *S&T Daily*, 1 December 2022, http://stdaily.com/index/kejixinwen/202212/0b501c685dd2495489d9810372f39538.shtml
[933] "China Astronaut Research and Training Center (CARTC) and our academy take all-round cooperation to a new level" [中国航天员科研训练中心与我院全方位合作迈向新台阶], *Xiangtan University*, 21 January 2019, https://hjzy.xtu.edu.cn/info/1041/1420.htm
[934] "Students from the School of Design and Arts won several awards in the first "Future Cockpit Innovation Design Competition" [设计艺术学院学子获首届“未来座舱创新设计大赛”多项大奖], *Hunan University*, Accessed July 2024, https://admi.hnu.edu.cn/info/1138/5377.htm
[935] "The First Council and Technical Committee Meeting of China Nuclear Power Human Factors Engineering and Technology Research Center was successfully held" [中国核电人因工程技术研究中心第一届理事会暨技术委员会第一次会议顺利召开], *China.com*, 13 May 2024, http://szjj.china.com.cn/2024-05/13/content_42786542.html
[936] "Institute of Human Factors Engineering and Intelligent Interaction" [人因工程与智能交互研究所], *Tsinghua University*, Accessed July 2024, https://www.ie.tsinghua.edu.cn/kxyj/yjs/rygcyznjhyjs.htm
[937] "China Shipbuilding Group Ship Human Factors Engineering Center Recruitment Information" [中国船舶集团舰船人因工程中心招聘信息], *National Resources Recruitment*, Accessed July 2024, http://m.gdpdd.com/e/action/ShowInfo.php?classid=22&id=8055
[938] "Institute of Human Factors Engineering and Intelligent Interaction" [人因工程与智能交互研究所], *Tsinghua University*, Accessed July 2024, https://www.ie.tsinghua.edu.cn/kxyj/yjs/rygcyznjhyjs.htm
[939] “China Astronaut Research and Training Center (CARTC) and our academy take all-round cooperation to a new level" [中国航天员科研训练中心与我院全方位合作迈向新台阶], *Xiangtan University*, 21 January 2019, https://hjzy.xtu.edu.cn/info/1041/1420.htm
[940] “China Astronaut Research and Training Center (CARTC) and our academy take all-round cooperation to a new level" [中国航天员科研训练中心与我院全方位合作迈向新台阶], *Xiangtan University*, 21 January 2019, https://hjzy.xtu.edu.cn/info/1041/1420.htm
[941] "Deep plowing in Chinese medicine and aerospace medicine Innovative aerospace Chinese medicine research and development--Note: Prof. Liu Xinmin, Institute of New Pharmaceutical Technology, Ningbo University" [深耕中医和航天医学 创新航天中医药研发——记宁波大学新药技术研究院刘新民教授], *China Daily*, 22 November 2023, https://tech.chinadaily.com.cn/a/202311/22/WS655dc3d7a310d5acd876ff97.html
[942] "Lingang Laboratory-China Astronaut Center State Key Laboratory of Human Factors Engineering "Searching for Space Brain Program" Project 2022 Project Application Guidelines" [临港实验室-中国航天员中心人因工程国家级重点实验室 “求索太空脑计划”项目 2022 年度项目申报指南], *Shanghai Center for Brain Science and Brain-Inspired Technology*, 2022, https://www.bsbii.cn/website/67/content/2021/1639572945270.html
[943] "Cool! Shaoguan Shixing made a special space pen 4 months after the flying sky" [牛！韶关始兴造专用太空笔 4 个月后再“飞天”], *Southcn.com*, 16 October 2021, https://pc.nfnews.com/90/5842493.html
[944] "Chinese scientists conduct research on space robotics and its on-orbit assembly technology" [我国科学家对太空机器人技术及其在轨组装技术进行研究], *S&T Daily*, 1 December 2022, http://stdaily.com/index/kejixinwen/202212/0b501c685dd2495489d9810372f39538.shtml

[945] Li Xianxue [李先学] et al., "Comfort analysis on ejection seat cushion based on sitting pressure" [基于坐应力分析的弹射座椅座垫舒适性研究], *Journal of Medical Biomechanics* [医用生物力学], 2014, 29(2), https://pubs.cstam.org.cn/article/id/071b0cae-ff6b-4554-95fb-728fe3d12d57
[946] "TU's "Shen Gong" flies with "Tiangong" to start the first space brain-machine interaction experiment in the history of mankind" [天大“神工”随“天宫”飞天 开启人类历史上首次太空脑-机交互实验], *Tianjin University*, 18 September 2016, http://news.tju.edu.cn/info/1012/35694.htm
[947] "The First Council and Technical Committee Meeting of China Nuclear Power Human Factors Engineering and Technology Research Center was successfully held" [中国核电人因工程技术研究中心第一届理事会暨技术委员会第一次会议顺利召开], *China.com*, 13 May 2024, http://szjj.china.com.cn/2024-05/13/content_42786542.html
[948] "Chen Shanguang, Director of National Key Laboratory of Human Factors Engineering, visited the university" [人因工程全国重点实验室主任陈善广来校访问], *Central South University*, 26 September 2023, https://news.csu.edu.cn/info/1003/156998.htm
[949] "Students from the School of Design and Arts won several awards in the first "Future Cockpit Innovation Design Competition" [设计艺术学院学子获首届“未来座舱创新设计大赛”多项大奖], *Hunan University*, Accessed July 2024, https://admi.hnu.edu.cn/info/1138/5377.htm
[950] "Students from the School of Design and Arts won several awards in the first "Future Cockpit Innovation Design Competition" [设计艺术学院学子获首届“未来座舱创新设计大赛”多项大奖], *Hunan University*, Accessed July 2024, https://admi.hnu.edu.cn/info/1138/5377.htm
[951] "Session 9 of "Century-old Machinery, Smart Future" Masters Forum: Prof. Zhang Wei - Case Study on Human Factors Engineering and Driving Safety - Driver Stress Monitoring" [“百年机械、智造未来”大师论坛第九场：张伟教授——人因工程与驾驶安全研究案例-驾驶员压力监测], *Southeast University*, 18 April 2023, https://me.seu.edu.cn/2023/0418/c38451a442028/page.htm
[952] "Inauguration Ceremony of the Key Laboratory of Industrial Design and Human-Machine Ergonomics of the Ministry of Industry and Information Technology and the First Meeting of the Academic Committee Successfully Held" [工业设计与人机工效工信部重点实验室揭牌仪式及学术委员会第一次会议顺利举行], *Northwestern Polytechnical University*, 3 December 2018, https://news.nwpu.edu.cn/info/1002/60063.htm
[953] "Chen Shanguang, Director of National Key Laboratory of Human Factors Engineering, visited the university" [人因工程全国重点实验室主任陈善广来校访问], *Central South University*, 26 September 2023, https://news.csu.edu.cn/info/1003/156998.htm
[954] "China Astronaut Research and Training Center (CARTC) and our academy take all-round cooperation to a new level" [中国航天员科研训练中心与我院全方位合作迈向新台阶], *Xiangtan University*, 21 January 2019, https://hjzy.xtu.edu.cn/info/1041/1420.htm
[955] “China plans to build a 3-person space station around 2022” [我国计划 2022 年前后建成可载 3 人的空间站], *China National Space Administration*, 19 November 2019, https://www.cnsa.gov.cn/n6758823/n6758838/c6808208/content.html
[956] "Initiative for Developing Human Factors Engineering and Promoting "Made in China 2025" Campaign" [发展人因工程助推“中国制造 2025” 行动倡议书], *Sohu*, 17 July 2018, https://www.sohu.com/a/241705806_280422
[957] "Seek Development, Promote Cooperation -- Jiang Changhua and his delegation from the Key Laboratory of Human Factors Engineering visited the Laboratory of the Department of Psychology, ZJU" [谋发展，促合作 ——人因工程重点实验室姜昌华一行来访浙大心理系系实验室], *Zhejiang University*, 16 May 2023, http://www.psych.zju.edu.cn/2023/0516/c27577a2757847/page.htmcolla
[958] "TU's "Shen Gong" flies with "Tiangong" to start the first space brain-machine interaction experiment in the history of mankind" [天大“神工”随“天宫”飞天 开启人类历史上首次太空脑-机交互实验], *Tianjin University*, 18 September 2016, http://news.tju.edu.cn/info/1012/35694.htm
[959] "Astronaut Magazine" [航天员杂志]. *Xuekanba* [学刊吧], Accessed July 2024, https://www.xuekanba.com/qikan/6118.html
[960] "2021 IEEE/OES China Ocean Acoustics Conference" [中国海洋声学国际会议], *ICCSNT*, Accessed August 2024, http://www.iccsnt.org/COA2021/ShowArticle.asp?ArticleID=770
http://www.iccsnt.org/COA2021/index.asp

[961] Du Jiacheng [杜嘉诚] et al., "Dielectric and Piezoelectric Temperature Stability of BF-PT-BZT Ternary High Temperature Piezoelectric Ceramics" [BF-PT-BZT 三元系高温压电陶瓷的介电压电温度稳定性], *Piezoelectricity and Acoustooptics* [压电与声光], 2024, 46(1), https://www.opticsjournal.net/Articles/OJf0ea57852959d34a/km
[962] "Recruitment Information - Shanghai Ship Electronic Equipment Research Institute 2021 Master's Degree Transfer Work Officially Launched" [【招聘信息】上海船舶电子设备研究所 2021 年硕士研究生调剂工作正式启动], *Northwestern Polytechnical University*, 18 March 2021, https://hanghai.nwpu.edu.cn/info/1616/10678.htm
[963] "We extend our sincerest thanks to all the experts who reviewed manuscripts for the journal in 2019!" [向 2019 年为本刊审稿的各位专家致以最诚挚的谢意！], *Telecommunication Engineering* [电讯技术], 2 January 2020, http://www.teleonline.cn/dxjs/ch/reader/view_news.aspx?id=20200102162124001
16. "Directory of PRC Military Personalities March 2019," *Textore*, 2019.
[964] Xu Shi [徐袭], Shi Min [石敏], "Research on simulation to efficiency of testing target counter active acoustic homing torpedo" [试验靶标对抗主动声自导鱼雷效能仿真[, *Ship Science and Technology* [舰船科学技术], 2012, 12, www.cnki.nbtvu.net.cn/KCMS/detail/detail.aspx?filename=JCKX201212023&dbcode=CJFD&dbname=CJFD2012
Liu Jinchang [刘晋昌] et al., "Study and Implementation of the Auto-calibration System of Vector Hydrophone" [矢量水听器自动校准系统的研究及实现], *Acta Metrologica Sinica* [计量学报], 2011, 32(6), http://jlxb.china-csm.org:81/Jwk_jlxb/CN/abstract/abstract760.shtml
[965] Xu Shi [徐袭], Shi Min [石敏], "Research on simulation to efficiency of testing target counter active acoustic homing torpedo" [试验靶标对抗主动声自导鱼雷效能仿真[, *Ship Science and Technology* [舰船科学技术], 2012, 12, www.cnki.nbtvu.net.cn/KCMS/detail/detail.aspx?filename=JCKX201212023&dbcode=CJFD&dbname=CJFD2012
[966] "China's unmanned systems latest developments" [中国无人系统的最新发展], *Aviation World* [航空世界], 2015, 6, https://www.jxxfw.com/periodical/db702057883a0e77f34a18bbadd18869.html
[967] Xu Shi [徐袭], Shi Min [石敏], "Research on simulation to efficiency of testing target counter active acoustic homing torpedo" [试验靶标对抗主动声自导鱼雷效能仿真[, *Ship Science and Technology* [舰船科学技术], 2012, 12, www.cnki.nbtvu.net.cn/KCMS/detail/detail.aspx?filename=JCKX201212023&dbcode=CJFD&dbname=CJFD2012
[968] Yan Yuxia [严雨霞], Wang Biao [王彪], "A special method for non-uniform acoustic array with sparse reconstruction" [一种特殊的非均匀水声阵列稀疏重构方法], *Ship Science and Technology* [舰船科学技术], 2018, 40(3), http://www.jckxjsgw.com/viewmulu.aspx?qi_id=1799&mid=55970&xuhao=24
[969] Ni Chunguang [倪春光] et al., "Operational Strategy for Helicopter with Dipping Sonar to Search Submarine" [直升机使用吊放声纳搜潜作战的策略研究], *Journal of Unmanned Undersea Systems* [水下无人系统学报], 2013, 21(4), https://sxwrxtxb.xml-journal.net/cn/article/doi/10.11993/j.issn.1673-1948.2013.04.016
[970] Liu Jinchang [刘晋昌] et al., "Study and Implementation of the Auto-calibration System of Vector Hydrophone" [矢量水听器自动校准系统的研究及实现], *Acta Metrologica Sinica* [计量学报], 2011, 32(6), http://jlxb.china-csm.org:81/Jwk_jlxb/CN/abstract/abstract760.shtml
[971] Li Haochen [李昊辰] et al., "A sub-parent AUV with multi-load release capacity: principle, mechanism design, and performance testing" [子母式 AUV 多载荷布放机构设计与性能测试], *Chinese Journal of Ship Research* [中国舰船研究], 2024, 19(X), https://www.ship-research.com/cn/article/doi/10.19693/j.issn.1673-3185.03607
[972] "Zhang Feihu" [张飞虎], *Northwestern Polytechnical University*, Accessed August 2024, https://teacher.nwpu.edu.cn/2017010013.html
[973] Xia Zhijun [夏志军] et al., "Judging Method of Trajectory Type for Incoming Torpedo Based on Bearing Variation Information" [基于舷角变化信息的来袭鱼雷弹道类型判别方法], *Journal of Ordnance Equipment Engineering* [兵器装备工程学报], 2019, 40(11), https://bzxb.cqut.edu.cn/newsinfo.aspx?id=1004
[974] "School of Computing and Information Technology: Hydroacoustics and hydroacoustic countermeasures face challenges, confront reality, and look to the future" [计算机与信息学院：水声和水声对抗面临挑战，面对现实，面向未来], *Hohai University*, 26 October 2016, https://www.hhu.edu.cn/_t128/2016/1027/c271a82125/page.htm

[975] Du Xuanmin [杜选民], Array Signal Processing Techniques for Sonar [声纳阵列信号处理技术], *Electronic Industry Press* [:电子工业出版社], 2018, https://spacelib.zjhu.edu.cn/space/searchDetailLocal/m323d19049f18dfaa88a5da86a8d82e1a
[976] "Academic report: oceanographic fundamentals of hydroacoustic engineering to the deep blue" [学术报告：水声工程走向深蓝的海洋学基本功], *Southeast University*, 16 May 2019, https://radio.seu.edu.cn/2019/0516/c15986a273205/page.htm
[977] "Academic Exchange | Application of Parametric Array Technology in Hydroacoustic Engineering and Its Related Issues" [学术交流 | 参量阵技术在水声工程中的应用及其相关问题研究], *The Paper*, 16 September 2021, https://m.thepaper.cn/newsDetail_forward_14540630
[978] "2019 Hydroacoustic Countermeasures Technology Symposium Held in Shenyang" [2019 水声对抗技术学术交流会"在沈阳召开], *Technical Acoustics* [声学技术], 2019, 05, http://cnki.cqgmy.edu.cn/KCMS/detail/detail.aspx?filename=SXJS201905003&dbcode=CJFQ&dbname=CJFD2019
[979] "2021 IEEE/OES China Ocean Acoustics Conference" [中国海洋声学国际会议], *ICCSNT*, Accessed August 2024, http://www.iccsnt.org/COA2021/ShowArticle.asp?ArticleID=770
http://www.iccsnt.org/COA2021/index.asp
[980] Yan Yuxia [严雨霞], Wang Biao [王彪], "A special method for non-uniform acoustic array with sparse reconstruction" [一种特殊的非均匀水声阵列稀疏重构方法], *Ship Science and Technology* [舰船科学技术], 2018, 40(3), http://www.jckxjsgw.com/viewmulu.aspx?qi_id=1799&mid=55970&xuhao=24
[981] Li Haochen [李昊辰] et al., "A sub-parent AUV with multi-load release capacity: principle, mechanism design, and performance testing" [子母式 AUV 多载荷布放机构设计与性能测试], Chinese Journakl of Ship Research [中国舰船研究], 2024, 19(X), https://www.ship-research.com/cn/article/doi/10.19693/j.issn.1673-3185.03607
Xia Zhijun [夏志军] et al., "Judging Method of Trajectory Type for Incoming Torpedo Based on Bearing Variation Information" [基于舷角变化信息的来袭鱼雷弹道类型判别方法], Journal of Ordnance Equipment Engineering [兵器装备工程学报], 2019, 40(11), https://bzxb.cqut.edu.cn/newsinfo.aspx?id=1004
[982] Wu Yi [吴仪] et al., "Electromechanical analogical analysis and experimental study of hydrodynamic infrasound transducers " [流体动力式次声换能器机电类比分析与试验研究], *Technical Acoustics* [声学技术], 2023, 42(3), https://cytsk.zwu.edu.cn:8080/asset/detail.aspx?id=2031225657320
[983] Xu Shi [徐袭], Shi Min [石敏], "Research on simulation to efficiency of testing target counter active acoustic homing torpedo" [试验靶标对抗主动声自导鱼雷效能仿真[, Ship Science and Technology [舰船科学技术], 2012, 12, www.cnki.nbtvu.net.cn/KCMS/detail/detail.aspx?filename=JCKX201212023&dbcode=CJFD&dbname=CJFD2012
Liu Jinchang [刘晋昌] et al., "Study and Implementation of the Auto-calibration System of Vector Hydrophone" [矢量水听器自动校准系统的研究及实现], Acta Metrologica Sinica [计量学报], 2011, 32(6), http://jlxb.china-csm.org:81/Jwk_jlxb/CN/abstract/abstract760.shtml
[984] "China Association for Science and Technology 9th Party Congress Representative Qiao Gang: Creating Underwater "Clairvoyance" "Shunfeng Ear"" [中国科协九大代表乔钢：打造水下"千里眼""顺风耳"], *Heilongjiang Northeast Online* [黑龙江东北网], 30 May 2017. http://webcache.googleusercontent.com/search?q=cache%3Ahttps%3A%2F%2Fheilongjiang.dbw.cn%2Fsystem%2F2017%2F05%2F30%2F057658239.shtml&rlz=1C1CHBD_enUS895US895&oq=cache%3Ahttps%3A%2F%2Fheilongjiang.dbw.cn%2Fsystem%2F2017%2F05%2F30%2F057658239.shtml&aqs=chrome..69i57j69i58.2215j0j4&sourceid=chrome&ie=UTF-8
[985] "The 2024 Symposium of the Hydroacoustics Branch of the Acoustical Society of China was held in Wuhan, Hubei" [中国声学学会水声学分会 2024 年学术交流会在湖北武汉召开], *CAS Institute of Acoustics*, 23 December 2024, http://ioa.cas.cn/jlhz/xsjl/202412/t20241226_7510686.html
[986] "Key Labs" [重点实验室], *Harbin University of Engineering*, Accessed 2021, http://webcache.googleusercontent.com/search?q=cache%3Awww.hrbeu.edu.cn%2Fkxyj%2Fssjs.aspx&rlz=1C1CHBD_enUS895US895&oq=cache%3Awww.hrbeu.edu.cn%2Fkxyj%2Fssjs.aspx&aqs=chrome..69i57j69i58.1640j0j4&sourceid=chrome&ie=UTF-8
[987] "Lab overview"[实验室概况], *Harbin Engineering University*, Accessed April 2025, August 2022, https://web.archive.org/web/20220810072448/https://uast.hrbeu.edu.cn/sysgk.htm

[988] "National Key Laboratory of Underwater Acoustic Science and Technology" [水声技术国家重点实验室], *Harbin Engineering University*, 21 November 2017, webcache.googleusercontent.com/search?q=cache%3Auae.hrbeu.edu.cn%2Fen5%2F2017%2F1129%2Fc6266a174685%2Fpage.htm&rlz=1C1CHB
"Key Labs" [重点实验室], Harbin University of Engineering [哈尔滨工程大学], Accessed 2021, http://webcache.googleusercontent.com/search?q=cache%3Awww.hrbeu.edu.cn%2Fkxyj%2Fssjs.aspx&rlz=1C1CHBD_enUS895US895&oq=cache%3Awww.hrbeu.edu.cn%2Fkxyj%2Fssjs.aspx&aqs=chrome..69i57j69i58.1640j0j4&sourceid=chrome&ie=UTF-8
[989] "School of Underwater Acoustic Engineering Academic Teams" [水声工程学院学术团队], *Harbin Engineering University*, Accessed 2021, webcache.googleusercontent.com/search?q=cache:bJWejZfyzCsJ:uae.hrbeu.edu.cn/3771/list.htm+&cd=1&hl=en&ct=clnk&gl=us
[990] "National Key Laboratory of Underwater Acoustic Science and Technology" [水声技术国家重点实验室], *Harbin Engineering University*, 21 November 2017, webcache.googleusercontent.com/search?q=cache%3Auae.hrbeu.edu.cn%2Fen5%2F2017%2F1129%2Fc6266a174685%2Fpage.htm&rlz=1C1CHB
[991] "National Key Laboratory of Underwater Acoustic Science and Technology" [水声技术国家重点实验室], *Harbin Engineering University*, 21 November 2017, webcache.googleusercontent.com/search?q=cache%3Auae.hrbeu.edu.cn%2Fen5%2F2017%2F1129%2Fc6266a174685%2Fpage.htm&rlz=1C1CHB
[992] "National Key Laboratory of Underwater Acoustic Science and Technology" [水声技术国家重点实验室], *Harbin Engineering University*, 21 November 2017, webcache.googleusercontent.com/search?q=cache%3Auae.hrbeu.edu.cn%2Fen5%2F2017%2F1129%2Fc6266a174685%2Fpage.htm&rlz=1C1CHB
[993] "School of Underwater Acoustic Engineering Academic Teams" [水声工程学院学术团队], Harbin Engineering University, Accessed 2021, webcache.googleusercontent.com/search?q=cache:bJWejZfyzCsJ:uae.hrbeu.edu.cn/3771/list.htm+&cd=1&hl=en&ct=clnk&gl=us
[994] "School of Underwater Acoustic Engineering Academic Teams" [水声工程学院学术团队], Harbin Engineering University, Accessed 2021, webcache.googleusercontent.com/search?q=cache:bJWejZfyzCsJ:uae.hrbeu.edu.cn/3771/list.htm+&cd=1&hl=en&ct=clnk&gl=us
"Promoting the industrialization process of deep-sea equipment--Sun Dajun" [推动深海装备的产业化进程——孙大军], *China.com* [中国网], 18 February 2016. http://ocean.china.com.cn/2016-02/18/content_37819261.htm
[995] "Organization Structure" [组织结构], Harbin Engineering University, Accessed August 2022, https://web.archive.org/web/20220810090023/http://uast.hrbeu.edu.cn/sysgk/zzjg.htm
[996] "Organization Structure" [组织结构], *Harbin Engineering University*, Accessed August 2022, https://web.archive.org/web/20220810090023/http://uast.hrbeu.edu.cn/sysgk/zzjg.htm
[997] "Academic Committee" [学术委员会], *Harbin Engineering University*, 19 May 2021, https://web.archive.org/web/20220930222822/http://uast.hrbeu.edu.cn/info/1041/1060.htm
[998] "Yang Desen" [杨德森], *Jiangsu University of Science and Technology* [*江苏科技大学*], 10 March 2019, http://yjsb.just.edu.cn/2019/0310/c7146a75733/page.htm
[999] "Promoting the industrialization process of deep-sea equipment--Sun Dajun" [推动深海装备的产业化进程——孙大军], *China.com* [中国网], 18 February 2016. http://ocean.china.com.cn/2016-02/18/content_37819261.htm
[1000] "Harbin Engineering University, School of Hydroacoustic Engineering 2015 Master's Degree Admissions" [哈尔滨工程大学水声工程学院 2015 年硕士研究生招生简章], *Dalian University of Technology* [大连理工大学], 19 March 2015, https://vehicle.dlut.edu.cn/info/1024/2035.htm
[1001] "Deep-sea unmanned equipment industry alliance established in Sanya" [深远海无人装备产业联盟在三亚成立], *Xinhua*, 16 December 2024, http://hq.news.cn/20241216/989351e8156a4aa2930a1d6dab704d59/c.html
[1002] "School of Underwater Acoustics" [水声工程学院], *Harbin Institute of Technology*, Accessed 2021, https://mweb.eol.cn/2524/article/151175.html

[1003] "800 Acoustics Experts Gather at HEU to Discuss "Intelligent Sound, Leading Innovation"" [全国 800 声学专家汇聚哈工程研讨“智能声态，引领创新"], *S&T Daily*, 25 September 2017, http://www.stdaily.com/02/difangdongt/2017-09/25/content_579713.shtml?from=groupmessage&isappinstalled=0
“What did the forum attended by four Academy of Engineering members say? Bringing brainstorming on the development of marine information technology” [四位工程院院士参加的论坛说啥了？带来海洋信息技术发展的头脑风暴], *Sohu*, 19 January 2019, https://www.sohu.com/a/290093002_349336
[1004] "More than 400 experts from 10 countries gathered! Together we will have an Ocean Acoustics event!" [10 国 400 余专家齐聚！共襄海洋声学盛会!], *Tencent*, 30 May 2024, https://news.qq.com/rain/a/20240530A08UWP00
[1005] “IEEE/OES China Ocean Acoustics Symposium” [IEEE/OES 中国海洋声学研讨会], *AConf.org*, 9 November 2016. https://www.aconf.org/conf_81725.IEEE/OES%E4%B8%AD%E5%9B%BD%E6%B5%B7%E6%B4%8B%E5%A3%B0%E5%AD%A6%E7%A0%94%E8%AE%A8%E4%BC%9A.html
“2021 IEEE/OES China Oceanic Acoustics Symposium” [2021 IEEE/OES 中国海洋声学国际会议], *COA 2021*, 14 July 2021. http://www.chinaoceanacoustics.cn/COA2021/index.asp
[1006] Zhengxian Wei et al., “Data Access Based on a Guide Map of the Underwater Wireless Sensor Network,” *Sensors* 17 (2017). https://www.researchgate.net/publication/320461452_Data_Access_Based_on_a_Guide_Map_of_the_Underwater_Wireless_Sensor_Network
“International Forum of Ocean Information 2020,” *Harbin Engineering University*, 10 April 2020, https://subctech.com/wp-content/uploads/2020/04/International-Forum-of-Ocean-Information-2020-IFOI-2020.pdf
[1007] Zhang Youwen [张友文] et al., “Simulation and experimental verification of near-range high-speed hydroacoustic millimeter wave communication” [近程高速水声毫米波通信仿真与试验验证], *Applied Acoustics* [应用声学] 4 (2019).
[1008] “Practical exploration of promoting collaborative innovation in the School of Hydroacoustics of Harbin Engineering University” [哈尔滨工程大学水声学院推进协同创新的实践探索], *New Orient* [新东方], 5 January 2013, http://webcache.googleusercontent.com/search?q=cache:HY9f-WcU1YIJ:daxue.xdf.cn/201212/9266329.html+&cd=8&hl=en&ct=clnk&gl=us
“US blacklists 'China's MIT' as tech war enters new phase,” *Nikkei Asia*, 17 July 2020. https://asia.nikkei.com/Business/Technology/US-blacklists-China-s-MIT-as-tech-war-enters-new-phase
[1009] "Open sharing" [开放共享], *Harbin Engineering University*, Accessed August 2022, https://web.archive.org/web/20220810082713/http://uast.hrbeu.edu.cn/kfgx.htm
[1010] Li Xiang [李霜], "Open Day of the National Key Laboratory of Hydroacoustic Technology of Harbin Engineering University" [哈工程水声技术国家级重点实验室开放日启幕], *Harbin News Broadcast* [哈尔滨新闻广播], 24 May (No Year Given). https://orientalhaerbin.zainanjing365.com/siteapp/gdmm/jsp?service_name=gdmmArticle&method_name=shareJsp&id=1986&appscheme=gdmm-zheb
[1011] "National Key Laboratory of Hydrodynamics (participation)" [水动力学全国重点实验室（参与）], *Harbin Engineering University College of Shipbuilding Engineering*, 28 February 2021, http://sec.hrbeu.edu.cn/2024/0313/c469a322561/page.htm
[1012] "Unit Introduction" [单位介绍], *China Ship Scientific Research Center*, Accessed June 2024, http://www.cssrc.com.cn/about/22.html
[1013] 5. "Call for Papers for the 13th National Academic Conference on Fluid Mechanics (First Round)" [第十三届全国流体力学学术会议征文通知（第一轮)], *The Chinese Society of Theoretical and Applied Mechanics*, 23 January 2024, https://cstam.org.cn/article/19461847002509312.html
Li Peng [李鹏], "Quantitative experimental study on the stability and ventilation rate of super vacuoles in a high speed water tunnel" [高速水洞中超空泡稳定性与通气率定量试验研究], *Ship Mechanics* [船舶力学], 2024, 4, http://222.29.77.169/100000/detail/article/6638387b617c922bc4d1386a.html?q=%E7%BA%BF%E6%80%A7%E7%AD%89%E5%BC%8F%E7%BA%A6%E6%9D%9F%E4%BC%98%E5%8C%96%E9%97%AE%E9%A2%98)&org=100000&uorg=999999

[1014] "National Key Laboratory of Hydrodynamics (participation)" [水动力学全国重点实验室（参与）], *Harbin Engineering University College of Shipbuilding Engineering*, 28 February 2021, http://sec.hrbeu.edu.cn/2024/0313/c469a322561/page.htm
[1015] He Shuaikang [何帅康] et al., "Measurement and identification of ice loads on hull structures in far field based on dynamic effects" [基于动力效应的船体远场冰载荷测量与识别], *Chinese Journal of Ship Research* [中国舰船研究], 2021, 16(5), http://www.ship-research.com/cn/article/Y2021/I5/54
[1016] Zhao Qiaosheng [赵桥生] et al., "Computational Study on Space Motion Simulation of Manned Submersible" [载人潜水器空间运动仿真计算研究], *Proceedings of the 30th National Symposium on Hydrodynamics and the 15th National Symposium on Hydrodynamics* [第三十届全国水动力学研讨会暨第十五届全国水动力学学术会议论文集], 16 August 2019, https://d.wanfangdata.com.cn/conference/9824477
[1017] Zhang Jun [张军] et al., "Numerical simulation of projectile flow through ice-water mixtures" [弹体穿越冰水混合物流动过程的数值模拟], *Journal of Missiles* [导弹学报], 2020, 3, http://www.cqvip.com/qk/92261x/202003/7102937916.html
Zhang Chun [张春] et al., "Flow field characteristics of underwater supersonic over-expanded gas jet" [水下超声速过膨胀燃气射流的流场特性], *Journal of Aerospace Propulsion* [航空动力学报], 2022, 8, http://www.jasp.com.cn/jasp_cn/article/abstract/202208007?st=article_issue
[1018] "National Key Laboratory of Hydrodynamics (participation)" [水动力学全国重点实验室（参与）], *Harbin Engineering University College of Shipbuilding Engineering,* 28 February 2021, http://sec.hrbeu.edu.cn/2024/0313/c469a322561/page.htm
[1019] "Guidelines for 2020 Open Fund Projects of Key Laboratory of Hydrodynamics, Key Laboratory of Ship Vibration and Noise and Provincial Key Laboratory of Green Ship Technology" [关于水动力学重点实验室、船舶振动噪声重点实验室和省绿色船舶技术重点实验室 2020 年开放基金项目申报指南], *Hunan Civil-military Integration of public service platform*, 22 June 2020, https://www.hnjmrh.gov.cn/newweb/newinfo/detail/3839/
[1020] "Notice of Academic Report on Strategic Needs and Frontier Technologies of Deep-Sea Equipment" [深海装备的战略需求与前沿技术学术报告通知], *Beijing Institute of Technology*, 11 March 2016, https://www.bit.edu.cn/tzgg17/jzyg2/a122582.htm
[1021] "Call for Papers for the 13th National Academic Conference on Fluid Mechanics (First Round)" [第十三届全国流体力学学术会议征文通知（第一轮)], *The Chinese Society of Theoretical and Applied Mechanics*, 23 January 2024, https://cstam.org.cn/article/19461847002509312.html
[1022] "The 9th National Conference on CFD for Shipbuilding and Offshore Engineering" [第九届全国船舶与海洋工程 CFD 会议], *Shanghai Jiao Tong University*, 3 April 2024, https://dcwan.sjtu.edu.cn/News/showDetail.aspx?tid=1175
[1023] "The 14th National Hydrodynamics Academic Conference and the 28th National Symposium on Hydrodynamics and the 2nd Editorial Board of the 8th Session of Hydrodynamics Research and Progress" [第十四届全国水动力学学术会议暨第二十八届全国水动力学研讨会并《水动力学研究与进展》八届二次编委会], *Journal of Hydrodynamics*, Accessed June 2024, http://www.jhydrodynamics.com/en/editorial-committee/
[1024] "The 7th CMHL International Symposium on Computational Hydrodynamics for Ships and Offshore Engineering Held Online" [第七届 CMHL 船舶与海洋工程计算水动力学国际研讨会线上召开], *Shanghai Jiao Tong University*, 31 January 2024, https://dcwan.sjtu.edu.cn/News/showDetail.aspx?tid=1155
[1025] He Shuaikang [何帅康] et al., "Measurement and identification of ice loads on hull structures in far field based on dynamic effects" [基于动力效应的船体远场冰载荷测量与识别], *Chinese Journal of Ship Research* [中国舰船研究], 2021, 16(5), http://www.ship-research.com/cn/article/Y2021/I5/54
[1026] "Visualizing the surge phenomenon" [可视化激波现象], *30th National Book Expo Purchasing Platform*, 23 March 2023, http://gph.sbhjn.com/bookshow.asp?id=2531219
"Call for Papers for the 12th National Hypersonic Science and Technology Conference (First Round)" [第十二届全国高超声速科技学术会议（第一轮）征文通知], *CAS Institute of Mechanics*, 2019, http://lhd.imech.ac.cn/kjdt/201903/P020190312564437135630.pdf

Wei Feng [卫锋] et al., “Design and experimental study of microtrimmed shaped turning circle internal rotary air intakes” [微修形异型转圆内转式进气道的设计与试验研究], *Propulsion Technology* [推进技术], 2017 6, https://d.wanfangdata.com.cn/periodical/tjjs201706003

[1027] Kang Zhongtao [康忠涛] et al., "Linear stability analysis of conical liquid film with coaxial annular gas flow" [同轴环缝气流作用下锥形液膜线性稳定性分析], *Journal of National University of Defense Technology* [国防科技大学学报], 2019 2, http://journal.nudt.edu.cn/wap/ch/reader/view_abstract.aspx?file_no=201902003&flag=1

[1028] "Visualizing the surge phenomenon" [可视化激波现象], *30th National Book Expo Purchasing Platform*, 23 March 2023, http://gph.sbhjn.com/bookshow.asp?id=2531219

[1029] Li Xin [李欣], "The Key Laboratory of Hypersonic Ramjet Engine Technology successfully held the first Combustion Symposium" [高超声速冲压发动机技术重点实验室成功召开第一届燃烧学研讨会], *Propulsion Technology* [推进技术], 2011 6, http://www.cqvip.com/QK/97609X/20116/40676054.html

[1030] “Beijing Power Machinery Institute" [北京动力机械研究所], *iGuopin*, Accessed February 2024, https://www.iguopin.com/company?id=10685397110843983

[1031] "Notice of 2012 Open Fund Application for the Key Laboratory of Hypersonic Ram Engine Technology" [关于高超声速冲压发动机技术重点实验室 2012 年开放基金申请的通知], *Beijing Institute of Technology*, 27 March 2012, https://www.bit.edu.cn/tzgg17/kyxs/a74365.htm

[1032] Wei Feng [卫锋] et al., “Design and experimental study of microtrimmed shaped shaped turning circle internal rotary air intakes” [微修形异型转圆内转式进气道的设计与试验研究], *Propulsion Technology* [推进技术], 2017 6, https://d.wanfangdata.com.cn/periodical/tjjs201706003

Wei Feng [卫锋] et al., "Investigation of Starting Performance of a 3D Inward Turning Inlet through Fixed-Exit Bleed Model" [利用渗透边界模型分析三维内转式进气道启动性能], *Journal of Propulsion Technology*, 2017, http://tjjs.ijournals.cn/tjjs/ch/reader/view_abstract.aspx?file_no=20171105&flag=1

Wu Yingchuan [吴颖川] et al., "An overview of hypersonic aero-propulsion integration test facilities" [高超声速机体/推进一体化试验设备概述], *Science and Technology Review* [科技导报], 2020 38(12), http://www.kjdb.org/CN/abstract/abstract15836.shtml

Meng Yupeng [孟宇鹏] et al., "Development of Hypersonic Inlet-Vehicle Integrative Design Technology" [高超声速进气道飞行器一体化设计技术的发展], *Physics of Gases* [气体物理], 2021 6(4), https://pubs.cstam.org.cn/article/doi/10.19527/j.cnki.2096-1642.0861?viewType=HTML

[1033] Sun Mingbo [孙明波] et al., "NUMERICAL SIMULATION OF THE SCRAMJET ENGINE: FROM NUMERICAL FLIGHT TO INTELLIGENT NUMERICAL FLIGHT" [超燃冲压发动机仿真: 从数值飞行到数智飞行], *Chinese Journal of Theoretical and Applied Mechanics* [力学学报, ], 2022 54(3), https://pubs.cstam.org.cn/article/doi/10.6052/0459-1879-21-397

[1034] Xue Xiaobin [许晓斌] et al., "Experimental investigation on lifting body aerodynamic force with simulated aft-body jet" [升力体飞行器尾喷流模拟气动力试验方法研究], *Acta Aerodynamica Sinica* [空气动力学学报], 2016 31(1), http://kqdlxxb.xml-journal.net/cn/article/id/11776

[1035] Sun Jian [ 孙健], Liu Weiqiang [刘伟强],"Investigation on integral model of heat-pipe-cooled leading edge of hypersonic vehicle" [高超声速飞行器热管冷却前缘结构一体化建模分析], *Acta Physica Sinica* [物理学报], 2013 62(7), https://wulixb.iphy.ac.cn/article/doi/10.7498/aps.62.074401

[1036] "Sixteenth China Youth Science and Technology Award winners are being publicized, Changsha 3 professors on the list" [第十六届中国青年科技奖获奖人选正在公示，长沙 3 名教授上榜], *Changsha Knowledge Online* [长沙知识网], 1 September 2020, https://ios.icswb.com/h/149/20200901/674184.html

[1037] "A study of unsteady combustion oscillations in supersonic gas flows" [超声速气流中的非稳态燃烧振荡研究], *State Key Laboratory of High-Temperature Gas Dynamics*, 17 August 2016, http://lhd.imech.cas.cn/xshd/201609/t20160921_348787.html

[1038] "Zheng Riheng" [郑日恒], *X-mol*, Accessed February 2024, https://www.x-mol.com/university/faculty/374087

[1039] Shen Chibing [沈赤兵], "Nonlinear static and response characteristics of liquid rocket motors" [液体火箭发动机非线性静特性与响应特性], *Scientific Press* [科学出版社], January 2019, http://www.yuntaigo.com/book.action?recordid=a2JoZm9rYWM2NjY=

[1040] "Visualizing the surge phenomenon" [可视化激波现象], *30th National Book Expo Purchasing Platform*, 23 March 2023, http://gph.sbhjn.com/bookshow.asp?id=2531219
[1041] "Notice on Organizing the 2018 Annual Academic Conference of Air and Space Power Composites and Applications Specialized Committee of Chinese Composites Society" [关于举办中国复合材料学会空天动力复合材料及应用专业委员会 2018 年度学术会议的通知], *Chinese Society for Composite Materials*, 14 May 2018, http://www.csfcm.org.cn/site/content/1247.html
[1042] "Call for Papers for the First China Air and Space Propulsion Technology Forum" [首届中国空天推进技术论坛征文通知], *Sohu*, 4 April 2018, https://www.sohu.com/a/227212261_607269
[1043] "Zhejiang University College of Aeronautics and Astronautics Successfully Hosted the 18th National Hypersonic Aerodynamic/Thermal Symposium" [浙江大学航空航天学院成功承办第十八届全国高超声速气动力/热学术交流会], *Zhejiang University School of Aeronautics and Astronautics*, 9 December 2016, http://saa.zju.edu.cn/2016/1209/c67630a2615357/page.htm
[1044] "The 17th Chinese Symposium on Aerodynamics and Physical Gas Dynamics" [第十七届中国空气动力学物理气体动力学学术交流研讨会], *Beijing Institute of Applied Physics and Computational Mathematics* [北京应用物理与计算数学研究所], 28 August 2015, http://www.iapcm.ac.cn/cbscicomp2019/29-0
[1045] "2nd International Symposium on Thermal and Fluid Dynamics Successfully Held in Beijing" [实验室第二届热与流体动力学国际研讨会在北京成功举办], *State Key Laboratory of Multiphase Flow in Power Engineering*, 9 August 2021, http://mfpe.xjtu.edu.cn/info/1079/6691.htm
[1046] "The 9th Asian Joint Conference on Propulsion and Power (AJCPP 2018) was successfully held in Xiamen" [第九届亚洲推进与动力联合会议（AJCPP 2018）在厦门顺利召开], *Xiamen University*, 18 March 2018, http://webcache.googleusercontent.com/search?client=firefox-b-1-d&q=cache%3Ay05tc.cclfjc.com%2Finfo%2F1015%2F1107.htm
[1047] "National Key Laboratory of Inertial Technology" [惯性技术国家级重点实验室], *Beihang School of Instrumentation and Optoelectric Engineering* [北京航空航天大学仪器科学与光电工程学院], 26 June 2012. https://web.archive.org/web/20190521030532/http://yqgdxy.buaa.edu.cn/content.jsp?urltype=news.NewsContentUrl&wbtreeid=1089&wbnewsid=1824
"The School of Instrument Science and opto-electronic Engineering organized the 2011 Top Ten News Selection" [仪器科学与光电工程学院组织 2011 年度学院十大新闻评选], *Beihang School of Instrumentation and Optoelectric Engineering* [北京航空航天大学仪器科学与光电工程学院], 16 January 2012. https://yqgdxy.buaa.edu.cn/content.jsp?urltype=news.NewsContentUrl&wbtreeid=1026&wbnewsid=2683
[1048] "'"China Education News" published Professor Fang Jiancheng's speech at the "Chinese Dream" symposium: Carrying dreams, loyalty and cultivating people, and being an excellent gardener in the new era" [《中国教育报》刊载房建成教授在"中国梦"座谈会上的发言：怀揣梦想、立德树人，做新时期的优秀园丁], *Beihang School of Instrumentation and Optoelectric Engineering* [北京航空航天大学仪器科学与光电工程学院], 28 March 2013. https://yqgdxy.buaa.edu.cn/content.jsp?urltype=news.NewsContentUrl&wbtreeid=1026&wbnewsid=2627;
"Beihang has a kind of eternal "gyro spirit"-the relentless pursuit of the "gyro dream" of three generations of Beihang people" [北航有一种永恒的"陀螺精神" ——记三代北航人"陀螺梦"的不懈追求], Beihang School of Instrumentation and Optoelectric Engineering [北京航空航天大学仪器科学与光电工程学院], 13 October 2015. https://yqgdxy.buaa.edu.cn/content.jsp?urltype=news.NewsContentUrl&wbtreeid=1026&wbnewsid=2543
"[Reproduced] Speech by alumni room built at the symposium on learning Qian Xuesen's advanced deeds in the education system" [［转载］校友房建成在教育系统学习钱学森先进事迹座谈会上的发言], General Alumni Association of Southeast University [东南大学校友总会], 8 December 2011. https://seuaa.seu.edu.cn/2011/1208/c1657a21162/page.htm
[1049] "Supplement No. 4 to Part 744 -ENTITY LIST," *Bureau of Industry and Security*, 8 April 2021. https://www.bis.doc.gov/index.php/documents/regulations-docs/2326-supplement-no-4-to-part-744-entity-list-4/file;
"Introduction to Institution" [院校简介], China Postgraduate Admissions Information Network [国研究生招生信息网], accessed April 2021. https://yz.chsi.com.cn/sch/schoolInfo--schId-367814,categoryId-483322.dhtml
[1050] "Public announcement of bidding results of supervision service procurement for Beihang University Shahe Phase III National Defense Key Laboratory of Inertial Technology, Beijing University of Aeronautics and Astronautics" [北京航空航天大学前沿科学技术创新研究院北京航空航天大学沙河三期惯性技术国防重点实

验室建设项目监理服务采购竞价结果公示], *Beijing University of Aeronautics and Astronautics Bidding and Purchasing Management Center* [北京航空航天大学招标采购管理中心], 5 January 2021. https://web.archive.org/web/20210418010819/https://zbcg.buaa.edu.cn/info/1151/18302.htm

[1051] See the following sources:

1. "Institution = Key Laboratory of Inertial Technology, Beijing University of Aeronautics and Astronautics" ["机构=北京航空航天大学惯性技术重点实验室"], *Guangdong Scholarship Service Platform* [广东文献共享服务平台], accessed June 2021. http://www.gdstl.net/articles/articlesearch.aspx?invokemethod=search&q=%7b%22sType%22%3a%220%22%2c%22customRules%22%3a%22(organ_text%3a%5c%22%e5%8c%97%e4%ba%ac%e8%88%aa%e7%a9%ba%e8%88%aa%e5%a4%a9%e5%a4%a7%e5%ad%a6%e6%83%af%e6%80%a7%e6%8a%80%e6%9c%af%e9%87%8d%e7%82%b9%e5%ae%9e%e9%aa%8c%e5%ae%a4%5c%22%7e2%20OR%20showorgan%3a%5c%22%e5%8c%97%e4%ba%ac%e8%88%aa%e7%a9%ba%e8%88%aa%e5%a4%a9%e5%a4%a7%e5%ad%a6%e6%83%af%e6%80%a7%e6%8a%80%e6%9c%af%e9%87%8d%e7%82%b9%e5%ae%9e%e9%aa%8c%e5%ae%a4%5c%22%7e2%20OR%20organ_e%3a%5c%22%e5%8c%97%e4%ba%ac%e8%88%aa%e7%a9%ba%e8%88%aa%e5%a4%a9%e5%a4%a7%e5%ad%a6%e6%83%af%e6%80%a7%e6%8a%80%e6%9c%af%e9%87%8d%e7%82%b9%e5%ae%9e%e9%aa%8c%e5%ae%a4%5c%22%7e2)%22%2c%22customShowCondition%22%3a%22%e6%9c%ba%e6%9e%84%3d%e5%8c%97%e4%ba%ac%e8%88%aa%e7%a9%ba%e8%88%aa%e5%a4%a9%e5%a4%a7%e5%ad%a6%e6%83%af%e6%80%a7%e6%8a%80%e6%9c%af%e9%87%8d%e7%82%b9%e5%ae%9e%e9%aa%8c%e5%ae%a4%22%2c%22ajaxKeys%22%3a%22%e5%8c%97%e4%ba%ac%e8%88%aa%e7%a9%ba%e8%88%aa%e5%a4%a9%e5%a4%a7%e5%ad%a6%e6%83%af%e6%80%a7%e6%8a%80%e6%9c%af%e9%87%8d%e7%82%b9%e5%ae%9e%e9%aa%8c%e5%ae%a4%22%2c%22clusterFilter%22%3a%22%22%7d&;
2. "Inertial Technology" "Key Laboratory"" ["惯性技术" "重点实验室"], *Baidu Academic* [百度学术], accessed June 2021. https://archive.ph/sNHaE;
3. "Search: The institution = the Key Laboratory of Inertial Technology, Beijing University of Aeronautics and Astronautics" [查找： 机构=北京航空航天大学惯性技术重点实验室], accessed June 2021.

[1052] "National Key Laboratory of Inertial Technology" [惯性技术国家级重点实验室], *Beihang School of Instrumentation and Optoelectric Engineering* [北京航空航天大学仪器科学与光电工程学院], 26 June 2012. https://web.archive.org/web/20190521030532/http://yqgdxy.buaa.edu.cn/content.jsp?urltype=news.NewsContentUrl&wbtreeid=1089&wbnewsid=1824

[1053] "National Key Laboratory of Inertial Technology" [惯性技术国家级重点实验室], *Beihang School of Instrumentation and Optoelectric Engineering* [北京航空航天大学仪器科学与光电工程学院], 26 June 2012. https://web.archive.org/web/20190521030532/http://yqgdxy.buaa.edu.cn/content.jsp?urltype=news.NewsContentUrl&wbtreeid=1089&wbnewsid

[1054] "National Key Laboratory of Inertial Technology" [惯性技术国家级重点实验室], *Beihang School of Instrumentation and Optoelectric Engineering* [北京航空航天大学仪器科学与光电工程学院], 26 June 2012. https://web.archive.org/web/20190521030532/http://yqgdxy.buaa.edu.cn/content.jsp?urltype=news.NewsContentUrl&wbtreeid=1089&wbnewsid

[1055] "The National Key Laboratory of Inertial Technology held the third meeting of the first academic committee" [惯性技术国家级重点实验室召开第一届学术委员会第三次会议], *Beihang School of Instrumentation and Optoelectric Engineering* [北京航空航天大学仪器科学与光电工程学院], 28 November 2013. https://yqgdxy.buaa.edu.cn/content.jsp?urltype=news.NewsContentUrl&wbtreeid=1026&wbnewsid=2659

[1056] "The National Key Laboratory of Inertial Technology held the third meeting of the first academic committee" [惯性技术国家级重点实验室召开第一届学术委员会第三次会议], *Beihang School of Instrumentation and Optoelectric Engineering* [北京航空航天大学仪器科学与光电工程学院], 28 November 2013. https://yqgdxy.buaa.edu.cn/content.jsp?urltype=news.NewsContentUrl&wbtreeid=1026&wbnewsid=2659

[1057] "[Reproduced] Speech by alumni room built at the symposium on learning Qian Xuesen's advanced deeds in the education system" [［转载］校友房建成在教育系统学习钱学森先进事迹座谈会上的发言], *General Alumni*

*Association of Southeast University* [东南大学校友总会], 8 December 2011. https://seuaa.seu.edu.cn/2011/1208/c1657a21162/page.htm

[1058] "Fang Jiancheng" [房建成], *Beihang Institute of Precision Mechanics and Quantum Sensing* [北京航空航天大学精密仪器与量子传感研究院], 18 September 2019. https://piqs.buaa.edu.cn/info/1032/1036.htm

[1059] "Control Institute of the Eighth Academy of Aerospace to build a key laboratory of inertial technology" [航天八院控制所打造惯性技术重点实验室], *China Space News* [中国航天报], 11 February 2015. http://www.spacechina.com/n25/n2014789/n2014809/c848495/content.html

[1060] "2019 Recruitment Guide of Nanjing Shenwei opto-electronic Technology Research Institute Co., Ltd." [南京申威光电技术研究院有限公司 2019 年招聘简章], N*anjing Economic and Technological Development Zone Management Committee* [京经济技术开发区管委会], 8 October 2019. http://jjkfq.nanjing.gov.cn/tzgg/201910/t20191008_1671227.html

[1061] "Aviation Gyro (Beijing) Photoelectricity Technology Co., Ltd" [中航捷锐（北京）光电技术有限公司], *Aviation Gyro (Beijing) Photoelectricity Technology Co., Ltd* [中航捷锐（北京）光电技术有限公司], 20 December 2017. http://www.avic-gyro.com/Portal.do?method=detailView&returnChannelID=22&contentID=3

[1062] "Fang Jiancheng" [房建成], *Beihang Institute of Precision Mechanics and Quantum Sensing* [北京航空航天大学精密仪器与量子传感研究院], 18 September 2019. https://piqs.buaa.edu.cn/info/1032/1036.htm

[1063] "National Key Laboratory of Inertial Technology" [惯性技术国家级重点实验室], *Beihang School of Instrumentation and Optoelectric Engineering* [北京航空航天大学仪器科学与光电工程学院], 26 June 2012. https://web.archive.org/web/20190521030532/http://yqgdxy.buaa.edu.cn/content.jsp?urltype=news.NewsContentUrl&wbtreeid=1089&wbnewsid=1824

[1064] "Exploring the Mystery of Military Systems Engineering Research - Introduction to the Institute for Systems Engineering Research" [探寻军事系统工程科研的奥秘 - 系统工程研究院简介], *China Graduate Student Recruitment Information Network* [中国研究生招生信息网], AccessedOctober 2023, https://yz.chsi.com.cn/news/file.do?method=downFile&id=2106965907&attach=true&hist=false.

[1065] "Exploring the Mystery of Military Systems Engineering Research - Introduction to the Institute for Systems Engineering Research" [探寻军事系统工程科研的奥秘 - 系统工程研究院简介], *China Graduate Student Recruitment Information Network* [中国研究生招生信息网], AccessedOctober 2023, https://yz.chsi.com.cn/news/file.do?method=downFile&id=2106965907&attach=true&hist=false.
Kuang Xiaohui [况晓辉] et al., "MultilayerTopology Structural Vulnerability Analysis Algorithm for Large-scale Distributed System" [一种基于多层拓扑的大规模分布式系统 结构脆弱性分析算法], Computer Science [计算机科学], August 2016 43(8), https://www.jsjkx.com/EN/article/openArticlePDF.jsp?id=15841

[1066] Deng Huan [邓欢] et al., *Journal of Cyber Security* [信息安全学报], 15 March 2023, http://jcs.iie.ac.cn/xxaqxb/ch/reader/view_abstract.aspx?flag=2&file_no=202303150000002&journal_id=xxaqxb

[1067] Zhao Haotao [赵海涛], "Evaluation method for autonomous communication and networking capability of UAV" [无人机自主通信和组网能力评估方法], *Journal on Communications* [通信学报], 2020 41(8), https://www.infocomm-journal.com/txxb/CN/10.11959/j.issn.1000-436x.2020143

[1068] "Survey on software vulnerability analysis based on machine learning" [基于机器学习的软件脆弱性分析方法综述], *Computer Engineering & Science* [计算机工程与科学], 2018 11, https://lib.cqvip.com/Qikan/Article/Detail?id=676741060&from=Qikan_Article_Detail

[1069] Zhuang Honglin [庄洪林] et al., "Construction of Strategic Early-Warning System in Cyberspace" [网络空间战略预警体系的建设思考], *China Engineering Science* [中国工程科学], 2021 23(2), https://journal.hep.com.cn/sscae/EN/article/downloadArticleFile.do?attachType=PDF&id=29703

[1070] Zhao Haotao [赵海涛], "Evaluation method for autonomous communication and networking capability of UAV" [无人机自主通信和组网能力评估方法], *Journal on Communications* [通信学报], 2020 41(8), https://www.infocomm-journal.com/txxb/CN/10.11959/j.issn.1000-436x.2020143

[1071] Chen Jinyin [陈晋音] et al., "Membership inference attacks against transfer learning for generalized model" [面向正常拟合迁移学习模型的成员推理攻击], *Journal on Communications* [通信学报], 2021 42(10), https://www.infocomm-journal.com/txxb/CN/10.11959/j.issn.1000-436x.2021209

[1072] "The First Command and Control Network Security Conference was successfully held in Hangzhou" [第一届指挥控制网络安全大会在杭州成功召开], *SECRSS* [安全内参], 9 November 2020, https://www.secrss.com/articles/26964
[1073] "Good Opportunity for Private Enterprises to Participate in the Military, Free Exhibition of Outstanding Products |"Vertical and Horizontal" Cyberspace Security Innovation Forum and Exhibition Conference will be opened soon!" [民企参军好机会，优秀产品免费展 |"纵横"网络空间安全创新论坛暨展览大会即将开幕!], *Antpedia*, 1 April 2019, https://ibook.antpedia.com/x/299630.html
[1074] Kang Zhongtao [康忠涛] et al., "Linear stability analysis of conical liquid film with coaxial annular gas flow" [同轴环缝气流作用下锥形液膜线性稳定性分析], *Journal of National University of Defense Technology* [国防科技大学学报], 2019 2, http://journal.nudt.edu.cn/wap/ch/reader/view_abstract.aspx?file_no=201902003&flag=1
[1075] "RHG Tournament Platform Lands on "Zongheng Cup" Artificial Intelligence Automated Attack and Defense Exercises or Becomes the Industry Normal" [RHG 赛事平台落地"纵横杯" 人工智能自动化攻防演练或成行业常态], *163.com*, 30 March 2021, https://www.163.com/dy/article/G6BOH3NE0531NODR.html
[1076] "IEEE DSC 2022 | Meeting the New Challenges of Cyberspace Data Security," *Chinese Information Processing Society of China*, 19 July 2022, http://www.cipsc.org.cn/pic_content.php?&xuhao=20220719
[1077] "The 6th International Conference on Cyberspace Data Science, organized by Pengcheng Lab, was held in Shenzhen" [鹏城实验室承办的第六届国际网络空间数据科学大会在深举行], *Pencheng Laboratory*, 14 October 2021, https://www.pcl.ac.cn/html/944/2021-10-14/content-3870.html
[1078] "Dr. Rui Zhang was invited to give a keynote speech at ICINS 2014" [张锐研究员应邀参加 ICINS 2014 国际会议并作主旨讲演], *State Key Laboratory of Information Security*, 15 November 2014, http://www.sklois.cn/xwdt/sysxw/201411/t20141129_270498.html
[1079] "Full Updated Agenda Announced for the 2024 First National Conference on Big Models and Decision Intelligence" [2024 首届全国大模型与决策智能大会最新全部议程公布], *National University of Defene Technology*, 19 July 2024, https://www.nudt.edu.cn/xwgg/tzgg/d87509632b724f7db284fd9359564ec4.htm (same director as prior lab)
[1080] "Prof. Liu Zhong of National University of Defense Technology: "Leader" in the field of C2 systems" [国防科技大学教授刘忠：指控系统领域的"排头兵"], *China News*, 28 December 2015, https://www.chinanews.com.cn/m/mil/2015/12-28/7691788.shtml
[1081] "Key Lab of Information Systems Engineering" [信息系统工程重点实验室], *Baidu Baike*, Accessed February 2024, https://baike.baidu.com/item/%E4%BF%A1%E6%81%AF%E7%B3%BB%E7%BB%9F%E5%B7%A5%E7%A8%8B%E9%87%8D%E7%82%B9%E5%AE%9E%E9%AA%8C%E5%AE%A4/3455150#reference-1
[1082] "Prof. Liu Zhong of National University of Defense Technology: "Leader" in the field of C2 systems" [国防科技大学教授刘忠：指控系统领域的"排头兵"], *China News*, 28 December 2015, https://www.chinanews.com.cn/m/mil/2015/12-28/7691788.shtml
[1083] "Key Lab of Information Systems Engineering" [信息系统工程重点实验室], *Baidu Baike*, Accessed February 2024, https://baike.baidu.com/item/%E4%BF%A1%E6%81%AF%E7%B3%BB%E7%BB%9F%E5%B7%A5%E7%A8%8B%E9%87%8D%E7%82%B9%E5%AE%9E%E9%AA%8C%E5%AE%A4/3455150#reference-1
[1084] "Prof. Liu Zhong of National University of Defense Technology: "Leader" in the field of C2 systems" [国防科技大学教授刘忠：指控系统领域的"排头兵"], *China News*, 28 December 2015, https://www.chinanews.com.cn/m/mil/2015/12-28/7691788.shtml
[1085] "Guidelines for Stabilization Support Items Open to the Public in State Key Laboratory of Information System Engineering " [信息系统工程国家级重点实验室稳定支持项对外开放课题指南], *Weixin*, 13 July 2023, https://mp.weixin.qq.com/s/jiuFyJK6aDjwi
[1086] "Prof. Liu Zhong of National University of Defense Technology: "Leader" in the field of C2 systems" [国防科技大学教授刘忠：指控系统领域的"排头兵"], *China News*, 28 December 2015, https://www.chinanews.com.cn/m/mil/2015/12-28/7691788.shtml
"Giving intelligent wings to the army tent" [为"中军帐"插上智能化翅膀], *Xinhua*, 18 January 2016, http://www.xinhuanet.com/politics/2016-01/18/c_128640726.htm

"Help the wisdom of the "war skull" thunder - Professor Liu Zhong, Chief Engineer of the College of Information Systems and Management, National University of Defense Technology" [助智“战颅”起惊霆——记国防科技大学信息系统与管理学院总工程师刘忠教授], *China Daily*, 29 December 2015, http://china.chinadaily.com.cn/2015-12/29/content_22850844.htm

[1087] Wang Zhiqiang [王志强] et al., "Brief analysis of the approach for military information system integration" [军事信息系统集成途径浅析], *Journal of Anhui University (Natural Sciences)* [安徽大学学报(自然科学版)], 2009, 33(5), https://www.alljournals.cn/view_abstract.aspx?pcid=01BA20E8BA813E1908F3698710BBFEFEE816345F465FEBA5&cid=96E6E851B5104576C2DD9FC1FBCB69EF&jid=BEDC21901A7FF33D05045952074DFAA4&aid=349E6C6314CE463698520BFAA201E0E1&yid=DE12191FBD62783C&vid=&iid=&sid=&eid=&from_absract=1

[1088] "Research on ontology-based CADM modeling approach" [基于本体的 CADM 建模方法研究], *Fire Control and Command Control* [火力与指挥控制], 2007, 32(10), https://d.wanfangdata.com.cn/periodical/hlyzhkz200710019

[1089] "Additions and Revisions to the Entity List and Conforming Removal From the Unverified List," *Federal Register*, 19 December 2022, https://www.federalregister.gov/documents/2022/12/19/2022-27151/additions-and-revisions-to-the-entity-list-and-conforming-removal-from-the-unverified-list

[1090] "The 10th C4ISR Technical Forum was held in our university" [第十届 C4ISR 技术论坛在我校召开], *Sun Yat-sen University*, 10 November 2020, https://www.sysu.edu.cn/news/info/2161/503741.htm

[1091] "Prof. Liu Zhong of National University of Defense Technology: "Leader" in the field of C2 systems" [国防科技大学教授刘忠：指控系统领域的"排头兵"], *China News*, 28 December 2015, https://www.chinanews.com.cn/m/mil/2015/12-28/7691788.shtml

"Dispelling the "fog" of modern warfare, he constructed the "strongest brain" for winning" [驱散现代战争“迷雾”，他为打赢制胜构造“最强大脑”], *National University of Defense Technology*, 25 November 2021, https://42.48.27.41/zjkd/kdgs/7d5cde7a6f624b0d99e13468cf340923.htm

[1092] "Giving intelligent wings to the army tent" [为“中军帐”插上智能化翅膀], *Xinhua*, 18 January 2016, http://www.xinhuanet.com/politics/2016-01/18/c_128640726.htm

"Help the wisdom of the "war skull" thunder - Professor Liu Zhong, Chief Engineer of the College of Information Systems and Management, National University of Defense Technology" [助智“战颅”起惊霆——记国防科技大学信息系统与管理学院总工程师刘忠教授], *China Daily*, 29 December 2015, http://china.chinadaily.com.cn/2015-12/29/content_22850844.htm

[1093] "Dispelling the "fog" of modern warfare, he constructed the "strongest brain" for winning" [驱散现代战争“迷雾”，他为打赢制胜构造“最强大脑”], *National University of Defense Technology*, 25 November 2021, https://42.48.27.41/zjkd/kdgs/7d5cde7a6f624b0d99e13468cf340923.htm

[1094] "Edge Combat and Edge Command and Control--Interview with Zhang Weiming, Director of Key Laboratory of Information System Engineering, National University of Defense Technology" [边缘作战与边缘指挥控制——访国防科技大学信息系统工程重点实验室主任张维明], *Sohu*, 3 July 2022, https://www.sohu.com/a/563396126_358040

[1095] "Introduction to CASIC 4th Academy 17th Research Institute" [中国航天科工集团第四研究院十七所招聘简介], *Xidian University*, 21 February 2014, https://see.xidian.edu.cn/html/news/6503.html

[1096] "September 27, 2016, Electronics Institute hosts CETC 28th RI presentation" [2016 年 9 月 27 日电院承办中电 28 所宣讲会], *Shanghai Jiao Tong University*, 26 September 2016, https://kyb.seiee.sjtu.edu.cn/xsb/detail/2494_676.htm?nocache=1

[1097] See, for example, Yi Kan [易侃], "Highlights of the Conference丨C4ISR Theory and Technology Summit Forum was successfully held in Beijing" [大会精彩回顾丨C4ISR 理论与技术高峰论坛在京成功召开], *Sohu*, 8 July 2021, https://www.sohu.com/a/476335007_358040

[1098] "National University of Defense Technology College of Information System and Management Recruitment Announcement for PhD and Postdoctoral Recruitment in October 2016" [国防科学技术大学信息系统与管理学院 2016 年 10 月招聘博士、博士后公告], *51Boshi*, 8 October 2016, http://www.51boshi.net/News/4920161089436.html

[1099] "Joint Academic Seminar of Research Center for E-Commerce and Information Management and Research Center for Management Decision and Optimization Successfully Held" [电子商务与信息管理研究中心、管理决策与优化研究中心联合学术研讨会顺利举行], *Central South University*, 28 December 2021, https://bs.csu.edu.cn/info/1046/13412.htm
[1100] "Research on the service-oriented system of C2 system for networked joint warfighting" [网络化联合作战的指控系统服务化体系研究], *Tai Xueshu*, 8 June 2021, https://doc.taixueshu.com/conference/20130047zho_60160.html
[1101] "National University of Defense Technology College of Information System and Management Recruitment Announcement for PhD and Postdoctoral Recruitment in October 2016" [国防科学技术大学信息系统与管理学院2016年10月招聘博士、博士后公告], *51Boshi*, 8 October 2016, http://www.51boshi.net/News/4920161089436.html
[1102] Hou Lulin [侯绿林] et al., "Recent progress in controllability of complex network" [复杂网络可控性研究现状综述], *Acta Physica Sinica* [物理学报], 2015 64(18), https://wulixb.iphy.ac.cn/article/doi/10.7498/aps.64.188901
[1103] Lei Hongtao [雷洪涛] et al., "Key Technologies of Planning and Control for Cross-domain Coordination on Joint Operational Actions" [联合作战行动跨域协同计划与控制关键技术], *Journal of Command and Control*, August 2023 9(4), https://www.jc2.org.cn/CN/article/downloadArticleFile.do?attachType=PDF&id=551
[1104] "Research on the service-oriented system of C2 system for networked joint warfighting" [网络化联合作战的指控系统服务化体系研究], *Tai Xueshu*, 8 June 2021, https://doc.taixueshu.com/conference/20130047zho_60160.html
[1105] Shu Zhen [舒振], "Military information system architecture design method and application analysis" [军事信息系统体系结构设计方法及其应用分析], *Science & Technology Review* [科技导报], 2018 36(20), http://www.kjdb.org/CN/abstract/abstract15045.shtml
[1106] Liu Gang [刘刚], "Research on the design method of satellite information application chain centered on information flow" [以信息流为中心的卫星信息应用链设计方法研究], *Equipment Academy Journal* [装备学院学报], 2014 3, http://222.29.81.175/246010/detail/article/57715b24ede4fe1a6cd24ab8.html?org=246010&uorg=246010&q=%E4%BF%A1%E6%81%AF%E6%96%B9%E6%B3%95)
[1107] Liu Gang [刘钢], "Constraint-guided genetic algorithm for anti-ship missile route planning" [约束引导的反舰导弹航路规划遗传算法], *Journal of Ballistics*, 2012 4, https://d.wanfangdata.com.cn/periodical/ChlQZXJpb2RpY2FsQ0hJTmV3UzIwMjMwNDI2Eg1kZHhiMjAxMjA0MDAzGgh6Z2gxcHk0bg%253D%253D
[1108] Wang Zhiqiang [王志强] et al., "Brief analysis of the approach for military information system integration" [军事信息系统集成途径浅析], *Journal of Anhui University (Natural Sciences)* [安徽大学学报(自然科学版)], 2009, 33(5), https://www.alljournals.cn/view_abstract.aspx?pcid=01BA20E8BA813E1908F3698710BBFEFEE816345F465FEBA5&cid=96E6E851B5104576C2DD9FC1FBCB69EF&jid=BEDC21901A7FF33D05045952074DFAA4&aid=349E6C6314CE463698520BFAA201E0E1
[1109] "Research on ontology-based CADM modeling approach" [基于本体的CADM建模方法研究], *Fire Control and Command Control* [火力与指挥控制], 2007, 32(10), https://d.wanfangdata.com.cn/periodical/hlyzhkz200710019
[1110] "Guidelines for Stabilization Support Items Open to the Public in State Key Laboratory of Information System Engineering " [信息系统工程国家级重点实验室稳定支持项对外开放课题指南], *Weixin*, 13 July 2023, https://mp.weixin.qq.com/s/jiuFyJK6aDjwi
[1111] "Prof. Liu Zhong of National University of Defense Technology: "Leader" in the field of C2 systems" [国防科技大学教授刘忠：指控系统领域的"排头兵"], *China News*, 28 December 2015, https://www.chinanews.com.cn/m/mil/2015/12-28/7691788.shtml
[1112] "CASC 17th RI independently researched and developed digital intelligent security command system" [航天17所自主研发数字化智能安防指挥系统], *EEWorld*, 17 August 2009, https://news.eeworld.com.cn/afdz/2009/0817/article_1816.html?ipcity__1865=n4%2BhDKAKiK7IPCw40yObGd4DvWqxpDmwBpD

[1113] "Dispelling the "fog" of modern warfare, he constructed the "strongest brain" for winning" [驱散现代战争“迷雾”，他为打赢制胜构造“最强大脑”], *National University of Defense Technology*, 25 November 2021, https://42.48.27.41/zjkd/kdgs/7d5cde7a6f624b0d99e13468cf340923.htm
"Introduction of Instructor Faculty, College of Systems Engineering, National University of Defense Technology-Zhang Weiming" [国防科技大学系统工程学院导师教师师资介绍简介-张维明], *Free Kaoyan*, 21 August 2021, http://school.freekaoyan.com/hn/nudt/daoshi/2021/08-21/16295432811517617.shtml
"Edge Combat and Edge Command and Control--Interview with Zhang Weiming, Director of Key Laboratory of Information System Engineering, National University of Defense Technology" [边缘作战与边缘指挥控制——访国防科技大学信息系统工程重点实验室主任张维明], *Sohu*, 3 July 2022, https://www.sohu.com/a/563396126_358040
[1114] "Distributed Intelligent Command and Control Technology" [分布式智能指挥控制技术], *China Command and Control Society* [指挥与控制学报], 25 August 2023, https://www.jc2.org.cn/CN/article/downloadArticleFile.do?attachType=PDF&id=550
"2023 6th IEEE International Unmanned Systems Conference" [2023 第六届 IEEE 国际无人系统大会], *International Conference on Unmanned Systems*, 2023, https://icus.c2.org.cn/uploads/admin/202306292481/649cf5a3b7236.pdf
[1115] "Distributed Intelligent Command and Control Technology" [分布式智能指挥控制技术], *China Command and Control Society* [指挥与控制学报], 25 August 2023, https://www.jc2.org.cn/CN/article/downloadArticleFile.do?attachType=PDF&id=550
[1116] “Joint Academic Seminar of Research Center for E-Commerce and Information Management and Research Center for Management Decision and Optimization Successfully Held” [电子商务与信息管理研究中心、管理决策与优化研究中心联合学术研讨会顺利举行], *Central South University*, 28 December 2021, https://bs.csu.edu.cn/info/1046/13412.htm
[1117] "Assistant Principal Luo Zhonghyun led a visit to the 28th Research Institute of China Electronics Technology Group Corp." [校长助理罗钟铉带队走访中国电子科技集团公司第二十八研究所], *Dalian University of Technology*, 27 February 2017, https://news.dlut.edu.cn/info/1011/32249.htm
[1118] "Group News | Innovation breakthrough, they are very confident in the key laboratory" [集团动态 | 创新突破，身在重点实验室的他们很有信心], *Sohu*, 15 August 2019, https://www.sohu.com/a/333996317_779538
[1119] "Information Forum: Theoretical Social Sciences" [信息讲坛:理论社会科学], *Renmin University*, 11 December 2011, http://info.ruc.edu.cn/jsky/xsky/jzxx/fe59318ab2ca4ee3b93af8fee26481ca.htm
[1120] “Joint Academic Seminar of Research Center for E-Commerce and Information Management and Research Center for Management Decision and Optimization Successfully Held” [电子商务与信息管理研究中心、管理决策与优化研究中心联合学术研讨会顺利举行], *Central South University*, 28 December 2021, https://bs.csu.edu.cn/info/1046/13412.htm
[1121] "2023 6th IEEE International Unmanned Systems Conference" [2023 第六届 IEEE 国际无人系统大会], *International Conference on Unmanned Systems*, 2023, https://icus.c2.org.cn/uploads/admin/202306292481/649cf5a3b7236.pdf
[1122] "2023 6th IEEE International Unmanned Systems Conference" [2023 第六届 IEEE 国际无人系统大会], *International Conference on Unmanned Systems*, 2023, https://icus.c2.org.cn/uploads/admin/202306292481/649cf5a3b7236.pdf
[1123] "Beijing Forsun Boyuan Technology Co." [北京峰盛博远科技有限公司], *Baidu Baike*, Accessed July 2024, https://baike.baidu.com/item/%E5%8C%97%E4%BA%AC%E5%B3%B0%E7%9B%9B%E5%8D%9A%E8%BF%9C%E7%A7%91%E6%8A%80%E6%9C%89%E9%99%90%E5%85%AC%E5%8F%B8/2818400
[1124] Yan Kedong [颜克冬] et al., "Key Models and Technologies in Credibility Analysis of Open Source Intelligence System" [开源情报可信分析系统的关键模型与技术], *Command Information System and Technology* [指挥信息系统与技术], 2023 01, http://cnki.sdll.cn:85/KCMS/detail/detail.aspx?filename=ZHXT202301009&dbcode=CJFD&dbname=CJFD2023
Liu Gang [刘刚], “Research on the design method of satellite information application chain centered on information flow” [以信息流为中心的卫星信息应用链设计方法研究], *Equipment Academy Journal* [装备学院学报], 2014 3,

http://222.29.81.175/246010/detail/article/57715b24ede4fe1a6cd24ab8.html?org=246010&uorg=246010&q=%E4%BF%A1%E6%81%AF%E6%96%B9%E6%B3%95)

[1125] Yan Kedong [颜克冬] et al., "Key Models and Technologies in Credibility Analysis of Open Source Intelligence System" [开源情报可信分析系统的关键模型与技术], *Command Information System and Technology* [指挥信息系统与技术], 2023 01, http://cnki.sdll.cn:85/KCMS/detail/detail.aspx?filename=ZHXT202301009&dbcode=CJFD&dbname=CJFD2023

[1126] Liu Gang [刘刚], "Research on the design method of satellite information application chain centered on information flow" [以信息流为中心的卫星信息应用链设计方法研究], *Equipment Academy Journal* [装备学院学报], 2014 3, http://222.29.81.175/246010/detail/article/57715b24ede4fe1a6cd24ab8.html?org=246010&uorg=246010&q=%E4%BF%A1%E6%81%AF%E6%96%B9%E6%B3%95)

16. "Guidelines for Stabilization Support Items Open to the Public in State Key Laboratory

[1127] William C. Hannas, Huey-Meei Chang, "Chinese Power and Artificial Intelligence: Perspectives and Challenges," *Routledge*, 2023, hhttps://books.google.com/books?id=bKh2EAAAQBAJ&pg=PT235&lpg=PT235&dq=%22%E4%BF%A1%E6%81%AF%E7%B3%BB%E7%BB%9F%E5%B7%A5%E7%A8%8B%E9%87%8D%E7%82%B9%E5%AE%9E%E9%AA%8C%E5%AE%A4%22&source=bl&ots=iu4CZ66uS7&sig=ACfU3U2wxsepVb5m4kCdUaH5V8w8LHEFuA&hl=en&sa=X&ved=2ahUKEwjBvpe9zbyEAxUvKFkFHZSKA1w4bhDoAXoECAMQAw#v=onepage&q=%22%E4%BF%A1%E6%81%AF%E7%B3%BB%E7%BB%9F%E5%B7%A5%E7%A8%8B%E9%87%8D%E7%82%B9%E5%AE%9E%E9%AA%8C%E5%AE%A4%22&f=false

[1128] "720,000 RMB research grant support! 2022 National Big Data and Computational Intelligence Challenge goes live!" [72 万研究经费支持！2022 全国大数据与计算智能挑战赛上线！], *Data Fountain*, 10 June 2022, https://hub.baai.ac.cn/view/17855

[1129] "Highlights of the Conference丨C4ISR Theory and Technology Summit Successfully Held" [大会精彩回顾丨C4ISR 理论与技术高峰论坛成功举办], *Xuehua*, 31 July 2019, https://www.xuehua.us/a/5ebafa1286ec4d48b7d01f24

[1130] "The 10th C4ISR Technical Forum was held in our university" [第十届 C4ISR 技术论坛在我校召开], *Sun Yat-sen University*, 10 November 2020, https://www.sysu.edu.cn/news/info/2161/503741.htm

[1131] "C4ISR Theory and Technology Forum Successfully Held in Beijing" [C4ISR 理论与技术论坛在京成功召开], *Sohu*, 27 October 2023, https://www.sohu.com/a/731944997_358040

[1132] "Conference Introduction" [大会简介], *Huiyi Guanjia*, April 2023, http://baoming.huiyiguanjia.com/Enroll/index?mid=4783329978099195819&language=&source=56535

[1133] "2023 6th IEEE International Unmanned Systems Conference" [2023 第六届 IEEE 国际无人系统大会], *International Conference on Unmanned Systems*, 2023, https://icus.c2.org.cn/uploads/admin/202306292481/649cf5a3b7236.pdf

[1134] Hou Lulin [侯绿林] et al., "Recent progress in controllability of complex network" [复杂网络可控性研究现状综述], *Acta Physica Sinica* [物理学报], 2015 64(18), https://wulixb.iphy.ac.cn/article/doi/10.7498/aps.64.188901

Liu Gang [刘钢], "Constraint-guided genetic algorithm for anti-ship missile route planning" [约束引导的反舰导弹航路规划遗传算法], *Journal of Ballistics*, 2012 4, https://d.wanfangdata.com.cn/periodical/ChlQZXJpb2RpY2FsQ0hJTmV3UzIwMjMwNDI2Eg1kZHhiMjAxMjA0MDAzGgh6Z2gxcHk0bg%253D%253D

[1135] "Guidelines for Stabilization Support Items Open to the Public in State Key Laboratory of Information System Engineering " [信息系统工程国家级重点实验室稳定支持项对外开放课题指南], *Weixin*, 13 July 2023, https://mp.weixin.qq.com/s/jiuFyJK6aDjwi

[1136] "National Key Laboratory of Infrared Detection inaugurated" [红外探测全国重点实验室揭牌], *CAS Shanghai Institute of Technical Physics*, 27 September 2023, http://sitp.cas.cn/xwzx/zhxw/202309/t20230927_6888330.html

[1137] "2.7 Billion Project Settles Here in Shunyi, Bringing Numerous Job Opportunities" [27 亿项目落户顺义这里，带来众多工作机会], *Sohu*, 2 July 2019, https://www.sohu.com/a/324363166_99986045

[1138] "National Key Laboratory of Infrared Detection inaugurated" [红外探测全国重点实验室揭牌], *CAS Shanghai Institute of Technical Physics*, 27 September 2023, http://sitp.cas.cn/xwzx/zhxw/202309/t20230927_6888330.html

[1139] The official seal visible in the image lables it as a National Key Lab. "Prof. Zhou Feng Elected as Member of Academic Committee of National Key Laboratory of Infrared Detection" [周峰教授当选为红外探测全国重点实验室学术委员会委员], *Beijing University of Posts and Telecommunications*, 28 September 2023, https://ic.bupt.edu.cn/info/1023/1301.htm
[1140] "A study of infrared focal plane readout circuits for astronomical applications" [天文应用红外焦平面读出电路研究], *Infrared and Laser Engineering* [红外与激光工程], January 2024 53(1), https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjKkJfXpfKEAxV5EVkFHWpCDak4HhAWegQIBRAB&url=https%3A%2F%2Fwww.sciengine.com%2Fdoi%2Fpdf%2FAB936B606DCF47B7A98A76B491BCFD09&usg=AOvVaw1Q8v9fUQUIG1V8I30TKuCJ&opi=89978449
[1141] "Official Announcement | ESIT 2024, to be held in Hangzhou in September this year" [官宣定档 | ESIT 2024，将于今年 9 月在杭州召开], *Chinese Laser Press*, 13 March 2024, https://clp.ac.cn/M/News/Details?id=PT240313000067mIoLr
[1142] "2023 Western China Photovoltaic Industry Innovation and Development Forum" [2023 中国西部光电产业创新发展论坛], *CCWPE*, 2023, http://www.ccwpe.com/news2.asp?id=1940x
[1143] "Institution Intro" [机构简介], *Shanghai Institute of Technical Physics*, Accessed March 2024, http://sitp.cas.cn/jggk/jgjj/
[1144] "Kunming Institute of Physics (211 Institute) Introduction" [昆明物理研究所(211 所)简介], *Kaoyan*, Accessed March 2024, https://m.kaoyan.com/yanzhao/fz211/jianjie/
[1145] "Company Intro" [公司概况], *North Night Vision Institute*, Accessed March 2024, http://www.nvir.cn/col/col630/index.html
[1146] "In-depth implementation of innovation-driven development strategy to strive to build the photovoltaic field of science and technology innovation pacesetter" [深入实施创新驱动发展战略着力打造光电领域科技创新排头兵], *Modern SOE Research*, 2023, 10, https://www.fuyoutech.club/web/mag_article/170499/1008629404
[1147] "Institution Intro" [机构简介], *Shanghai Institute of Technical Physics*, Accessed March 2024, http://sitp.cas.cn/jggk/jgjj/
[1148] "National Key Laboratory of Infrared Detection inaugurated" [红外探测全国重点实验室揭牌], *CAS Shanghai Institute of Technical Physics*, 27 September 2023, http://sitp.cas.cn/xwzx/zhxw/202309/t20230927_6888330.html
[1149] "National Key Laboratory of Infrared Detection inaugurated" [红外探测全国重点实验室揭牌], *CAS Shanghai Institute of Technical Physics,* 27 September 2023, http://sitp.cas.cn/xwzx/zhxw/202309/t20230927_6888330.html
[1150] "National Key Laboratory of Infrared Detection inaugurated" [红外探测全国重点实验室揭牌], *CAS Shanghai Institute of Technical Physics,* 27 September 2023, http://sitp.cas.cn/xwzx/zhxw/202309/t20230927_6888330.html
[1151] "2023 Western China Photovoltaic Industry Innovation and Development Forum" [2023 中国西部光电产业创新发展论坛], *CCWPE*, 2023, http://www.ccwpe.com/news2.asp?id=1940x
[1152] "National Key Laboratory of Infrared Detection inaugurated" [红外探测全国重点实验室揭牌], *CAS Shanghai Institute of Technical Physics*, 27 September 2023, http://sitp.cas.cn/xwzx/zhxw/202309/t20230927_6888330.html
[1153] "The Party Branch of Center for Materials and Instruments and the Party Branch of Physics Laboratory carried out a special study on the reorganization of national key laboratories" [材器中心党支部和物理室党支部围绕全国重点实验室重组工作开展专题学习], *Shanghai Institute of Technical Physics*, 3 July 2023, http://www.sitp.ac.cn/xwzx/zhxw/202307/t20230703_6802226.html
[1154] "The 5th Conference on Infrared Technology and its Applications" [第五届红外技术及其应用大会], *Sohu*, 6 March 2024, https://www.sohu.com/a/762307957_121124363
[1155] "Official Announcement | ESIT 2024, to be held in Hangzhou in September this year" [官宣定档 | ESIT 2024，将于今年 9 月在杭州召开], *Chinese Laser Press*, 13 March 2024, https://clp.ac.cn/M/News/Details?id=PT240313000067mIoLr
[1156] "A study of infrared focal plane readout circuits for astronomical applications" [天文应用红外焦平面读出电路研究], *Infrared and Laser Engineering* [红外与激光工程], January 2024 53(1), https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=
[1157] "Building airplanes, flying airplanes, repairing airplanes, Tsinghua graduates do it all!" [造飞机、开飞机、修飞机，清华毕业生，全了！], *China Communist Youth League*, 26 August 2024, https://m.cyol.com/gb/articles/2024-08/26/content_R4qxGWiGVK.html

[1158] Duan Yu [段昱], Jia Meng [贾蒙], "Avionics Essays" [航空电子综合系统论文], *Lunwen90.cn*, Accessed July 2024, (opens word doc) https://www.lunwen90.cn/docDown/d9905ee85a244e107978820e.doc&ved=2ahUKEwjqis2Nkq6HAxVqFlkFHcdQDvUQFnoECBEQAQ&usg=AOvVaw2xCB2MjbQb9zTof6OeYZIE

[1159] Duan Yu [段昱], Jia Meng [贾蒙], "Avionics Essays" [航空电子综合系统论文], *Lunwen90.cn,* Accessed July 2024, (opens word doc) https://www.lunwen90.cn/docDown/d9905ee85a244e107978820e.doc&ved=2ahUKEwjqis2Nkq6HAxVqFlkFHcdQDvUQFnoECBEQAQ&usg=AOvVaw2xCB2MjbQb9zTof6OeYZIE

[1160] "Wang Jinyan, Director of Shanghai Electric Power Research Institute: Sixty Years of Storms and Struggles to Inspire and Climb the Peak Again on the Road of Innovation" [上电所所长王金岩：六十年风雨励志 创新路再攀高峰], *Sohu*, 6 June 2017, https://www.sohu.com/a/146451367_115926

[1161] Zhao Hongsheng [赵鸿盛], "Overview of research on flight technical error estimation in performance based navigation" [性能基导航中飞行技术误差估计研究综述], *Journal of Traffic and Transportation Engineering* [交通运输工程学报], 2014, 14(5), https://transport.chd.edu.cn/article/id/201405013

Wang Dan [王丹] et al., "Research on practical navigation performance evaluation method for land-based regional navigation" [陆基区域导航实际导航性能评估方法研究], Aviation Electronic Technology [航空电子技术], 2018, 02, http://124.222.178.136/paper/paperCode?paperId=29389

[1162] Zheng Weiming [郑伟铭] et al., "Multi-UAV cooperative pigeon-inspired optimization search method for moving targets" [针对运动目标的多无人机协同鸽群优化搜索方法], *Control Theory and Technology* [控制理论与应用], 2023, 40(4), www.jcta.alljournals.ac.cn/cta_cn/ch/reader/view_abstract.aspx?file_no=CCTA210466

Chen Cong [陈聪], "Manned/unmanned aircraft cooperative operation style and key technology" [有人/无人机协同作战样式及关键技术], *The 13th Annual Academic Conference of Shanghai Association of Science and Technology and the 2015 Annual Academic Conference of Shanghai Society of Aeronautics and Astronautics* [上海市科学技术协会第十三届学术年会暨上海市航空学会 2015 年学术年会], 1 October 2015, https://wf.pub/conference/article:159_wfid%3Aconference8776138

[1163] JJ Long, Thomas Corbett, Dan Shats, "Organization and Structure of the Aviation Industry Corporation of China (AVIC)," *China Aerospace Studies Institute*, January 2024, https://www.airuniversity.af.edu/Portals/10/CASI/documents/Research/Infrastructure/2024-01-22-avic-organization-v2.pdf

[1164] "Wang Jinyan, Director of Shanghai Electric Power Research Institute: Sixty Years of Storms and Struggles to Inspire and Climb the Peak Again on the Road of Innovation" [上电所所长王金岩：六十年风雨励志 创新路再攀高峰], *Sohu*, 6 June 2017, https://www.sohu.com/a/146451367_115926

[1165] "Wang Jinyan, Director of Shanghai Electric Power Research Institute: Sixty Years of Storms and Struggles to Inspire and Climb the Peak Again on the Road of Innovation" [上电所所长王金岩：六十年风雨励志 创新路再攀高峰], *Sohu*, 6 June 2017, https://www.sohu.com/a/146451367_115926

[1166] Zhao Hongsheng [赵鸿盛], "Overview of research on flight technical error estimation in performance based navigation" [性能基导航中飞行技术误差估计研究综述], *Journal of Traffic and Transportation Engineering* [交通运输工程学报], 2014, 14(5), https://transport.chd.edu.cn/article/id/201405013

Wang Dan [王丹] et al., "Research on practical navigation performance evaluation method for land-based regional navigation" [陆基区域导航实际导航性能评估方法研究], *Aviation Electronic Technology* [航空电子技术], 2018, 02, http://124.222.178.136/paper/paperCode?paperId=29389

[1167] Gao Yue [高悦], "Task meta-model modeling of air combat systembased on system architecture design" [ 基于体系结构设计的空战系统任务元模型建模], *Systems Engineering and Electronics* [系统工程与电子技术], 2021, 43(11), https://www.sys-ele.com/CN/10.12305/j.issn.1001-506X.2021.11.23

[1168] Chen Cong [陈聪], "Manned/unmanned aircraft cooperative operation style and key technology" [有人/无人机协同作战样式及关键技术], *The 13th Annual Academic Conference of Shanghai Association of Science and Technology and the 2015 Annual Academic Conference of Shanghai Society of Aeronautics and Astronautics* [上海市科学技术协会第十三届学术年会暨上海市航空学会 2015 年学术年会], 1 October 2015, https://wf.pub/conference/article:159_wfid%3Aconference8776138

[1169] Zheng Weiming [郑伟铭] et al., "Multi-UAV cooperative pigeon-inspired optimization search method for moving targets" [针对运动目标的多无人机协同鸽群优化搜索方法], *Control Theory and Technology* [控制理论与应用], 2023, 40(4), www.jcta.alljournals.ac.cn/cta_cn/ch/reader/view_abstract.aspx?file_no=CCTA210466
[1170] Wang Haiyan [王海燕] et al., "Layout Design of Display Interface for a New Generation Fighter" [新一代战斗机显控界面布局设计研究], *Electro-Mechanical Engineering* [电子机械工程], 2011, 27(4), http://dzjxgc.ijournals.cn/ch/reader/view_abstract.aspx?file_no=20110416&st=alljournals
[1171] "Mr. Wang Jinyan, Director of 615 Institute of Aviation Industry, gave a lecture on "Academic Life" and "Sailing Lecture Hall" at the Aviation Academy" [航空工业 615 所所长王金岩做客航院"学术人生"暨"启航讲堂"系列讲座], *Tsinghua University*, 10 September 2019, https://www.tsinghua.edu.cn/info/1175/18947.htm
[1172] "Wang Jinyan" [ 王金岩], *Shine Consultant* [士研咨询], Accessed July 2024, http://www.shine-consultant.com/teachers_view.aspx?TypeId=487&Id=3697&FId=t26:487:26
[1173] "Avionics R&D costs account for 40% of total warplane R&D" [航电系统研发成本占战机总研发四成], *Sohu*, 29 May 2017, https://www.sohu.com/a/144503664_819742
[1174] "Mr. Wu Jianmin, Deputy Chief Engineer of 615 Institute, was appointed as an adjunct professor of our university" [615 所吴建民副总师受聘我校兼职教授], *Nanjing University of Aeronautics and Astronautics*, 25 January 2017, http://cs.nuaa.edu.cn/2017/0125/c10846a175096/page.htm
[1175] "2023 National Academic Conference on Data Chain Technology Successfully Held" [2023 年度全国数据链技术学术会议成功举办], *Sohu*, 21 August 2023, https://www.sohu.com/a/713676440_358040
[1176] "2021 First National Air Intelligence Gaming Competition Officially Launched" [2021 首届全国空中智能博弈大赛正式启动], *81it.com*, 7 July 2017, http://www.81it.com/2021/0707/13076.html
[1177] "The Fifth China Aviation Weapons Conference" [第五届中国航空兵器大会], *Aconf.cn*, 20 October 2017, https://www.aconf.cn/conf_110206
[1178] "2024 (13th) International Forum on Aircraft Avionics May 29-30, Shanghai, China" [2024（第十三届）飞机航空电子国际论坛 5 月 29-30 日 中国·上海], *C114.com.cn*, 4 February 2024, https://www.c114.com.cn/expo/15/a1254339.html
[1179] "Smart Avionics for Green Flight | New Tracks, New Fields, New Horizons" [智慧航电赋能绿色飞行 | 新赛道、新领域、新视野], *thepaper.cn*, 17 May 2023, https://m.thepaper.cn/newsDetail_forward_23125823
[1180] Zhao Hongsheng [赵鸿盛], "Overview of research on flight technical error estimation in performance based navigation" [性能基导航中飞行技术误差估计研究综述], *Journal of Traffic and Transportation Engineering* [交通运输工程学报], 2014, 14(5), https://transport.chd.edu.cn/article/id/201405013
[1181] Wu Xinpeng [吴欣蓬] et al., "Anomalous Flight Behavior Mining Based on Density Clustering and Matching Algorithm" [基于密度聚类与匹配算法的异常飞行行为挖掘], *NUAA Journal* [南京航空航天大学学报], 2021, 6, https://m.fx361.com/news/2021/1231/13443687.html
[1182] From a photo on website
[1183] "Significant achievements have been achieved in the "Tenth Five-Year Plan" and "211 Project" of Central South University" [中南大学"十五""211 工程"建设成效显著], *Chinese University Alumni Association* [中国校友会网], 14 January 2009. https://web.archive.org/web/20171017074513/https://cuaa.net/paihang/news/news.jsp?information_id=88343; Central South University Powder Metallurgy Research Institute [中南大学粉末冶金研究院], Baidu Baike [百度百科], accessed March 2021. https://baike.baidu.com/item/%E4%B8%AD%E5%8D%97%E5%A4%A7%E5%AD%A6%E7%B2%89%E6%9C%AB%E5%86%B6%E9%87%91%E7%A0%94%E7%A9%B6%E9%99%A2/3376109
"The construction project of the key laboratory of lightweight and high-strength structural materials passed the completion acceptance" [轻质高强结构材料重点实验室建设项目通过竣工验收], *Powder Metallurgy Research Institute* [粉末冶金研究院], 22 December 2016. https://web.archive.org/web/20210323213212/https://webcache.googleusercontent.com/search?q=cache%3AIoccVLUbsBgJ%3Anews.csu.edu.cn%2Finfo%2F1004%2F131852.htm&client=firefox-b-d&hl=en&gl=ca&strip=1&vwsrc=0
[1184] "Postdoctoral Recruitment at the Key Laboratory of Lightweight and High-strength Structural Materials for National Defense Technology, Central South University" [中南大学轻质高强结构材料国防科技重点实验室博士

后招聘], *Central South University* [中南大学], 1 April 2019. http://www.liuxuehr.com/m/view.php?aid=36121 / https://archive.fo/tsmkN

[1185] "School Introduction" [学院简介], *Powder Metallurgy Research Institute* [粉末冶金研究院], Accessed 2021, https://web.archive.org/web/20210118233626/http://pmri.csu.edu.cn/Content.aspx?moduleid=124e4346-b2ae-4a9b-a893-6ac02a89de9b

[1186] "Postdoctoral Recruitment at the Key Laboratory of Lightweight and High-strength Structural Materials for National Defense Technology, Central South University" [中南大学轻质高强结构材料国防科技重点实验室博士后招聘], *Central South University Powder Metallurgy Research Institute* [中南大学粉末冶金研究院], 28 March 2019. https://web.archive.org/web/20210323230754/http://pmri.csu.edu.cn/Content.aspx?moduleid=bfe4a8da-c100-4006-a830-fd54c76fbea8&id=77dcd9b1-24b7-4236-9e39-a7099cd08c58

[1187] "2019 China Aerospace Conference Aerospace Advanced Materials and Manufacturing Forum and the 6th Aerospace Engineering and High-Performance Material Demand and Application High-end Forum" [2019 年中国航天大会宇航先进材料与制造论坛暨第六届航天工程和高性能材料需求与应用高端论坛], *CSU Powder Metallurgy Research Institute* [中南大学粉末冶金研究院], 19 April 2019. https://web.archive.org/web/20200226145909/http:/pmri.csu.edu.cn/Content.aspx?moduleid=bfe4a8da-c100-4006-a830-fd54c76fb000&id=27fbfeea-6e3c-4e21-8983-b54681cc2951

[1188] "2019 China Aerospace Conference Aerospace Advanced Materials and Manufacturing Forum and the 6th Aerospace Engineering and High-Performance Material Demand and Application High-end Forum" [2019 年中国航天大会宇航先进材料与制造论坛暨第六届航天工程和高性能材料需求与应用高端论坛], *CSU Powder Metallurgy Research Institute* [中南大学粉末冶金研究院], 19 April 2019. https://web.archive.org/web/20200226145909/http:/pmri.csu.edu.cn/Content.aspx?moduleid=bfe4a8da-c100-4006-a830-fd54c76fb000&id=27fbfeea-6e3c-4e21-8983-b54681cc2951

"The 4th China (Tongling) International Forum on the Development of Copper-based New Materials Industry Held" [第四届中国（铜陵）铜基新材料产业发展国际论坛召开], *China Nonferrous Metals Fabrication Industry Association* [中国有色金属加工工业协会], 20 September 2018. https://web.archive.org/web/20210326212138/http://www.cnfa.net.cn/institute/show-1945.aspx

[1189] "R&D Platforms" [研发平台], *CSUN*, Accessed March 2025, http://www.xn--rhq488cx9av63h.xn--ses554g/jxcx/6358009.html

[1190] "The 2nd High-end Forum on Aerospace Engineering and High-Performance Materials Demand and Application Lunar Exploration Engineering and Space Environment, New Materials Academic Conference" [第二届航天工程和高性能材料需求与应用高端论坛 探月工程与空间环境、新材料学术研讨会], *aconf.cn*, accessed March 2021, https://www.aconf.cn/conf_32747.html

"The 3rd Aerospace Engineering and High-Performance Material Demand and Application Technology Exchange Conference Notice" [第三届航天工程和高性能材料需求与应用技术交流会 会议通知], *Conference affairs group* [会务组], 24 September 2015. http://new.zghtqk.com/cn/ch/reader/view_news.aspx?id=20150924092308953 / https://web.archive.org/web/20210331152249/https://webcache.googleusercontent.com/search?q=cache%3AhNF6k8D8VsMJ%3Anew.zghtqk.com%2Fcn%2Fch%2Freader%2Fview_news.aspx%3Fid%253D20150924092308953&client=firefox-b-d&hl=en&gl=us&strip=1&vwsrc=0

""China Aerospace 60th Anniversary and the 4th Aerospace Engineering and High-Performance Material Demand and Application High-end Forum" Conference Notice" ["中国航天 60 周年暨第四届航天工程和高性能材料需求与应用高端论坛"会议通知], *Forum Organizing Committee* [论坛组委会], 2 September 2016. https://web.archive.org/web/20210321164619/https://new.zghtqk.com/cn/ch/reader/view_news.aspx?id=20160902094125700

""The Fifth Aerospace Engineering and High-Performance Material Demand and Application High-end Forum" Conference Notice" ["第五届航天工程和高性能材料需求与应用高端论坛"会议通知], *CSU Powder Metallurgy Research Institute* [中南大学粉末冶金研究院], 22 May 2018. http://202.197.61.123/Content.aspx?moduleid=bfe4a8da-c100-4006-a830-fd54c76fb000&id=5db635e8-ded1-4fde-a148-550be24985a3

"2019 China Aerospace Conference Aerospace Advanced Materials and Manufacturing Forum and the 6th Aerospace Engineering and High-Performance Material Demand and Application High-end Forum" [2019 年中国航天大会宇航先进材料与制造论坛暨第六届航天工程和高性能材料需求与应用高端论坛], *CSU Powder*

*Metallurgy Research Institute* [中南大学粉末冶金研究院], 19 April 2019. https://web.archive.org/web/20200226145909/http:/pmri.csu.edu.cn/Content.aspx?moduleid=bfe4a8da-c100-4006-a830-fd54c76fb000&id=27fbfeea-6e3c-4e21-8983-b54681cc2951

[1191] "School Introduction" [学院简介], *Powder Metallurgy Research Institute* [粉末冶金研究院], Accessed 2021, https://web.archive.org/web/20210118233626/http://pmri.csu.edu.cn/Content.aspx?moduleid=124e4346-b2ae-4a9b-a893-6ac02a89de9b

[1192] "Starting a New Journey under the Party Flag, Party Building Leads to a New Story--The Party Branch of Institute of Space Power Technology of Aerospace Academy and the Party Branch of Thermal Process Research Center of the Eleventh Institute of the Sixth Academy of Space Science and Technology held a joint building activity" [高擎党旗启新程 党建引领谱新篇——航天学院空天动力技术研究所党支部与航天科技六院十一所热过程研究中心党支部举行共建活动], *Northwestern Polytechnical University*, 18 December 2023, https://hangtian.nwpu.edu.cn/info/1804/26861.htm

[1193] "Sixth Academy 11th RI successfully held a seminar on air and space propulsion flow combustion and cutting-edge cross technology" [六院 11 所成功举办空天推进流动燃烧及前沿交叉技术研讨会], *Sohu*, 5 August 2024, https://www.sohu.com/a/798669258_121117464

[1194] "Guidelines for the 2022 Open Program of the State Key Laboratory of Liquid Rocket Motor Technology" [液体火箭发动机技术国家级重点实验室 2022 年度对外开放项目指南], *China Aerospace*, 1 August 2022, https://www.chinaerospace.com/article/show/7913416fc9e321ecff3f637c82988fb8

[1195] "Guidelines for the 2022 Open Program of the State Key Laboratory of Liquid Rocket Motor Technology" [液体火箭发动机技术国家级重点实验室 2022 年度对外开放项目指南], *China Aerospace*, 1 August 2022, https://www.chinaerospace.com/article/show/7913416fc9e321ecff3f637c82988fb8

[1196] "Guidelines for the 2022 Open Program of the State Key Laboratory of Liquid Rocket Motor Technology" [液体火箭发动机技术国家级重点实验室 2022 年度对外开放项目指南], *China Aerospace*, 1 August 2022, https://www.chinaerospace.com/article/show/7913416fc9e321ecff3f637c82988fb8

[1197] "Key Laboratory of Liquid Rocket Engine, 11th Institute of Sixth Academy of Space Science and Technology, officially operates" [航天科技六院 11 所液体火箭发动机重点实验室正式运行], *Sohu*, 22 November 2017, https://www.sohu.com/a/205852705_313834

[1198] "School of Mechanical Power "Walking with the Motherland" Summer Employment Guidance Internship Practice Group went to Xi'an for practice" [机械动力学院"与祖国同行"暑期就业引导实习实践团赴西安开展实践], *Shanghai Jiao Tong University*, 3 July 2023, http://www.yuhlin.net/student_garden/75032.html
"Tan Yonghua: Always keep an "ambition" [谭永华：始终保持一颗"雄心"], *Scientific Chinese* [科学中国人], 28 June 2022, http://scichi.cn/content.php?id=6873&cid=1
"The Sixth Academy of Astronautics Organizes "Open Day" for State-level Key Laboratories" [航天六院举办国家级重点实验室"开放日"活动], *Toutiao*, 24 May 2019, https://www.toutiao.com/article/6694535862480273927/?source=seo_tt_juhe&wid=1721327530416

[1199] "Xinhua News Agency 丨 China's high-thrust liquid rocket engine test bed all-system debugging completed" [新华全媒+丨我国大推力液体火箭发动机试车台全系统调试完成], *Xinhua*, 11 April 2023, http://www.news.cn/politics/2023-04/11/c_1129512133.htm
"Liquid Power Fusion Additive Manufacturing Innovation and Design Forum and 3D Printing Design Competition Concluded in Shaanxi Province" [液体动力融合增材制造创新设计论坛暨 3D 打印设计大赛在陕落幕], *CN West*, 10 April 2023, http://m.cnwest.com/xian/a/2023/04/10/21393425.html

[1200] "Academic Committee Meeting of the Key Laboratory of Liquid Rocket Motor Technology" [三院士莅临 | 液体火箭发动机技术重点实验室召开学术委员会会议], *Sohu*, 3 March 2023, https://www.sohu.com/a/649299463_121117464
"Science and Technology Division of the Sixth Academy of CASC 11th RI: Strengthening the construction of innovation platforms, optimizing the innovation and R&D mode, deepening basic frontier research, promoting the high level of self-reliance of liquid power" [航天科技六院 11 所科技处：强化创新平台建设 优化创新研发模式 深化基础前沿研究 推举液体动力高水平自立自强], *CASC*, 17 Januaru 2023, http://zhuanti.spacechina.com/n3642067/n3642236/c3718270/content.html

[1201] "School of Mechanical Power "Walking with the Motherland" Summer Employment Guidance Internship Practice Group went to Xi'an for practice" [机械动力学院"与祖国同行"暑期就业引导实习实践团赴西安开展实践], *Shanghai Jiao Tong University*, 3 July 2023, http://www.yuhlin.net/student_garden/75032.html
"Liquid-liquid coaxial double centrifugal nozzles for liquid rocket motors: A study on the working characteristics of liquid-liquid coaxial double centrifugal nozzles" [【航天日·桂航大讲坛】液体火箭发动机液液同轴双离心喷嘴工作特性研究], *Guilin University of Aerospace Technology*, 19 April 2024, https://news.guat.edu.cn/info/1004/8757.htm
[1202] "Proceedings of the 128th Youth Academic Salon of Chinese Mechanics Society" [中国力学学会第 128 次青年学术沙龙活动纪要], *Sohu*, 18 July 2024, https://m.sohu.com/a/794292208_121123680
[1203] "Xi'an Aerospace Base: Innovative "Power" to Dream of Space" [西安航天基地：创新"动力"逐梦太空], *CN West*, 23 November 2023, http://m.cnwest.com/zwyw/a/2023/11/23/22089650.html
[1204] "Wang Chunmin: Forging the Source of Power in Space with Continuous Innovation" [王春民：以持续创新锻造问鼎太空力量之源], *Scientific Chinese* [科学中国人], 28 June 2022, http://www.scichi.cn/content.php?id=6878&cid=1
[1205] "Introduction" [期刊介绍], *Journal of Rocket Propulsion*, Accessed July 2024, http://hjtjnew.paperopen.com/Corp/10.aspx
[1206] "School of Mechanical Power "Walking with the Motherland" Summer Employment Guidance Internship Practice Group went to Xi'an for practice" [机械动力学院"与祖国同行"暑期就业引导实习实践团赴西安开展实践], *Shanghai Jiao Tong University*, 3 July 2023, http://www.yuhlin.net/student_garden/75032.html
"Tan Yonghua: Always keep an "ambition" [谭永华：始终保持一颗"雄心"], *Scientific Chinese* [科学中国人], 28 June 2022, http://scichi.cn/content.php?id=6873&cid=1
"The Sixth Academy of Astronautics Organizes "Open Day" for State-level Key Laboratories" [航天六院举办国家级重点实验室"开放日"活动], *Toutiao*, 24 May 2019, https://www.toutiao.com/article/6694535862480273927/?source=seo_tt_juhe&wid=1721327530416
[1207] "Guidelines for the 2022 Open Program of the State Key Laboratory of Liquid Rocket Motor Technology" [液体火箭发动机技术国家级重点实验室 2022 年度对外开放项目指南], *China Aerospace*, 1 August 2022, https://www.chinaerospace.com/article/show/7913416fc9e321ecff3f637c82988fb8
[1208] Chen Jianhua [陈建华] et al., "Booster Stage Propulsion System for Launch Vehicle Long March 5" [长征五号运载火箭助推动力系统], *Journal of Propulsion Technology*, July 2021, 42(7), http://tjjs.ijournals.cn/ch/reader/download_pdf_file.aspx?journal_id=tjjs&file_name=A8D77C701D04C8818E601FA72B68EA04CCC1A715CF105A4C3851A6AD491732E09F47A45399B116BD5FA0EDC888BD81DA&open_type=self&file_no=202107002
Chen Jianhua [陈建华] et al., "General Technical Review of Long March 5 Liquid Oxygen Kerosene Engine" [长征五号"火箭液氧煤油发动机总体技术], *Journal of Deep Space Exploration* [深空探测], August 2021, 8(4), https://jdse.bit.edu.cn/sktcxb/cn/article/pdf/preview/10.15982/j.issn.2096-9287.2021.20210003.pdf
[1209] "Proceedings of the 128th Youth Academic Salon of Chinese Mechanics Society" [中国力学学会第 128 次青年学术沙龙活动纪要], *Sohu*, 18 July 2024, https://m.sohu.com/a/794292208_121123680
[1210] "Academic Committee Meeting of the Key Laboratory of Liquid Rocket Motor Technology" [三院士莅临 | 液体火箭发动机技术重点实验室召开学术委员会会议], *Sohu*, 3 March 2023, https://www.sohu.com/a/649299463_121117464
[1211] "China Aerospace Congress 2023 "Belt and Road" Aerospace Dialogue - Flying to the Moon, Powering Up" [2023 年中国航天大会"一带一路"航天对话——飞天逐月，动力托举], *Northwestern Polytechnical University*, 24 April 2023, https://hangtian.nwpu.edu.cn/info/1808/20921.htm
[1212] "Liquid-liquid coaxial double centrifugal nozzles for liquid rocket motors: A study on the working characteristics of liquid-liquid coaxial double centrifugal nozzles" [【航天日·桂航大讲坛】液体火箭发动机液液同轴双离心喷嘴工作特性研究], *Guilin University of Aerospace Technology*, 19 April 2024, https://news.guat.edu.cn/info/1004/8757.htm
[1213] "Starting a New Journey under the Party Flag, Party Building Leads to a New Story--The Party Branch of Institute of Space Power Technology of Aerospace Academy and the Party Branch of Thermal Process Research Center of the Eleventh Institute of the Sixth Academy of Space Science and Technology held a joint building

activity" [高擎党旗启新程 党建引领谱新篇——航天学院空天动力技术研究所党支部与航天科技六院十一所热过程研究中心党支部举行共建活动], *Northwestern Polytechnical University*, 18 December 2023, https://hangtian.nwpu.edu.cn/info/1804/26861.htm

[1214] "Dr. Han Yajie, a PhD student at the School of Aeronautics and Astronautics, won the Outstanding Paper Award at the 18th Annual China Electric Propulsion Symposium" [航空航天学院韩亚杰博士生获第十八届中国电推进学术年会优秀论文奖], *Dalian University of Technology*, 25 April 2023, https://aa.dlut.edu.cn/info/1039/1216.htm

[1215] "Liquid Power Fusion Additive Manufacturing Innovation and Design Forum and 3D Printing Design Competition Concluded in Shaanxi Province" [液体动力融合增材制造创新设计论坛暨 3D 打印设计大赛在陕落幕], *CN West*, 10 April 2023, http://m.cnwest.com/xian/a/2023/04/10/21393425.html

[1216] "China and Italy carry out liquid rocket engine simulation technology exchanges at the 11th Institute of the Sixth Academy of CASC" [航天科技六院 11 所中意开展液体火箭发动机仿真技术交流], *China National Space Administration*, 14 May 2018, https://www.cnsa.gov.cn/n6758823/n6758838/c6801427/content.html

[1217] "2019 Space Propulsion Technology Workshop held in Xi'an" [2019 年空间推进技术研讨会在西安举行], *CNR*, 10 September 2019, http://www.cnr.cn/sxpd/sx/20190910/t20190910_524771819.shtml

[1218] "Guidelines for the 2021 Open Program of the State Key Laboratory of Liquid Rocket Motor Technology" [液体火箭发动机技术国家级重点实验室 2021 年度对外开放项目指南], *bilibili*, 21 December 2021, https://www.bilibili.com/read/cv14520033/

[1219] "Shengxi Elementary School kicks off 2017 spring sports season" [胜西小学 2017 春季运动会隆重开幕], *Sichuan Education Network* [四川教育在线], 1 April 2017, https://m.scjyxw.com/show.php?classid=82&id=40200

[1220] "Recruitment--General Staff 57th Research Institute Graduate Student Recruitment Conference" [招贤纳士——总参 57 研究所研究生招生会], *Southwest Jiaotong University* [西北交通大学], 26 October 2010, https://book.swjtu.edu.cn/Mobile/shownews-20701.shtml

[1221] "Prospectus of the 57th Research Institute of the Strategic Support Forces for the 2018 Examination" [战略支援部队第五十七研究所 2018 考研招生章程], Free Kaoyan, 15 October 2017, http://school.freekaoyan.com/sc/zc57s/2017/10-15/1508060293737539.shtml

[1222] "Yang Xiaoniu" [杨小牛], *Geren Jianli*, Accessed July 2021, http://m.gerenjianli.com/Mingren/47/gt6da19otm.html

[1223] "Academicians from my school" [毕业于我校的院士], *Anqing No. 1 Middle School* [安庆第一中学], 12 September 2012, http://www.aqyz.net/bnyz/ysfc/623294.html

[1224] "Wang Xiaoning Thesis Achievements" [汪晓宁论文成果], *Southwest Jiaotong University*, Accessed July 2021, https://faculty.swjtu.edu.cn/wangxiaoning/zh_CN/lwcg/10516/list/index.htm

[1225] "Yang Xiaoniu" [杨小牛], *Geren Jianli*, Accessed July 2021, http://m.gerenjianli.com/Mingren/47/gt6da19otm.html

[1226] "Academicians from my school" [毕业于我校的院士], *Anqing No. 1 Middle School* [安庆第一中学], 12 September 2012, http://www.aqyz.net/bnyz/ysfc/623294.html

[1227] "Wang Xiaoning Thesis Achievements" [汪晓宁论文成果], *Southwest Jiaotong University*, Accessed July 2021, https://faculty.swjtu.edu.cn/wangxiaoning/zh_CN/lwcg/10516/list/index.htm

[1228] "Recruitment--General Staff 57th Research Institute Graduate Student Recruitment Conference" [招贤纳士——总参 57 研究所研究生招生会], *Southwest Jiaotong University* [西北交通大学], 26 October 2010, https://book.swjtu.edu.cn/Mobile/shownews-20701.shtml
"Wang Xiaoning Thesis Achievements" [汪晓宁论文成果], Southwest Jiaotong University, Accessed July 2021, https://faculty.swjtu.edu.cn/wangxiaoning/zh_CN/lwcg/10516/list/index.htm

[1229] "Shengxi Elementary School kicks off 2017 spring sports season" [胜西小学 2017 春季运动会隆重开幕], *Sichuan Education Network* [四川教育在线], 1 April 2017, https://m.scjyxw.com/show.php?classid=82&id=40200

[1230] "Nationak Key Lab of Marine Corrosion and Protection" [海洋腐蚀与防护全国重点实验室], *ECORR*, 13 December 2024, http://www.ecorr.org.cn/dhTJDAOHANG/cjzl/yejiedongtai/2024-12-13/193085.html

[1231] "Chapter One Marine Scientific Research Institutions" [第一章 海洋科研机构], *Qingdao City Affairs Network* [青岛市情网], Accessed 2021, https://web.archive.org/web/20210603182953/http://qdsq.qingdao.gov.cn/n15752132/n30400816/n30400892/n30485333/151215041533467773.html

"Several major organizers, co-hosts, and organizer style spotlight" [几大主办方、合作承办方、承办方风采聚焦], *Friends of Corrosion Protection* [腐蚀防护之友], 13 September 2016. https://archive.ph/lfp8t; "Topics | Several organizers and co-organizers in the spotlight" [专题 | 几大主办方、协办方风采聚焦], *Friends of Corrosion Protection* [腐蚀防护之友], 20 December 2017. https://archive.ph/2tvVZ
"Shazikou will build a national defense science and technology laboratory to solve marine corrosion problems" [沙子口将建国防科技实验室 解决海洋腐蚀问题], *Qilu Evening News* [齐鲁晚报], 24 June 2013. https://web.archive.org/web/20210604203032/https://qd.ifeng.com/fgqd/detail_2013_06/24/926586_0.shtml
[1232] "Chapter One Marine Scientific Research Institutions" [第一章 海洋科研机构], *Qingdao City Affairs Network* [青岛市情网], Accessed 2021, https://web.archive.org/web/20210603182953/http://qdsq.qingdao.gov.cn/n15752132/n30400816/n30400892/n30485333/151215041533467773.html
"Several major organizers, co-hosts, and organizer style spotlight" [几大主办方、合作承办方、承办方风采聚焦], *Friends of Corrosion Protection* [腐蚀防护之友], 13 September 2016. https://archive.ph/lfp8t; "Topics | Several organizers and co-organizers in the spotlight" [专题 | 几大主办方、协办方风采聚焦], *Friends of Corrosion Protection* [腐蚀防护之友], 20 December 2017. https://archive.ph/2tvVZ
[1233] "Unit Profile" [单位简介], *CSIC 725th RI* [中国船舶重工集团公司第七二五研究所], Accessed 2021, https://web.archive.org/web/20210117150629/http://www.725.com.cn/intro/1.html (Chinese) / https://web.archive.org/web/20210125094159/http://www.sunruigroup.com/intro/1.html (English)
[1234] "Supplement No. 4 to Part 744 -ENTITY LIST," *Bureau of Industry and Security*, 8 April 2021. https://www.bis.doc.gov/index.php/documents/regulation-docs/691-supplement-no-4-to-part-744-entity-list/file
[1235] "Organization Profile" [机构简介], Xiamen Ship Coating Testing Station of China Shipbuilding Industry [中国船舶工业船舶涂料厦门检测站], Accessed 2021, https://web.archive.org/web/20180824215432/http://725coatest.com/lm.asp?id=2
[1236] "Shazikou will build a national defense science and technology laboratory to solve marine corrosion problems" [沙子口将建国防科技实验室 解决海洋腐蚀问题], *Qilu Evening News* [齐鲁晚报], 24 June 2013. https://web.archive.org/web/20210604203032/https://qd.ifeng.com/fgqd/detail_2013_06/24/926586_0.shtml
"Luoyang China Ship Heavy Industry No.725 Office" [中国船舶重工集团公司第七二五研究所青岛分部], *Qcc.com* [企查查], Accessed 2021, https://web.archive.org/web/20210604185531/https://webcache.googleusercontent.com/search?q=cache%3An57ISL429QkJ%3Ahttps%3A%2F%2Fwww.qcc.com%2Ffirm%2F18ccbf86d8d67554e35b961ea3a2fe3b.html&client=firefox-b-d&hl=en&gl=ca&strip=1&vwsrc=0 / https://timetravel.mementoweb.org/reconstruct/https://m.qcc.com/more_permissionDetail?id=1482339cfec55d56e66265ebb1dc8be9_7
"Xijiang Science and Technology Exchange Center" [西姜科技交流中心], *Baidu Maps* [百度地图], Accessed 2021, https://map.baidu.com/?shareurl=1&poiShareUid=0249aba4be4ac57ecae33c4c
[1237] "Several major organizers, co-hosts, and organizer style spotlight" [几大主办方、合作承办方、承办方风采聚焦], *Friends of Corrosion Protection* [腐蚀防护之友], 13 September 2016. https://archive.ph/lfp8t; "Topics | Several organizers and co-organizers in the spotlight" [专题 | 几大主办方、协办方风采聚焦], *Friends of Corrosion Protection* [腐蚀防护之友], 20 December 2017. https://archive.ph/2tvVZ
[1238] "Nationak Key Lab of Marine Corrosion and Protection" [海洋腐蚀与防护全国重点实验室], *ECORR*, 13 December 2024, http://www.ecorr.org.cn/dhTJDAOHANG/cjzl/yejiedongtai/2024-12-13/193085.html
[1239] "Several major organizers, co-hosts, and organizer style spotlight" [几大主办方、合作承办方、承办方风采聚焦], *Friends of Corrosion Protection* [腐蚀防护之友], 13 September 2016. https://archive.ph/lfp8t; "Topics | Several organizers and co-organizers in the spotlight" [专题 | 几大主办方、协办方风采聚焦], *Friends of Corrosion Protection* [腐蚀防护之友], 20 December 2017. https://archive.ph/2tvVZ
[1240] "R&D Strength" [研发实力], Sunrui Marine Environment Engineering Co., Ltd [青岛双瑞海洋环境工程股份有限公司], Accessed 2021, https://web.archive.org/web/20210603183937/http://www.sunrui.net/jsyf/yfsl/index.htm (Chinese) / https://web.archive.org/web/20210603184016/http://www.sunrui.net/English/TechnologyRampD/Rs/index.htm (English)

[1241] "Nationak Key Lab of Marine Corrosion and Protection" [海洋腐蚀与防护全国重点实验室], *ECORR*, 13 December 2024, http://www.ecorr.org.cn/dhTJDAOHANG/cjzl/yejiedongtai/2024-12-13/193085.html
[1242] "Xu Likun: Concentrate on ship corrosion protection research and help my country build a maritime power" [许立坤：潜心船舶腐蚀防护研究 助力我国海洋强国建设], *Friends of Corrosion and Protection* [腐蚀与防护之友], 18 December 2019. https://web.archive.org/web/20210605021522/http://www.ecorr.org/dhTJDAOHANG/yjsd/gaoduanfangtan/2019-12-18/175878.html
[1243] "Sun Mingxian, Editor-in-Chief of the Special Issue "Marine Environment Test and Equipment Effect Evaluation Technology"" ["海洋环境试验与装备效应评价技术"专刊主编孙明先], *Equipment Environmental Engineering* [装备环境工程],2019 年第 4 期. https://archive.ph/j3DH5
[1244] "Pitting Characteristics of 304 Stainless Steel in the Atmospheric Environment of the South China Sea" [南海大气环境下 304 不锈钢的点蚀特性研究], Surface Technology [表面技术], 2018,47(12). https://web.archive.org/web/20210605022716/http://www.surface-techj.com/bmjs/ch/reader/view_abstract.aspx?file_no=201812007&flag=1
"Corrosion Behaviors of Aluminum Alloys in Different Harbors" [不同港口海域铝合金腐蚀行为研究], Equipment Environmental Engineering [装备环境工程], 2019,16(4). https://archive.ph/dBET6
"Studies on Corrosion and Protection of Heat Exchange Tubes of B30 Copper-Nickel Alloy" [B30 铜镍合金换热管腐蚀与防护研究进展], Development and Application of Materials [材料开发与应用], 2020 年第 1 期. https://web.archive.org/web/20210605030929/http://www.nmglib.com:8901/article/detail.aspx?id=7101293033
"Marine Antifouling Coatings: Development and Trends" [海洋防污涂料发展现状与研究趋势], Development and Application of Materials [材料开发与应用], 2014 年 01 期. https://web.archive.org/web/20210605031952/https://gb.oversea.cnki.net/KCMS/detail/detail.aspx?filename=CLKY201401002&dbcode=CJFD&dbname=CJFD2014
[1245] "Nationak Key Lab of Marine Corrosion and Protection" [海洋腐蚀与防护全国重点实验室], *ECORR*, 13 December 2024, http://www.ecorr.org.cn/dhTJDAOHANG/cjzl/yejiedongtai/2024-12-13/193085.html
[1246] "Secretary General Li Yanqing chaired a series of ISO/TC8 meetings" [李彦庆秘书长主持召开 ISO/TC8 系列会议], iMarine, 31 May 2023, https://www.imarine.cn/104736.html
"Led by Chinese shipbuilders! This international standard is released" [中国船企主导！这项国际标准发布], iMarine, 21 August 2023, https://www.imarine.cn/114106.html
[1247] "Second Round of Notification of the 22nd World Corrosion Congress" [第 22 届世界腐蚀大会第二轮通知], *Chinese Society for Corrosion and Protection*, 9 July 2024, https://www.cscp.org.cn/site/content/2543.html
[1248] "National Key Lab of Marine Corrosion and Protection" [海洋腐蚀与防护全国重点实验室], *ECORR*, 13 December 2024, http://www.ecorr.org.cn/dhTJDAOHANG/cjzl/yejiedongtai/2024-12-13/193085.html
[1249] "Organization Profile" [机构简介], *Xiamen Ship Coating Testing Station of China Shipbuilding Industry* [中国船舶工业船舶涂料厦门检测站], Accessed 2021, https://web.archive.org/web/20180824215432/http://725coatest.com/lm.asp?id=2
"Several major organizers, co-hosts, and organizer style spotlight" [几大主办方、合作承办方、承办方风采聚焦], *Friends of Corrosion Protection* [腐蚀防护之友], 13 September 2016. https://archive.ph/lfp8t; "Topics | Several organizers and co-organizers in the spotlight" [专题 | 几大主办方、协办方风采聚焦], *Friends of Corrosion Protection* [腐蚀防护之友], 20 December 2017. https://archive.ph/2tvVZ
"R&D Strength" [研发实力], *Sunrui Marine Environment Engineering Co*., Ltd [青岛双瑞海洋环境工程股份有限公司], Accessed 2021, https://web.archive.org/web/20210603183937/http://www.sunrui.net/jsyf/yfsl/index.htm (Chinese) / https://web.archive.org/web/20210603184016/http://www.sunrui.net/English/TechnologyRampD/Rs/index.htm (English)
[1250] "Organization Profile" [机构简介], *Xiamen Ship Coating Testing Station of China Shipbuilding Industry* [中国船舶工业船舶涂料厦门检测站], Accessed 2021, https://web.archive.org/web/20180824215432/http://725coatest.com/lm.asp?id=2

[1251] "Shazikou will build a national defense science and technology laboratory to solve marine corrosion problems" [沙子口将建国防科技实验室 解决海洋腐蚀问题], *Qilu Evening News* [齐鲁晚报], 24 June 2013. https://web.archive.org/web/20210604203032/https://qd.ifeng.com/fgqd/detail_2013_06/24/926586_0.shtml
"Qingdao Shuangrui Marine Environmental Engineering Co., Ltd." [青岛双瑞海洋环境工程有限公司*], China Shipbuilding Industry Corporation* [中国船舶重工股份有限公司], 21 January 2011. https://archive.is/Bs1Yu
[1252] "Awesome North Tech School of Materials!" [厉害了我的北理工材料学院!], *Beijing Institute of Technology*, 13 May 2017. https://www.bit.edu.cn/xww/wwhd/a139975.htm
[1253] "Notification of New Thinking in Materials Scholarship for 2018 from National Key Laboratory of Materials Technology for Impact Environment" [冲击环境材料技术国家级重点实验室材料新思维奖学金 2018 年度申报通知], *Beijing Institute of Technology*, 2018. https://www.bit.edu.cn/gbxxgk/gbgljg/gbxysz2/clxy/159235.htm
"Beijing Institute of Technology" [北京理工大学], *Beijing Institute of Technology*, Accessed 2021, https://www.bit.edu.cn/docs/2014-04/20140414111935110355.pdf
"The National Key Laboratory of Materials Technology for Impact Environment of Beihang University of Science and Technology is looking for outstanding talents from home and abroad!" [北理工冲击环境材料技术国家级重点实验室诚聘海内外优秀人才!], *Sohu*, 30 April 2020. https://www.sohu.com/a/388142939_427184
"How does a materials school become a bull? A chart to understand Beijing Institute of Technology" [材料牛校是如何养成的? 一张图看懂北京理工大学], *New Materials* [新材料], October 2016. https://www.d-long.com/eWebEditor/uploadfile/20161030195701234646 78.pdf
[1254] "Registration is now open for the "12 National Key Laboratories" event!" ["走进 12 家国家级重点实验室"活动开始报名啦!], *Shangye Xinzhi* [商业新知], 16 May 2019. https://www.shangyexinzhi.com/article/125769.html
"Notification of New Thinking in Materials Scholarship for 2018 from National Key Laboratory of Materials Technology for Impact Environment" [冲击环境材料技术国家级重点实验室材料新思维奖学金 2018 年度申报通知], *Beijing Institute of Technology*, 2018. https://www.bit.edu.cn/gbxxgk/gbgljg/gbxysz2/clxy/159235.htm
"Nature reports on BIT materials discipline: high entropy alloys, energy-containing, new nano energy " [Nature 报道北理工材料学科：高熵合金、含能、纳米新能源], *Tencent*, 25 March 2019. https://web.archive.org/web/20190521040518/https://new.qq.com/omn/20190325/20190325A0GQFN.html
[1255] "2021 Inner Mongolia Institute of Metallic Materials (52) Admissions" [2021 年内蒙古金属材料研究所(52 所)招生简章], *Inner Mongolia Institute of Metallic Materials (52)* [内蒙古金属材料研究所(52 所)], 12 September 2020. http://yz.kaoyan.com/nmg52/jianzhang/5f5cc3aaf16c5.html
"A research institute of China's weapons sent scientific researchers to visit and exchange with Golden Molybdenum's technology center" [中国兵器某研究所派出科研人员对金钼股份技术中心进行参观交流], *Jinduicheng Molybdenum Co.*, 14 December 2017. http://www.jdcmoly.com/technology/news_info/5/7176.shtml
[1256] "How does a materials school become a bull? A chart to understand Beijing Institute of Technology" [材料牛校是如何养成的? 一张图看懂北京理工大学], *New Materials* [新材料], October 2016. https://www.d-long.com/eWebEditor/uploadfile/20161030195701234646 78.pdf
[1257] "How does a materials school become a bull? A chart to understand Beijing Institute of Technology" [材料牛校是如何养成的? 一张图看懂北京理工大学], *New Materials* [新材料], October 2016. https://www.d-long.com/eWebEditor/uploadfile/20161030195701234646 78.pdf
"Li Shukui's group in the School of Materials of Beijing Institute of Technology recruits researchers in the field of special metal materials" [北京理工大学材料学院李树奎课题组特种金属材料方向招聘研究人员、研究工程师], *Tencent*, 25 February 2021. https://new.qq.com/omn/20210225/20210225A0BCJ100.html
[1258] National Materials Corrosion and Protection Data Center [国家材料腐蚀与防护科学数据中心], *National Science & Technology Infrastructure* [国家科技资源共享服务平台], 18 July 2019. http://www.corrdata.org.cn/dhTJDAOHANG/xinxiziyuan/zhaopinxinxi/2019-07-18/174621.html
[1259] "How does a materials school become a bull? A chart to understand Beijing Institute of Technology" [材料牛校是如何养成的? 一张图看懂北京理工大学], *New Materials* [新材料], October 2016. https://www.d-long.com/eWebEditor/uploadfile/20161030195701234646 78.pdf

[1260] "2020 Impact Environmental Materials Technology Key Laboratory Fund Project Guidelines " [2020 年冲击环境材料技术重点实验室基金项目指南], *MIIT*, 9 May 2020. http://jmjh.miit.gov.cn/web/newsInfoWebMessage.action?newsId=12886890
[1261] "Implementation of the transformation of the new titanium alloy material and its shaped parts preparation technology by Beihang University of Science and Technology" [北理工新型钛合金材料及其异型件制备技术实施转化, *Beijing Institute of Technology*, 29 November 2018. https://www.bit.edu.cn/xww/zhxw/162813.htm
"For China's "heavyweight weapons and equipment development" the largest contribution of 985, not Tsinghua, Peking University" [为我国"重量级武器装备研制"贡献最大的 985，不是清华、北大], *QQ*, 4 October 2019. https://kuaibao.qq.com/s/20191004A04ZNU00?refer=spider
[1262] "Beihang Institute of Materials Science and Technology publishes research results on ultra-high strength and high entropy alloys in Nature Communications" [北理工材料学院在《自然·通讯》发表超高强高熵合金研究成果], *Beijing Institute of Technology*, 12 October 2018. https://www.bit.edu.cn/xww/xzw/xsjl1/a160289.htm
[1263] "Nature reports on BIT materials discipline: high entropy alloys, energy-containing, new nano energy " [Nature 报道北理工材料学科：高熵合金、含能、纳米新能源], *Tencent*, 25 March 2019. https://web.archive.org/web/20190521040518/https://new.qq.com/omn/20190325/20190325A0GQFN.html
[1264] "Implementation of the transformation of the new titanium alloy material and its shaped parts preparation technology by Beihang University of Science and Technology" [北理工新型钛合金材料及其异型件制备技术实施转化, *Beijing Institute of Technology*, 29 November 2018. https://www.bit.edu.cn/xww/zhxw/162813.htm
[1265] "Li Shukui's group in the School of Materials of Beijing Institute of Technology recruits researchers in the field of special metal materials" [北京理工大学材料学院李树奎课题组特种金属材料方向招聘研究人员、研究工程师], *Tencent*, 25 February 2021. https://new.qq.com/omn/20210225/20210225A0BCJ100.html
[1266] "Cai Hongnian" [才鸿年], *Beijing Institute of Technology*, 4 April 2019. https://renshichu.bit.edu.cn/gbszdw/gblyys/b144012.htm
[1267] "A research institute of China's weapons sent scientific researchers to visit and exchange with Golden Molybdenum's technology center" [中国兵器某研究所派出科研人员对金钼股份技术中心进行参观交流], *Jinduicheng Molybdenum Co*., 14 December 2017. http://www.jdcmoly.com/technology/news_info/5/7176.shtml
[1268] "Beihang Institute of Materials Science and Technology publishes research results on ultra-high strength and high entropy alloys in Nature Communications" [北理工材料学院在《自然·通讯》发表超高强高熵合金研究成果], *Beijing Institute of Technology*, 12 October 2018. https://www.bit.edu.cn/xww/xzw/xsjl1/a160289.htm
[1269] "Wang Fuchi" [王富耻], *CIP Net* [中国协同创新网], Accessed 2021, http://expert.irsp.cn/resource/detail/76f43dd4-cec7-4d57-a559-b22afe04eb93
[1270] "A research institute of China's weapons sent scientific researchers to visit and exchange with Golden Molybdenum's technology center" [中国兵器某研究所派出科研人员对金钼股份技术中心进行参观交流], *Jinduicheng Molybdenum Co*., 14 December 2017. http://www.jdcmoly.com/technology/news_info/5/7176.shtml
[1271] "Deepening cooperation in artificial intelligence, detection, communication and other fields, Aerospace Science and Technology signed a strategic cooperation framework agreement with Beijing University of Technology" [深化人工智能、探测、通信等领域合作，航天科工与北京理工大学签署战略合作框架协议], 3SNews [泰伯网], 15 December 2020. http://www.3snews.net/enterprise/363000066439.html
[1272] "Implementation of the transformation of the new titanium alloy material and its shaped parts preparation technology by Beihang University of Science and Technology" [北理工新型钛合金材料及其异型件制备技术实施转化, *Beijing Institute of Technology*, 29 November 2018. https://www.bit.edu.cn/xww/zhxw/162813.htm
[1273] "Prof. Pravansu S. Mohanty, University of Michigan, USA, visited NIT School of Materials" [美国密歇根大学 Pravansu S. Mohanty 教授访问北理工材料学院], *Beijing Institute of Technology*, 12 April 2012. https://www.bit.edu.cn/gbxxgk/gbxysz2/clxy/75258.htm
[1274] "Proceedings of the 2014 International Fall Conference on Experimental Mechanics and International Symposium on Strong Dynamic Loads and Their Effects " [2014 年国际实验力学秋季会议暨国际强动载及其效应研讨会纪要], *Chinese Society of Theoretical and Applied Mechanics* [中国力学学会], 6 November 2014. https://www.cstam.org.cn/article/173369.html

[1275] "2018 International Symposium on Advanced Materials Research" [2018 先进材料研究国际研讨会], International Seminar on Advanced Materials Research, 2 August 2018. http://www.wiucas.ac.cn/uploadfile//2019/0902/20190902031406113.pdf
[1276] "Renowned American materials scientist lectures on "Extreme dynamic behavior of materials studied by high-energy pulsed laser"" [美国著名材料学家讲授"用高能脉冲激光研究材料极端动态行为"], *Beijing Institute of Technology*, 27 April 2018. https://www.bit.edu.cn/xww/zhxw/jxky1/153417.htm
[1277] "Prof. Pervak from Max Planck Institute for Quantum Optics, University of Munich, Germany, visited the School of Materials of Beihang University" [德国慕尼黑大学马普量子光学所 Pervak 教授访问北理工材料学院], *Beijing Institute of Technology*, Accessed 2021, https://www.bit.edu.cn/gbxxgk/gbgljg/gbxysz2/clxy/102752.htm
[1278] "Professor Zhang Xianghua, Director of French National Laboratory of Glass and Ceramics, gave a lecture at Beihang University of Science and Technology" [法国国家玻璃和陶瓷实验室主任章向华教授到北理工做学术报告], *Beijing Institute of Technology*, 16 May 2017. http://webcache.googleusercontent.com/search?q=cache%3Ahttps%3A%2F%2Fwww.bit.edu.cn%2Fxww%2Fxzw%2Fxsjl1%2F140074.htm&rlz=1C1CHBD_enUS895US895&oq=cache%3Ahttps%3A%2F%2Fwww.bit.edu.cn%2Fxww%2Fxzw%2Fxsjl1%2F140074.htm&aqs=chrome..69i57j69i58.1554j0j4&sourceid=chrome&ie=UTF-8
[1279] "The National Key Laboratory of Materials Technology for Impact Environment of Beihang University of Science and Technology is looking for outstanding talents from home and abroad!" [北理工冲击环境材料技术国家级重点实验室诚聘海内外优秀人才!], *Sohu*, 30 April 2020. https://www.sohu.com/a/388142939_427184
[1280] "The National Key Laboratory of Materials Technology for Impact Environment of Beihang University of Science and Technology is looking for outstanding talents from home and abroad!" [北理工冲击环境材料技术国家级重点实验室诚聘海内外优秀人才!], *Sohu*, 30 April 2020. https://www.sohu.com/a/388142939_427184 "Prof. Cheng Xingwang's group in the School of Materials of Beihang University of Science and Technology recruits postdocs in materials chemistry and other disciplines in 2018, 14-20w/year" [北理工材料学院程兴旺教授课题组 2018 年招材料化学等专业博士后，14-20w/年], *sztspi.com*, 7 September 2018. http://www.sztspi.com/archives/159092.html
[1281] "Registration is now open for the "12 National Key Laboratories" event!" ["走进 12 家国家级重点实验室"活动开始报名啦!], *Shangye Xinzhi* [商业新知], 16 May 2019. https://www.shangyexinzhi.com/article/125769.html
[1282] "The construction project of the Key Laboratory of Aerospace Science and Industry Metrology and Calibration Technology for National Defense Science and Technology successfully passed the on-site inspection of the National Defense Science and Industry Administration" [航天科工计量与校准技术国防科技重点实验室建设项目顺利通过国防科工局竣工验收现场审查], *Journal of Astronautic Metrology and Measurement* [宇航计测技术], (32) 2012. https://www.ixueshu.com/document/3750cf6b88dc8b12680d1b2eba3fad5e318947a18e7f9386.html
[1283] "The construction project of the Key Laboratory of Aerospace Science and Industry Metrology and Calibration Technology for National Defense Science and Technology successfully passed the on-site inspection of the National Defense Science and Industry Administration" [航天科工计量与校准技术国防科技重点实验室建设项目顺利通过国防科工局竣工验收现场审查], *Journal of Astronautic Metrology and Measurement* [宇航计测技术], (32) 2012. https://www.ixueshu.com/document/3750cf6b88dc8b12680d1b2eba3fad5e318947a18e7f9386.html
[1284] "About Us" [关于我们], *CASIC 203rd RI* [中国航天科工二院二〇三所], Accessed 2021, https://web.archive.org/web/20170702084442/http://casic203.com/article_list_1.html
[1285] "Addition of Certain Entities; and Modification of Entry on the Entity List," *Industry and Security Bureau, 1 August 2018*. https://www.federalregister.gov/documents/2018/08/01/2018-16474/addition-of-certain-entities-and-modification-of-entry-on-the-entity-list
[1286] "Brief Introduction of Aviation Industry Metrology Institute" [航空工业计量所简介] *Changcheng Institute of Metrology & Measurement* [北京长城计量测试技术研究所], accessed May 2021. http://www.cimm.com.cn/Contents/View.aspx?cid=4&pid=3
[1287] "Metrology and Testing Department" [计量测试部], *China Institute of Atomic Energy* [中国原子能科学研究院], Accessed 2021, http://www.ciae.ac.cn/subpage/danwei_7.htm; "National Defense Science and Technology Industry Ionizing Radiation Level One Metering Station" [国防科技工业电离辐射一级计量站], *China Institute of Atomic Energy* [中国原子能科学研究院], Accessed 2021, http://www.ciae.ac.cn/subpage/shiyanshi_6.htm

[1288] "Metrology and Testing Department" [计量测试部], *China Institute of Atomic Energy* [中国原子能科学研究院], Accessed 2021, http://www.ciae.ac.cn/subpage/danwei_7.htm; "National Defense Science and Technology Industry Ionizing Radiation Level One Metering Station" [国防科技工业电离辐射一级计量站], *China Institute of Atomic Energy* [中国原子能科学研究院], Accessed 2021, http://www.ciae.ac.cn/subpage/shiyanshi_6.htm
[1289] "The construction project of the Key Laboratory of Aerospace Science and Industry Metrology and Calibration Technology for National Defense Science and Technology successfully passed the on-site inspection of the National Defense Science and Industry Administration" [航天科工计量与校准技术国防科技重点实验室建设项目顺利通过国防科工局竣工验收现场审查], *Journal of Astronautic Metrology and Measurement* [宇航计测技术] (32) 2012. https://www.ixueshu.com/document/3750cf6b88dc8b12680d1b2eba3fad5e318947a18e7f9386.html
[1290] "Metrology and Testing Department" [计量测试部], *China Institute of Atomic Energy* [中国原子能科学研究院], Accessed 2021, http://www.ciae.ac.cn/subpage/danwei_7.htm; "National Defense Science and Technology Industry Ionizing Radiation Level One Metering Station" [国防科技工业电离辐射一级计量站], *China Institute of Atomic Energy* [中国原子能科学研究院], Accessed 2021, http://www.ciae.ac.cn/subpage/shiyanshi_6.htm
[1291] "The construction project of the Key Laboratory of Aerospace Science and Industry Metrology and Calibration Technology for National Defense Science and Technology successfully passed the on-site inspection of the National Defense Science and Industry Administration" [航天科工计量与校准技术国防科技重点实验室建设项目顺利通过国防科工局竣工验收现场审查], *Journal of Astronautic Metrology and Measurement* [宇航计测技术] (32) 2012. https://www.ixueshu.com/document/3750cf6b88dc8b12680d1b2eba3fad5e318947a18e7f9386.html
"Completion and acceptance of 203 key laboratories of the Second Academy of Aeronautics and Astronautics to enhance innovative research capabilities" [航天二院 203 所重点实验室竣工验收提升创新性研究能力*], China Quality News Network* [中国质量新闻网], 9 February 2021. http://m.cqn.com.cn/zgzlb/content/2012-02/09/content_1456892.htm
[1292] "Metrology and Testing Department" [计量测试部], *China Institute of Atomic Energy* [中国原子能科学研究院], Accessed 2021, http://www.ciae.ac.cn/subpage/danwei_7.htm; "National Defense Science and Technology Industry Ionizing Radiation Level One Metering Station" [国防科技工业电离辐射一级计量站], *China Institute of Atomic Energy* [中国原子能科学研究院], Accessed 2021, http://www.ciae.ac.cn/subpage/shiyanshi_6.htm
[1293] "Researcher Ma Song from the Institute of Metal Research of the Chinese Academy of Sciences and Researcher Yang Renfu from the Second Academy of Astronautics gave academic reports to the teachers and students of our school" [中国科学院金属研究所马嵩研究员、航天二院杨仁福研究员为我院师生作学术报告], *Zhengzhou Non-ferrous Metals Price Exchange Group* [郑州有色金属价格交流组], 11 July 2020. http://www.hebwjwc.com/jlls/6/xiangqing38036989.htm
"Zhang Shengkang" [张升康], *LinkedIn*, accessed May 2021. https://cn.linkedin.com/in/升康-张-915038b4)
"We are on the road of 100 years | Iron Law of the Iron Institute The Way to the Future Liaoning Railway Institute of Vocational Technology" [百年路上的我们|铁院铁律 大道致远 辽宁铁道职业技术学院], *People's Daily Online – Liaoning Channel* [人民网-辽宁频道], 14 April 2021. http://ln.people.com.cn/n2/2021/0414/c400028-34673880.html
[1294] "Metrology and Testing Department" [计量测试部], *China Institute of Atomic Energy* [中国原子能科学研究院], Accessed 2021, http://www.ciae.ac.cn/subpage/danwei_7.htm; "National Defense Science and Technology Industry Ionizing Radiation Level One Metering Station" [国防科技工业电离辐射一级计量站], *China Institute of Atomic Energy* [中国原子能科学研究院], Accessed 2021, http://www.ciae.ac.cn/subpage/shiyanshi_6.htm
[1295] "Metrology and Testing Department" [计量测试部], *China Institute of Atomic Energy* [中国原子能科学研究院], Accessed 2021, http://www.ciae.ac.cn/subpage/danwei_7.htm; "National Defense Science and Technology Industry Ionizing Radiation Level One Metering Station" [国防科技工业电离辐射一级计量站], *China Institute of Atomic Energy* [中国原子能科学研究院], Accessed 2021, http://www.ciae.ac.cn/subpage/shiyanshi_6.htm
[1296] See the following sources:

1. "2010 Metrology and Testing Academic Exchange Conference" [2010 年计量与测试学术交流会], *China Metrology and Control Network* [中国计量测控网], 11 August 2010. https://web.archive.org/web/20210503234855/http://www.jlck.cn/html/2010-8/35284.html; "2015

2. National Defense Radio, Electrical Metrology and Testing Academic Exchange Conference" [2015 国防无线电、电学计量与测试学术交流会], Huodongjia.com [活动家], Accessed 2021, https://m.huodongjia.com/event-9205308.html
3. "Rohde & Schwarz participated in the "2016 National Defense Metrology and Testing Academic Exchange Conference" [Hard City]" [罗德与施瓦茨公司参加"2016 国防计量与测试学术交流会"【硬之城】], 10 November 2016, *Allchips.com* [硬之城], https://www.allchips.com/news-12-6524.html
4. ""2018 National Defense Metrology and Testing Academic Exchange Conference" was successfully held in Xiamen" ["2018 国防计量与测试学术交流会"在厦门成功举办], *Journal of Astronautic Metrology and Measurement* [宇航计测技术], 2018 年 5 期. http://www.dptsg.com/qikan/0b8bb0a0fb728060bcde1fdc468ec25e.html; "Call for Papers on "2020
5. National Defense Metrology and Testing Conference"" ["2020 国防计量与测试学术交流会"征文通知], *Journal of Astronautic Metrology and Measurement* [宇航计测技术], 2020 年 1 期. http://www.dptsg.com/qikan/5b81284daac561bd576ce3172a4ce72c.html

[1297] Ibid

[1298] "Metrology and Testing Department" [计量测试部], *China Institute of Atomic Energy* [中国原子能科学研究院], Accessed 2021, http://www.ciae.ac.cn/subpage/danwei_7.htm; "National Defense Science and Technology Industry Ionizing Radiation Level One Metering Station" [国防科技工业电离辐射一级计量站], China Institute of Atomic Energy [中国原子能科学研究院], Accessed 2021, http://www.ciae.ac.cn/subpage/shiyanshi_6.htm

[1299] "About Us" [关于我们], *CASIC 203rd RI* [中国航天科工二院二〇三所], Accessed 2021, https://web.archive.org/web/20170702084442/http://casic203.com/article_list_1.html

[1300] "Command and communication system for WSND distinguish oneself," *Key Laboratory of Science and Technology on Micro-System*, 27 October 2017, http://english.sim.cas.cn/laboratory/WSNL/Achievements/201710/t20171030_184983.html

[1301] "Introduction to the Key Laboratory of Microsystems Technology" [微系统技术重点实验室简介], *Key Lab of Microsystems Technology*, 16 June 2016, http://www.sim.ac.cn/kybm2016/wxcgwsyb2016/yjsjj2016/201612/t20161209_4719317.html

[1302] "Introduction to the Key Laboratory of Microsystems Technology" [微系统技术重点实验室简介], *Key Lab of Microsystems Technology*, 16 June 2016, http://www.sim.ac.cn/kybm2016/wxcgwsyb2016/yjsjj2016/201612/t20161209_4719317.html

[1303] "MEMS expert Wang Yuelin: Hundred People Program, help me grow up" [MEMS 专家王跃林：百人计划，助我成长], *Sohu*, 28 August 2018, https://www.sohu.com/a/250421620_256868

[1304] "Introduction to the Key Laboratory of Microsystems Technology" [微系统技术重点实验室简介], *Key Lab of Microsystems Technology*, 16 June 2016, http://www.sim.ac.cn/kybm2016/wxcgwsyb2016/yjsjj2016/201612/t20161209_4719317.html
"Prof. Wang Yuelin was appointed as the Executive Director of Shaoxin Lab" [我校王跃林教授受聘为绍芯实验室执行主任], *Shaoxing University*, 10 November 2022, https://www.usx.edu.cn/info/1138/20981.htm

[1305] "Publications" [论文], *Shanghai Institute of Microsystems*, Accessed June 2024, http://sim.cas.cn/kybm2016/wxcgwsyb2016/kycg2016/lw2016/
"Introduction to the Key Laboratory of Microsystems Technology" [微系统技术重点实验室简介], *Key Lab of Microsystems Technology*, 16 June 2016, http://www.sim.ac.cn/kybm2016/wxcgwsyb2016/yjsjj2016/201612/t20161209_4719317.html

[1306] "Research Overview" [研究所概况], *Shanghai Institute of Microsystems*, Accessed June 2024, http://sim.cas.cn/skjj2016/yjsgk_129504/

[1307] "Research Overview" [研究所概况], *Shanghai Institute of Microsystems*, Accessed June 2024, http://sim.cas.cn/skjj2016/yjsgk_129504/

[1308] "SIMIT Milestones in 2000" [上海微系统所 2000 年大事记], *Shanghai Institute of Microsystems and Information Technology*, Accessed June 2024, http://www.sim.cas.cn/skjj2016/dsj_129512/202004/t20200404_5533805.html

[1309] "Research Projects" [科研项目], *Central South University*, Accessed June 2024, https://faculty.csu.edu.cn/zhangjunchao/zh_CN/zdylm/195917/list/index.htm

[1310] Chen Xinwei [陈昕韡] et al., " Load Balancing Routing Algorithm Based on AODV for Mobile Ad Hoc Network" [基于 AODV 的无线自组织网络负载均衡路由算法], *Computer Engineering* [计算机工程], 13 November 2015, http://www.ecice06.com/CN/10.3969/j.issn.1000-3428.2015.11.025
[1311] "Prof. Wang Yuelin was appointed as the Executive Director of Shaoxin Lab" [我校王跃林教授受聘为绍芯实验室执行主任], *Shaoxing University*, 10 November 2022, https://www.usx.edu.cn/info/1138/20981.htm
[1312] "Introduction to the Key Laboratory of Microsystems Technology" [微系统技术重点实验室简介], *Key Lab of Microsystems Technology*, 16 June 2016, http://www.sim.ac.cn/kybm2016/wxcgwsyb2016/yjsjj2016/201612/t20161209_4719317.html
[1313] "Municipal Bureau of Industry and Information Technology Multi-Initiatives to Promote the Integration of Industry, Academia and Research in the Field of Digital Economy" [市工信局多举措推进数字经济领域产学研融合发展], *Fuzhou Province*, 14 May 20121, http://www.fuzhou.gov.cn/zgfzzt/fzdxxxq/zz/xwdt/202105/t20210514_4099447.htm
[1314] Xiong Lei [熊磊] et al., "Study on Novel MEMS Mass Sensor" [新型 MEMS 质量传感器的研究], *Instrument Technique and Sensor* [仪表技术与传感器], 2011, 8, https://wenku.baidu.com/view/bf1af91559eef8c75fbfb386?pcf=2&fr=xueshu&bfetype=new&bfetype=new&_wkts_=1718135068308&needWelcomeRecommand=1
[1315] "Introduction to the Key Laboratory of Microsystems Technology" [微系统技术重点实验室简介], *Key Lab of Microsystems Technology*, 16 June 2016, http://www.sim.ac.cn/kybm2016/wxcgwsyb2016/yjsjj2016/201612/t20161209_4719317.html
[1316] Chen Xinwei [陈昕韡] et al., " Load Balancing Routing Algorithm Based on AODV for Mobile Ad Hoc Network" [基于 AODV 的无线自组织网络负载均衡路由算法], *Computer Engineering* [计算机工程], 13 Novmber 2015, http://www.ecice06.com/CN/10.3969/j.issn.1000-3428.2015.11.025
"Publications" [论文], *Shanghai Institute of Microsystems*, Accessed June 2024, http://sim.cas.cn/kybm2016/wxcgwsyb2016/kycg2016/lw2016/
"Introduction to the Key Laboratory of Microsystems Technology" [微系统技术重点实验室简介], *Key Lab of Microsystems Technology*, 16 June 2016, http://www.sim.ac.cn/kybm2016/wxcgwsyb2016/yjsjj2016/201612/t20161209_4719317.html
[1317] "2024 Fund Program Guidelines for State Key Laboratory of Microsystems Technology" [微系统技术国家重点实验室 2024 年基金项目指南], *Zao.news*, 6 January 2022, https://zh.zao.news/a/202201/1156857.html
[1318] "Command and communication system for WSND distinguish oneself," *Key Laboratory of Science and Technology on Micro-System*, 27 October 2017, http://english.sim.cas.cn/laboratory/WSNL/Achievements/201710/t20171030_184983.html
[1319] "The Standing Committee of the National People's Congress decides to approve two nuclear power projects; a number of large state-owned banks cut personal deposit rates" [国常会决定核准两个核电项目；多家国有大行下调个人存款利率], *Shenzhen Securities Times*, 15 September 2022, https://www.stcn.com/article/detail/684408.html
[1320] "Introduction to the Key Laboratory of Microsystems Technology" [微系统技术重点实验室简介], *Key Lab of Microsystems Technology*, 16 June 2016, http://www.sim.ac.cn/kybm2016/wxcgwsyb2016/yjsjj2016/201612/t20161209_4719317.html
[1321] "Research Office Director" [研究室主任], *Shanghai Institute of Microsystems*, Accessed June 2024, http://sim.cas.cn/kybm2016/wxcgwsyb2016/gk2016/yjszr2016/
[1322] "Xiaobin Yuan," *Shanghai Institute of Microsystems*, Accessed June 2024, http://english.sim.cas.cn/laboratory/WSNL/People/Researcher/201911/t20191130_226733.html
[1323] "Flexible Materials and Devices Topics" [柔性材料与器件专题], *EET-China*, 31 August 2021, https://www.eet-china.com/mp/a73601.html
[1324] "Talent Database" [人才库], *Shanghai Institute of Microsystems*, Accessed June 2024, http://sourcedb.sim.cas.cn/cn/expert/200907/t20090701_1884373.html
[1325] "The Standing Committee of the National People's Congress decides to approve two nuclear power projects; a number of large state-owned banks cut personal deposit rates" [国常会决定核准两个核电项目；多家国有大行下调个人存款利率], Shenzhen Securities Times, 15 September 2022, https://www.stcn.com/article/detail/684408.html

[1326] "2014 Master's Recruitment" [2014 年硕士招生简章], *Shanghai Institute of Microsystems*, 27 September 2013, http://www.sim.cas.cn/yjs/zsxx/yjs_sszs/201701/t20170112_4734252.html
Wang Wenrong [王文荣] et al., "Research on synthesis of high-quality and large-scale graphene films by chemical vapor deposition" [高质量大面积石墨烯的化学气相沉积制备方法研究], *Acta Physica Sinica* [物理学报], 2012, 61(3), https://wulixb.iphy.ac.cn/article/doi/10.7498/aps.61.038702
[1327] Xiong Lei [熊磊] et al., "Study on Novel MEMS Mass Sensor" [新型 MEMS 质量传感器的研究], *Instrument Technique and Sensor* [仪表技术与传感器], 2011, 8, https://wenku.baidu.com/view/bf1af91559eef8c75fbfb386?pcf=2&fr=xueshu&bfetype=new&bfetype=new&_wkts_=1718135068308&needWelcomeRecommand=1
"Talent Database" [人才库], *Shanghai Institute of Microsystems*, Accessed June 2024, http://sourcedb.sim.cas.cn/cn/expert/200907/t20090701_1884373.html
[1328] "Research Overview" [研究所概况], *Shanghai Institute of Microsystems*, Accessed June 2024, http://sim.cas.cn/skjj2016/yjsgk_129504/
[1329] "About Scifine" [关于事凡], *Scifine*, Accessed June 2024, http://www.scifine.com.cn/site/index
For further evidence of military use, see http://www.scifine.com.cn/site/groupActivity
[1330] "2021 Scholarship Award Ceremony of Shanghai Institute of Microsystems, Chinese Academy of Sciences (CAS)" [2021 年度中科院上海微系统所奖学金举行颁奖仪式], *University of Science and Technology of China*, 30 December 2021, https://sist.ustc.edu.cn/2021/1230/c5146a541716/page.htm
[1331] "The Key Laboratory of Microsystems Technology and the Key Laboratory of Avionics Comprehensive Technology carry out exchanges on the work of state-heavy laboratories" [微系统技术重点实验室与航电综合技术重点实验室开展国重实验室工作交流], *Shanghai Institute of Microsystems*, Accessed June 2024, https://www.sim.ac.cn/xwzx2016/xwkd2016/202106/t20210603_6078978.html
[1332] "The Standing Committee of the National People's Congress decides to approve two nuclear power projects; a number of large state-owned banks cut personal deposit rates" [国常会决定核准两个核电项目；多家国有大行下调个人存款利率], *Shenzhen Securities Times*, 15 September 2022, https://www.stcn.com/article/detail/684408.html
[1333] "Introduction to the Key Laboratory of Microsystems Technology" [微系统技术重点实验室简介], *Key Lab of Microsystems Technology*, 16 June 2016, http://www.sim.ac.cn/kybm2016/wxcgwsyb2016/yjsjj2016/201612/t20161209_4719317.html
[1334] "Cooperation Partners" [合作伙伴], *Scifine*, Accessed June 2024, http://www.scifine.com.cn/site/partner/14
[1335] "Test Platform" [测试平台], *Shanghai Institute of Microsystems*, Accessed June 2024, http://sim.cas.cn/kybm2016/wxcgwsyb2016/yjpt2016/cspt/
[1336] "Contact," *Shanghai Institute of Microsystems*, Accessed June 2024, http://english.sim.cas.cn/laboratory/WSNL/AU/Contact/
[1337] "Huaguang signed a contract to build the Jinan Research Center of State Key Laboratory of Solid State Laser Technology" [华光光电签约共建固体激光技术国家重点实验室济南研究中心], *OF Week*, 28 June 2022, https://laser.ofweek.com/2022-06/ART-8120-2400-30566027.html
[1338] "Huaguang signed a contract to build the Jinan Research Center of State Key Laboratory of Solid State Laser Technology" [华光光电签约共建固体激光技术国家重点实验室济南研究中心], *OF Week*, 28 June 2022, https://laser.ofweek.com/2022-06/ART-8120-2400-30566027.html
[1339] "Group News | Innovation breakthrough, they are very confident in the key laboratory" [集团动态 | 创新突破，身在重点实验室的他们很有信心], *Sohu*, 15 August 2019, https://www.sohu.com/a/333996317_779538
[1340] "Huaguang signed a contract to build the Jinan Research Center of State Key Laboratory of Solid State Laser Technology" [华光光电签约共建固体激光技术国家重点实验室济南研究中心], *OF Week*, 28 June 2022, https://laser.ofweek.com/2022-06/ART-8120-2400-30566027.html
[1341] "Chief Innovation Officer" Special Recommendation丨Qin Peng: Community Collaboration and Innovation to Build a New Engine for Laser Industry" ["首席创新官"特别推荐丨秦鹏：共同体协同创新，打造激光产业新引擎], *HWIEIC*, 16 August 2022, https://www.hwleic.net/news/xinwen/shandong_dazaochuangxinchuangyegongtongti_funeng_shiqiang_chanyefazhan_laojizhutuozouzaiqian_yongdanshimingkaixinju_.html

[1342] "North China Institute of Optoelectronic Technology" [华北光电技术研究所简介], *Kaoyan*, Accessed March 2024, https://m.kaoyan.com/yanzhao/ncrieo/jianjie/
[1343] "2.7 billion project settled here in Shunyi, bringing many job opportunities" [27 亿项目落户顺义这里，带来众多工作机会], *Sohu*, 2 July 2019, https://www.sohu.com/a/324363166_99986045
[1344] "Zhongguancun Shunyi Park 10 projects cloud signing total investment of more than 11 billion yuan" [中关村顺义园 10 个项目云签约 总投资额 110 余亿元], *Sohu*, 22 April 2020, https://www.sohu.com/a/390248276_99965849
[1345] "Beijing Innovation Industry Cluster Demonstration Zone (Shunyi) "New Products, New Technologies, New Scenarios" List Released" [北京创新产业集群示范区（顺义）"新产品新技术新场景"名录发布], *Beijing Daily*, 9 January 2023, https://bj.bjd.com.cn/5b165687a010550e5ddc0e6a/contentShare/5e719732e4b05e1038541c55/AP63bbc670e4b0fb99eeb317e6.html
[1346] "Nankai professor's interesting talk about physics, Tieyi students benefited a lot" [南开教授趣谈物理，铁一学子受益匪浅], *Luzhou Tieyi Senior High School*, 10 November 2016, https://ltyz.gx.cn/Item/500.aspx
[1347] "Huaguang signed a contract to build the Jinan Research Center of State Key Laboratory of Solid State Laser Technology" [华光光电签约共建固体激光技术国家重点实验室济南研究中心], *OF Week*, 28 June 2022, https://laser.ofweek.com/2022-06/ART-8120-2400-30566027.html
[1348] Zhao Hong [赵鸿] et al., "Research and Application of High Power Solid State Laser Technology" [高功率固体激光器技术研究与应用], *Infrared and Laser Engineering*, 2008 (Z3), http://www.alljournals.cn/view_abstract.aspx?pcid=5B3AB970F71A803DEACDC0559115BFCF0A068CD97DD29835&cid=1319827C0C74AAE8D654BEA21B7F54D3&jid=BCF8D62FB6050DC84A8E3BCBFE191837&aid=FF26F09C5583DB5FDCC272EC538FF00E&yid=67289AFF6305E306&vid=&iid=&sid=&eid=&from_absract=1
[1349] Xiang Jinsong [向劲松], Hu Yu [胡渝], "An Optimization of Optically Preamplified Laser Satellite Communication Systems" [带前置光放大的卫星激光通信系统的优化], *Journal of University of Electronic Science and Technology of China* [电子科技大学学报], 2006 35(4), http://www.juestc.uestc.edu.cn/article/id/2209
[1350] "Chief Innovation Officer" Special Recommendation丨Qin Peng: Community Collaboration and Innovation to Build a New Engine for Laser Industry" ["首席创新官"特别推荐丨秦鹏：共同体协同创新，打造激光产业新引擎], *HWIEIC*, 16 August 2022, https://www.hwleic.net/news/xinwen/shandong_dazaochuangxinchuangyegongtongti_funeng_shiqiang_chanyefazhan_laojizhutuozouzaiqian_yongdanshimingkaixinju_.html
[1351] "Group News | Innovation breakthrough, they are very confident in the key laboratory" [集团动态 | 创新突破，身在重点实验室的他们很有信心], *Sohu*, 15 August 2019, https://www.sohu.com/a/333996317_779538
[1352] "Huaguang signed a contract to build the Jinan Research Center of State Key Laboratory of Solid State Laser Technology" [华光光电签约共建固体激光技术国家重点实验室济南研究中心], *OF Week*, 28 June 2022, https://laser.ofweek.com/2022-06/ART-8120-2400-30566027.html
"Successful signing! State Key Laboratory of Solid State Laser Technology to set up research center in Jinan" [成功签约！固体激光技术国家重点实验室将在济南设立研究中心], *thepaper.cn*, 24 June 2022, https://m.thepaper.cn/baijiahao_18726460?sdkver=e06426d6&clientprefetch=1
"State Key Laboratory of Solid State Laser Technology to set up Jinan Research Center" [固体激光技术国家重点实验室将设立济南研究中心], *Sohu*, 25 June 2022, https://www.sohu.com/a/560799447_261880
[1353] Mi Guojiang [秘国江] et al., "High repetition frequency and high energy mode-locked laser technology" [高重复频率大能量锁模激光器技术], *Chinese Journal of Lasers* [中国激光] 2009 7, https://d.wanfangdata.com.cn/periodical/ChlQZXJpb2RpY2FsQ0hJTmV3UzIwMjMxMjI2Eg16Z2pnMjAwOTA3MDM5Ggg5bG5pcW1qOQ%3D%3D
[1354] "National Key Laboratory of Intelligent Marine Vehicle Technology" [智能海洋航行器技术全国重点实验室], *Harbin Engineering University*, 8 March 2024, https://web.archive.org/web/20240915021300/http://sec.hrbeu.edu.cn/2015/1204/c469a1096/page.htm
[1355] Chen Qianxin [陈潜心], The Department of Science and Technology Quality of the National Defense Bureau of Science and Industry came to the university to investigate the key laboratory construction project of underwater intelligent robotics [国防科工局科技质量司来校调研水下智能机器人技术国防科技重点实验室建设项目],

*Harbin Engineering University*, 23 April 2009.
http://webcache.googleusercontent.com/search?q=cache%3Anews.hrbeu.edu.cn%2Finfo%2F1141%2F61926.htm&rlz=1C1CHBD_enUS895US895&oq=cache%3Anews.hrbeu.edu.cn%2Finfo%2F1141%2F61926.htm&aqs=chrome..69i57j69i58.2735j0j4&sourceid=chrome&ie=UTF-8
"National Defense Science and Technology Key Laboratory of Underwater Robotics" [水下机器人技术国防科技重点实验室], *Harbin Engineering University*, Accessed 2021,
https://web.archive.org/web/20190520064036/http://www.hrbeu.edu.cn/kxyj/sxjqr.aspx
"Key Laboratory of Underwater Robotics undergoes on-site evaluation" [我校水下机器人技术重点实验室接受现场评估], *Harbin Engineering University*, 21 October 2015,
http://www.zzyedu.com.cn/xxfile/news_92_175_8816.html
[1356] "National Key Laboratory of Intelligent Marine Vehicle Technology" [智能海洋航行器技术全国重点实验室], *Harbin Engineering University*, 8 March 2024,
https://web.archive.org/web/20240915021300/http://sec.hrbeu.edu.cn/2015/1204/c469a1096/page.htm
[1357] "Key Laboratory of Underwater Robotics undergoes on-site evaluation" [我校水下机器人技术重点实验室接受现场评估], *Harbin Engineering University*, 21 October 2015,
http://www.zzyedu.com.cn/xxfile/news_92_175_8816.html
[1358] "The ocean is an endless treasure that we will spend our lives exploring"" ["海洋是无尽的宝藏，我们要用一生去探求"], *Harbin Engineering University*, 27 October 2017,
http://webcache.googleusercontent.com/search?q=cache:Owd9iKxnjGoJ:news.hrbeu.edu.cn/info/1082/7434.htm+&cd=5&hl=en&ct=clnk&gl=us
"Pioneer Education Team: Notes on the "Underwater Intelligent Robotics" National Defense Science and Technology Key Laboratory team" [先锋教科团队：记"水下智能机器人技术"国防科技重点实验室团队], *Harbin Engineering University*, 29 April 2011,
http://webcache.googleusercontent.com/search?q=cache%3Ahttp%3A%2F%2Fnews.hrbeu.edu.cn%2Finfo%2F1141%2F59822.htm&rlz=1C1CHBD_enUS895US895&oq=cache%3Ahttp%3A%2F%2Fnews.hrbeu.edu.cn%2Finfo%2F1141%2F59822.htm&aqs=chrome..69i57j69i58.4140j0j4&sourceid=chrome&ie=UTF-8
[1359] Hai Huang, Gerd Hirzinger et al., "An anthropomorphic controlled hand prosthesis system," *Journal of Zhejiang University*, 2012 (13),
http://www.jzus.zju.edu.cn/oldversion/article.php?doi=10.1631/jzus.C1100257&refdsp=ALL&comnowpage=0
[1360] Xu Yuru [徐玉如] et al., "AUV-State of the Art and Prospect," *Journal of Intelligent Systems* [智能系统学报], March 2006 (1), https://max.book118.com/html/2016/0122/33838360.shtm
[1361] Jonathan Ray et al., "China's Industrial and Military Robotics Development," *U.S.-China Economic and Security Review Commission*, October 2016.
https://www.uscc.gov/sites/default/files/Research/DGI_China's%20Industrial%20and%20Military%20Robotics%20Development.pdf
[1362] "Harbin Engineering University," *Australian Strategic Policy Institute*, Accessed 2021,
https://unitracker.aspi.org.au/universities/harbin-engineering-university/
[1363] "National Key Laboratory of Intelligent Marine Vehicle Technology" [智能海洋航行器技术全国重点实验室], *Harbin Engineering University*, 8 March 2024,
https://web.archive.org/web/20240915021300/http://sec.hrbeu.edu.cn/2015/1204/c469a1096/page.htm
[1364] "Just now! This Chinese university, again, won the world championship!" [刚刚！这所中国高校，又夺世界冠军!], *Guancha.cn*, 5 August 2019. https://www.guancha.cn/politics/2019_08_05_512376.shtml?s=zwyxgtjdt
"2019 RoboSub | Harbin Engineering University," *Youtube*, 28 July 2019.
https://www.youtube.com/watch?v=HVzQd87bgG0. Pool in video matches pool seen in
https://web.archive.org/web/20190520064036/http://www.hrbeu.edu.cn/kxyj/sxjqr.aspx
[1365] Chen Qianxin [陈潜心], The Department of Science and Technology Quality of the National Defense Bureau of Science and Industry came to the university to investigate the key laboratory construction project of underwater intelligent robotics [国防科工局科技质量司来校调研水下智能机器人技术国防科技重点实验室建设项目], Harbin Engineering University, 23 April 2009.
http://webcache.googleusercontent.com/search?q=cache%3Anews.hrbeu.edu.cn%2Finfo%2F1141%2F61926.htm&r

lz=1C1CHBD_enUS895US895&oq=cache%3Anews.hrbeu.edu.cn%2Finfo%2F1141%2F61926.htm&aqs=chrome..69i57j69i58.2735j0j4&sourceid=chrome&ie=UTF-8

[1366] "National Key Laboratory of Intelligent Marine Vehicle Technology" [智能海洋航行器技术全国重点实验室], Harbin Engineering University, 8 March 2024, https://web.archive.org/web/20240915021300/http://sec.hrbeu.edu.cn/2015/1204/c469a1096/page.htm

[1367] "Key Laboratory of Underwater Robotics for National Defense Technology" [水下机器人技术国防科技重点实验室], *Harbin Engineering University College of Marine Engineering* [哈尔滨工程大学船舶工程学院], 16 March 2016. http://webcache.googleusercontent.com/search?q=cache%3Asec.hrbeu.edu.cn%2F2015%2F1204%2Fc469a1096%2Fpage.htm&rlz=1C1CHBD_enUS895US895&oq=cache%3Asec.hrbeu.edu.cn%2F2015%2F1204%2Fc469a1096%2Fpage.htm&aqs=chrome.0.69i59j69i58j69i60.1680j0j4&sourceid=chrome&ie=UTF-8

[1368] "Key Laboratory of Underwater Robotics for National Defense Technology" [水下机器人技术国防科技重点实验室], *Harbin Engineering University College of Marine Engineering* [哈尔滨工程大学船舶工程学院], 16 March 2016. http://webcache.googleusercontent.com/search?q=cache%3Asec.hrbeu.edu.cn%2F2015%2F1204%2Fc469a1096%2Fpage.htm&rlz=1C1CHBD_enUS895US895&oq=cache%3Asec.hrbeu.edu.cn%2F2015%2F1204%2Fc469a1096%2Fpage.htm&aqs=chrome.0.69i59j69i58j69i60.1680j0j4&sourceid=chrome&ie=UTF-8

"Pioneer Education Team: Notes on the "Underwater Intelligent Robotics" National Defense Science and Technology Key Laboratory team" [先锋教科团队：记“水下智能机器人技术”国防科技重点实验室团队], *Harbin Engineering University*, 29 April 2011. http://webcache.googleusercontent.com/search?q=cache%3Ahttp%3A%2F%2Fnews.hrbeu.edu.cn%2Finfo%2F1141%2F59822.htm&rlz=1C1CHBD_enUS895US895&oq=cache%3Ahttp%3A%2F%2Fnews.hrbeu.edu.cn%2Finfo%2F1141%2F59822.htm&aqs=chrome..69i57j69i58.4140j0j4&sourceid=chrome&ie=UTF-8

[1369] "Stabilization Support Program for National Key Laboratory of Intelligent Marine Vehicle Technology FY2025 Project Declaration Guidelines" [智能海洋航行器技术全国重点实验室稳定支持计划 2025 年度项目申报指南], *Harbin Engineering University*, 31 May 2024, https://web.archive.org/web/20240819073107/http://sec.hrbeu.edu.cn/2024/0531/c229a326034/page.htm

[1370] "Good News! Harbin Engineering University developed the “Submarine Air-to-Space Transmedia Unmanned Vehicle” and successfully flew it!" [喜报！哈尔滨工程大学研发“潜空跨介质无人航行器”试飞成功!], *Sohu*, 5 November 2022, https://www.sohu.com/a/603020231_726570

[1371] Xu Yuru [徐玉如] et al., "AUV-State of the Art and Prospect," Journal of Intelligent Systems [智能系统学报], March 2006 (1). https://max.book118.com/html/2016/0122/33838360.shtm

[1372] "The mysterious HSU001 unmanned underwater vehicle, in fact, is not mysterious" [神秘的 HSU001 无人潜航器，其实并不神秘], *Guancha.cn* [观察], 4 October 2019. https://user.guancha.cn/main/content?id=181477. See also this article, which contains an apparent screengrab from a Harbin Engineering University webpage touting the University's involvement in this program: 【机器人】哈工程 全国第 2 ？ , Zhihu, Accessed 2021, https://www.zhihu.com/question/424045600/answer/1505747041

[1373] "Cool! The "Wukong" will be the world's first unmanned submersible to "visit" the deepest sea floor next year" [牛！哈工程“悟空”明年将进行万米深潜丨将成为世界首台“作客”最深海底的无人潜水器], Sohu, 29 November 2019. https://www.sohu.com/a/357316696_349336

[1374] Jonathan Ray et al., "China’s Industrial and Military Robotics Development," *U.S.-China Economic and Security Review Commission*, October 2016. https://www.uscc.gov/sites/default/files/Research/DGI_China's%20Industrial%20and%20Military%20Robotics%20Development.pdf

"Pioneer Education Team: Notes on the "Underwater Intelligent Robotics" National Defense Science and Technology Key Laboratory team" [先锋教科团队：记“水下智能机器人技术”国防科技重点实验室团队], *Harbin Engineering University*, 29 April 2011. http://webcache.googleusercontent.com/search?q=cache%3Ahttp%3A%2F%2Fnews.hrbeu.edu.cn%2Finfo%2F1141%2F59822.htm&rlz=1C1CHBD_enUS895US895&oq=cache%3Ahttp%3A%2F%2Fnews.hrbeu.edu.cn%2Finfo%2F1141%2F59822.htm&aqs=chrome..69i57j69i58.4140j0j4&sourceid=chrome&ie=UTF-8

[1375] " 9 experts gathered to discuss advanced emergency rescue equipment at High-Tech Fair Emergency Safety Technology Exhibition 2020" [9 位专家齐聚一堂，论道先进应急救援装备 高交会应急安全科技展 2020], *Sohu*,

18 November 2020. https://www.sohu.com/a/432613372_120152776?spm=smpc.author.fd-d.7.1609286400032Zw5NOp7

[1376] "The appointment ceremony of Li Ye Chair Professor was held by our university" [我校举行李晔讲座教授聘任仪式], *Dalian Maritime University* [大连海事大学], 28 April 2019. http://teoec.dlmu.edu.cn/info/1048/3194.htm

[1377] "School of Marine Engineering"" [船舶工程学院], *Harbin Engineering University*, Accessed 2021, https://mweb.eol.cn/2524/article/151430.html

[1378] "Good News! Harbin Engineering University developed the "Submarine Air-to-Space Transmedia Unmanned Vehicle" and successfully flew it!" [喜报！哈尔滨工程大学研发"潜空跨介质无人航行器"试飞成功!], *Sohu*, 5 November 2022, https://www.sohu.com/a/603020231_726570

[1379] "The ocean is an endless treasure that we will spend our lives exploring"" ["海洋是无尽的宝藏，我们要用一生去探求"], *Harbin Engineering University*, 27 October 2017. http://webcache.googleusercontent.com/search?q=cache:Owd9iKxnjGoJ:news.hrbeu.edu.cn/info/1082/7434.htm+&cd=5&hl=en&ct=clnk&gl=us

[1380] "Su Yumin" [苏玉民], *Innovation Talent* [创新人才], Accessed 2021, http://expert.irsp.cn/resource/detail/fc671899-4021-4189-bd1c-3ead0f6b3c56

"Key Laboratory of Underwater Robotics undergoes on-site evaluation" [我校水下机器人技术重点实验室接受现场评估], Harbin Engineering University, 21 October 2015, http://www.zzyedu.com.cn/xxfile/news_92_175_8816.html

[1381] "Deep-sea unmanned equipment industry alliance established in Sanya" [深远海无人装备产业联盟在三亚成立], *Xinhua*, 16 December 2024, http://hq.news.cn/20241216/989351e8156a4aa2930a1d6dab704d59/c.html

[1382] "Seafloor terrain-assisted navigation technology for deep-sea exploration and exploitation equipment" [海底地形辅助导航技术，为深海探测与开发装备指路引航], *Hohai University*, 28 November 2022, https://ghxy.hhu.edu.cn/2022/1128/c5653a252320/page.htm

[1383] "Pioneer Education Team: Notes on the "Underwater Intelligent Robotics" National Defense Science and Technology Key Laboratory team" [先锋教科团队：记"水下智能机器人技术"国防科技重点实验室团队], *Harbin Engineering University*, 29 April 2011. http://webcache.googleusercontent.com/search?q=cache%3Ahttp%3A%2F%2Fnews.hrbeu.edu.cn%2Finfo%2F1141%2F59822.htm&rlz=1C1CHBD_enUS895US895&oq=cache%3Ahttp%3A%2F%2Fnews.hrbeu.edu.cn%2Finfo%2F1141%2F59822.htm&aqs=chrome..69i57j69i58.4140j0j4&sourceid=chrome&ie=UTF-8

[1384] "National Defense Science and Technology Key Laboratory of Underwater Robotics" [水下机器人技术国防科技重点实验室], *Harbin Engineering University*, Accessed 2021, https://web.archive.org/web/20190520064036/http://www.hrbeu.edu.cn/kxyj/sxjqr.aspx

[1385] "Stabilization Support Program for National Key Laboratory of Intelligent Marine Vehicle Technology FY2025 Project Declaration Guidelines" [智能海洋航行器技术全国重点实验室稳定支持计划 2025 年度项目申报指南], *Harbin Engineering University*, 31 May 2024, https://web.archive.org/web/20240819073107/http://sec.hrbeu.edu.cn/2024/0531/c229a326034/page.htm

[1386] "Third Asia-Pacific Conference on Antennas and Propagation," *IEEE*, 26 July 2014, http://www.iccsnt.org/APCAP2014/ShowArticle.asp?ArticleID=231

[1387] "CASIC 25th RI youth team" [中国航天科工二院 25 所青春团队], *China National Space Administration*, 23 May 2013, cache:https://www.cnsa.gov.cn/n6758823/n6758838/c6770911/content.html

[1388] "CASIC 2nd Academy Introduction" [中国航天科工二院简介], *China Economy Online* [中国经济网], 14 October 2014, http://www.ce.cn/cysc/ztpd/14zt/htkg/dt/201410/14/t20141014_3698836.shtml

[1389] "The 25th Institute of the Second Academy of CASIC-University of Electronic Science and Technology of China jointly established the Joint Laboratory of Advanced Detection and Guidance" [中国航天科工二院二十五所-电子科技大学联合共建先进探测与导引联合实验室], *University of Electronic Science and Technology of China*, 19 December 2023, https://icse.uestc.edu.cn/info/1049/4324.htm

[1390] "The Second Academy of CASIC" [中国航天科工集团第二研究院简介], *Kaoyan.com*, 22 April 2014. https://yz.kaoyan.com/casicedu/jianjie/

"CASIC 2nd Academy Introduction" [中国航天科工二院简介], China Economy Online [中国经济网], 14 October 2014, http://www.ce.cn/cysc/ztpd/14zt/htkg/dt/201410/14/t20141014_3698836.shtml

[1391] "CHINA CHANGFENG MECHANICS AND ELECTRONICS TECHNOLOGY ACADEMY," *NTI*, Accessed August 2021. https://www.nti.org/learn/facilities/65/
[1392] "CASIC 25th Institute 2024 Campus Recruitment" [中国航天科工二院二十五所 2024 届校园招聘], *Peking University*, 8 March 2024, https://scc.pku.edu.cn/employment_22e903458df96e54018e1cd88ac921bd_0.html
[13931393] Luo Chenggao [罗成高] et al., "Advancing imaging and detecting technology for precision guidance" [精确制导前沿成像探测技术'], *Journal of National University of Defense Technology* [国防科技大学学报], October 2019, 41(5), journal.nudt.edu.cn/js/pdf/web/viewer.aspx?file_no=201905025&journal_id=gfkjdxxb
[1394] Zhang Hui [张慧] et al., "Research on W-Band FMCW ISAR System Imaging and Outfield Experiment" [W 波段 FMCW 体制 ISAR 系统成像及试验验证], *Aerospace Shanghai* [上海航天], 2018, 6, https://space.alljournals.cn/view_abstract.aspx?pcid=26FCEE7E0C06EA5863D91553F1CAF79C693AA6D910AD699D&cid=433C7FE4A4A0ED97&jid=35255C455B765C08CEB67497D203030E&aid=BE86B92BD3C50FD573EBF0E42679316E&yid=EA357AD73C8E13BC&iid=B31275AF3241DB2D&sid=B91E8C6D6FE990DB&eid=771469D9D58C34FF&referenced_num=%E6%80%BB%E8%A2%AB%E5%BC%95%EF%BC%9A1%EF%BC%8C%E8%87%AA%E5%BC%95%EF%BC%9A1%EF%BC%8C%E4%BB%96%E5%BC%95%EF%BC%9A0
[1395] Li Yueli [李悦丽] et al., "Forward-looking Imaging via Doppler Estimates of Sum-difference Measurements in Scanning Monopulse Radar" [基于单脉冲雷达和差通道多普勒估计的前视成像], *Journal of Radars* [雷达学报], 2021, 10(1), https://radars.ac.cn/cn/article/doi/10.12000/JR20111
[1396] "Representatives and members of the Internet information丨How to use 5G technology? Representatives and members say this" [代表委员谈网信丨如何用好 5G 技术？代表委员这样说], *Tibetan AR Office of Tourism Development*, 26 May 2020, https://lyfzt.xizang.gov.cn/ztzl_69/2020huiyi/202005/t20200526_141878.html
[1397] "Aerospace Defense Communication and Cooperative Detection Technology Forum Held in Weihai" [航天防务通信与协同探测技术论坛在威海举办], *China Daily*, 23 August 2023, http://cn.chinadaily.com.cn/a/202308/23/WS64e5f7d0a3109d7585e4a7bd.html
[1398] "Mr. Dong Shengbo: Building an Open, Collaborative and Shared Innovation Platform and Fostering a Collaborative Innovation Ecology" [董胜波委员：打造开放协作共享创新平台 培育协同创新生态], *S&T Daily*, 4 March 2022, http://stdaily.com/index/kejixinwen/202203/65b58e0a71ab4806823e20159523aef2.shtml
[1399] "Dr. Yue Zhao's Latest 2024 Comprehensive Analysis" [赵越博士最新 2024 年全方位解析], *Xuexivip*, 8 March 2024, https://m.xuexivip.cn/e/action/ShowInfo.php?classid=456&id=40654&act=910&act=910
[1400] "CASIC Committee: Forging Souls for Youth, Forging Swords for Great Powers" [航天科工团委：为青年铸魂，为大国铸剑, *Anhui Jingwen Education Technology Equipment Co*. [安徽省京文教育技术装备有限公司], August 2022, https://www.ahszyd.com/home/periodical/articleDetail?articleId=3759022
[1401] Li Yueli [李悦丽] et al., "Forward-looking Imaging via Doppler Estimates of Sum-difference Measurements in Scanning Monopulse Radar" [基于单脉冲雷达和差通道多普勒估计的前视成像], *Journal of Radars* [雷达学报], 2021, 10(1), https://radars.ac.cn/cn/article/doi/10.12000/JR20111
[1402] "The 25th Institute of the Second Academy of CASIC-University of Electronic Science and Technology of China jointly established the Joint Laboratory of Advanced Detection and Guidance" [中国航天科工二院二十五所-电子科技大学联合共建先进探测与导引联合实验室], *University of Electronic Science and Technology of China*, 19 December 2023, https://icse.uestc.edu.cn/info/1049/4324.htm
[1403] "Aerospace Defense Communication and Cooperative Detection Technology Forum Held in Weihai" [航天防务通信与协同探测技术论坛在威海举办], *China Daily*, 23 August 2023, http://cn.chinadaily.com.cn/a/202308/23/WS64e5f7d0a3109d7585e4a7bd.html
[1404] "Notice of the Second National Innovation and Creativity Competition of Air and Space Cup" [第二届"空天杯"全国创新创意大赛通知], *Chinese Society of Astronautics*, 29 April 2019, http://www.csaspace.org.cn/n2489262/n2489297/c2617370/content.html
[1405] "Forum on Advanced Air and Space Defense Technology" [先进空天防御技术高端论坛], *Chinese Society of Optical Engineering*, 2019, https://b2b.csoe.org.cn/meeting/show-45.html
[1406] "2023 The 16th IEEE International Conference on Electronic Measurement and Instrumentation was successfully held in Harbin, China" [2023 第 16 届 IEEE 国际电子测量与仪器学术会议在哈尔滨圆满召开], *Chinese Journal of Scientific Instrument* [仪器仪表学报], 2023, http://yqyb.etmchina.com/yqyb/news/view/20230905133326001

[1407] "CASIC 25th RI youth team" [中国航天科工二院 25 所青春团队], *China National Space Administration*, 23 May 2013, cache:https://www.cnsa.gov.cn/n6758823/n6758838/c6770911/content.html
[1408] "National Key Laboratory of Spectral Information Intelligent Processing Technology, Huazhong University of Science and Technology, China, Recruitment of Full-time Faculty in 2025" [华中科技大学谱信息智能处理技术全国重点实验室 2025 年招聘专任教师启事], *Gaoxiao Job*, 26 December 2024, https://www.gaoxiaojob.com/announcement/detail/281309.html
[1409] "National Key Laboratory of Multispectral Information Processing Technology" [多谱信息处理技术国家级重点实验室], *School of Artificial Intelligence and Automation, HUST* [华中科技大学人工智能与自动化学院], accessed April 2021. http://aia.hust.edu.cn/yxgk/xkjd/dpxxcljsgjjz.htm
[1410] "National Key Laboratory of Spectral Information Intelligent Processing Technology, Huazhong University of Science and Technology, China, Recruitment of Full-time Faculty in 2025" [华中科技大学谱信息智能处理技术全国重点实验室 2025 年招聘专任教师启事], *Gaoxiao Job*, 26 December 2024, https://www.gaoxiaojob.com/announcement/detail/281309.html
[1411] "National Key Laboratory of Multispectral Information Processing Technology" [多谱信息处理技术国家级重点实验室], *School of Artificial Intelligence and Automation, HUST* [华中科技大学人工智能与自动化学院], accessed April 2021. http://aia.hust.edu.cn/yxgk/xkjd/dpxxcljsgjjz.htm
[1412] "Scan of the Institute of Pattern Recognition and Artificial Intelligence at 30 years" [图像识别与人工智能研究所成立 30 年扫描], *School History Research Office (HUST)* [校史研究室], 26 January 2015. https://archive.fo/CnbIR
[1413] "Two championships and a runner-up! HUST!" [两冠一亚！华科大！], *China Youth Online* [钟琴在线], 30 June 2023, http://m.cyol.com/gb/articles/2023-06/30/content_99mKxLTaom.html
[1414] "Introduction to School" [本院简介], *HUST School of Artificial Intelligence and Automation* [华中科技大学人工智能与自动化学院], Accessed 2021, http://aia.hust.edu.cn/yxgk/byjj.htm / http://english.aia.hust.edu.cn/About/Director_s_Message.htm (English)
[1415] "National "XXXX" System Huazhong University of Science and Technology Institute of Image Recognition and Artificial Intelligence" [国家"XXXX"系统 华中科大图像识别与人工智能研究所], *Huazhong University of Science & Technology Overseas Alumni Network* [华中科技大学海外校友网], 21 January 2009. https://web.archive.org/web/20190607004407/http:/www.hust.org/forum/A0/p1/html/1799.html
"Department of Intelligent Science and Technology" [智能科学与技术系], *HUST School of Artificial Intelligence and Automation* [华中科技大学人工智能与自动化学院], Accessed 2021, http://aia.hust.edu.cn/yxgk/gxjj/znkxyjsx.htm
"National "XXXX" System Huazhong University of Science and Technology Institute of Image Recognition and Artificial Intelligence" [国家"XXXX"系统 华中科大图像识别与人工智能研究所], *Huazhong University of Science & Technology Overseas Alumni Network* [华中科技大学海外校友网], 21 January 2009. https://web.archive.org/web/20190607004407/http:/www.hust.org/forum/A0/p1/html/1799.html
[1416] "Professor Wang Yanwu was a guest of our school to talk about the construction of automation subject" [王燕舞教授做客我校谈自动化学科建设], *Engineering College* [工学院], 19 June 2017. http://news.hzau.edu.cn/2017/0619/49530.shtml
[1417] "National Key Laboratory of Spectral Information Intelligent Processing Technology, Huazhong University of Science and Technology, China, Recruitment of Full-time Faculty in 2025" [华中科技大学谱信息智能处理技术全国重点实验室 2025 年招聘专任教师启事], *Gaoxiao Job*, 26 December 2024, https://www.gaoxiaojob.com/announcement/detail/281309.html
[1418] "National Key Laboratory of Spectral Information Intelligent Processing Technology, Huazhong University of Science and Technology, China, Recruitment of Full-time Faculty in 2025" [华中科技大学谱信息智能处理技术全国重点实验室 2025 年招聘专任教师启事], *Gaoxiao Job*, 26 December 2024, https://www.gaoxiaojob.com/announcement/detail/281309.html
[1419] Zeng Uajie [曾雅洁] et al., "Ultrasonic carotid artery image level set segmentation method based on local Chan-Vese model" [基于局部 Chan-Vese 模型的超声颈动脉图像水平集分割方法研究], *Computer Science* [计算机科学] (40) 2013. http://www.jsjkx.com/CN/article/openArticlePDF.jsp?id=5542
[1420]

"Efficient Fast Algorithm of the Forward MDCT" [一种有效的 MDCT 快速算法], The 14th National Conference on Image and Graphics [第十四届全国图象图形学学术会议], May 2008.
"Research on Ultrasound Carotid Image Segmentation Methods Based on Local Chan-Vese Model Using Level Set Method" [基于局部 Chan-Vese 模型的超声颈动脉图像 水平集分割方法研究], *Computer Science* [计算机科学], Vo1. 40 No.11A Nov 2013.
[1421] "Introduction to School" [本院简介], *HUST School of Artificial Intelligence and Automation* [华中科技大学人工智能与自动化学院], accessed April 2021. http://aia.hust.edu.cn/yxgk/byjj.htm / http://english.aia.hust.edu.cn/About/Director_s_Message.htm (English)
[1422] "National Key Laboratory of Micro Nanofabrication Technology" [微米纳米加工技术全国重点实验室], *Shanghai Jiao Tong University*, 25 October 2023, https://www.seiee.sjtu.edu.cn/kyjd_gjj/85.htm
[1423] "National Key Laboratory of Advanced Micro and Nano Manufacture Technology" [微米纳米加工技术全国重点实验室], *Shanghai Jiao Tong University*, 25 October 2023, https://www.seiee.sjtu.edu.cn/kyjd_gjj/85.html
[1424] "Lab overview" [实验室概况], *Shanghai Jiao Tong University*, Accessed July 2018, https://web.archive.org/web/20180729064751/http://mnfab.sjtu.edu.cn/cn/content.aspx?info_lb=1&flag=1
[1425] "Lab overview" [实验室概况], *Shanghai Jiao Tong University*, Accessed July 2018, https://web.archive.org/web/20180729064751/http://mnfab.sjtu.edu.cn/cn/content.aspx?info_lb=1&flag=1
[1426] "Lab overview" [实验室概况], *Shanghai Jiao Tong University*, Accessed July 2018, https://web.archive.org/web/20180729064751/http://mnfab.sjtu.edu.cn/cn/content.aspx?info_lb=1&flag=1
[1427] "State Key Laboratory of Micron/Nano Processing Technology, Shanghai Jiaotong University" [上海交通大学微米/纳米加工技术国家级重点实验室], *Free Kaoyan*, 16 December 2012, http://school.freekaoyan.com/sh/sjtu/dongtai/20121216/1355665409109186.shtml
"State Key Laboratory of Micro/Nano Processing Technology (Joint)" [微米/纳米加工技术国家级重点实验室（联合）], *Peking University*, Accessed July 2024, http://www.labpku.cn/sysxx/gjzdsys/15.html
[1428] "State Key Laboratory of Micro/Nano Processing Technology (Joint)" [微米/纳米加工技术国家级重点实验室（联合）], *Peking University*, Accessed July 2024, http://www.labpku.cn/sysxx/gjzdsys/15.html
[1429] Alex Joske, "The China Defence Universities Tracker," *ASPI*, 2019, https://s3-ap-southeast-2.amazonaws.com/ad-aspi/2019-11/The%20China%20Defence%20Universities%20Tracker_0.pdf?ozIi2cWm.kXpe7XsEZ44vUMMQBNfnR_x
"Lab overview" [实验室概况], *Shanghai Jiao Tong University*, Accessed July 2018, https://web.archive.org/web/20180729064751/http://mnfab.sjtu.edu.cn/cn/content.aspx?info_lb=1&flag=1
Zheng Lingde [郑令德], "Construction of Key Laboratory of National Defense Science and Technology for Micro/Nano Processing Technology" [微米／纳米加工技术国防科技重点实验室建设启动], *Shanghai Education Yearly* [上海教育年鉴], 1997, https://web.archive.org/web/20191113051522/http://218.249.40.252:252/KCMS/detail/detail.aspx?filename=N2006030035000509&dbcode=CYFD&dbname=CYFD
[1430] Zheng Lingde [郑令德], "Construction of Key Laboratory of National Defense Science and Technology for Micro/Nano Processing Technology" [微米／纳米加工技术国防科技重点实验室建设启动], *Shanghai Education Yearly* [上海教育年鉴], 1997, https://web.archive.org/web/20191113051522/http://218.249.40.252:252/KCMS/detail/detail.aspx?filename=N2006030035000509&dbcode=CYFD&dbname=CYFD
[1431] "Blue Heron: Semiconductor Manufacturing International Corporation," *SOSi*, August 2020, https://www.jcapitalresearch.com/uploads/2/0/0/3/20032477/blue_heron_smic_footnoted.pdf
[1432] "Recruitment - Postdocs for "Micro-Nano Fluidics and Bio-MEMS" in State Key Laboratory of Micro/Nano Processing Technology (Peking University)" [【招聘】微米/纳米加工技术国家级重点实验室（北京大学）"微纳流体与生物微机电系统方向"招收博士后], *Peking University*, 28 February 2019, https://web.archive.org/web/20191028040616/www.ime.pku.edu.cn/xwtz/xwgg/1299115.htm
Institution address can be found at: "Bidding Announcement for the Property of Peking University Micro-Nano Electronics Building" [北京大学微纳电子大厦物业招标公告], *Peking University*, 26 September 2018, https://eecs.pku.edu.cn/xxkxjsxy/info/1026/5222.htm

[1433] "National Key Laboratory of Micro Nanofabrication Technology" [微米纳米加工技术全国重点实验室], *Shanghai Jiao Tong University*, 25 October 2023, https://www.seiee.sjtu.edu.cn/kyjd_gjj/85.html
[1434] "Lab overview" [实验室概况], *Shanghai Jiao Tong University*, Accessed July 2018, https://web.archive.org/web/20180729064751/http://mnfab.sjtu.edu.cn/cn/content.aspx?info_lb=1&flag=1
[1435] "State Key Laboratory of Micron/Nano Processing Technology, Shanghai Jiaotong University" [上海交通大学微米/纳米加工技术国家级重点实验室], *Free Kaoyan*, 16 December 2012, http://school.freekaoyan.com/sh/sjtu/dongtai/20121216/1355665409109186.shtml
[1436] "State Key Laboratory of Micro/Nano Processing Technology (Joint)" [微米/纳米加工技术国家级重点实验室（联合）], *Peking University*, Accessed July 2024, http://www.labpku.cn/sysxx/gjzdsys/15.html
[1437] "State Key Laboratory of Micro/Nano Processing Technology (Joint)" [微米/纳米加工技术国家级重点实验室（联合）], *Peking University*, Accessed July 2024, http://www.labpku.cn/sysxx/gjzdsys/15.html
[1438] "Literature Review on Structural Design and Frequency Characterization of Large Turning Angle Microphotographs" [大转角微振镜结构设计与频率特性分析文献综述], *Zongsu Net* [综述网[, 25 November 2022, https://www.zongshuwang.com/jixiejidian/jixiegongcheng/9040.html
[1439] "Platform Construction" [平台建设], *Beijing Institute of Collaborative Innovation*, Accessed July 2024, http://www.bici.org/en/onepage363.html
[1440] "State Key Laboratory of Micro Nanofabrication Technology" [微米纳米加工技术国家重点实验室], *Caigou* [中国教育装逼采购网], Accessed July 2024, https://web.archive.org/web/20100904161911/https://www.caigou.com.cn/Lab/Detail/lab_4.shtml
[1441] "National Key Laboratory of Micro Nanofabrication Technology" [微米纳米加工技术全国重点实验室], *Shanghai Jiao Tong University*, 25 October 2023, https://www.seiee.sjtu.edu.cn/kyjd_gjj/85.html
[1442] "Recruitment - Postdocs for "Micro-Nano Fluidics and Bio-MEMS" in State Key Laboratory of Micro/Nano Processing Technology (Peking University)" [【招聘】微米/纳米加工技术国家级重点实验室（北京大学）"微纳流体与生物微机电系统方向"招收博士后], *Peking University*, 28 February 2019, https://web.archive.org/web/20191028040616/www.ime.pku.edu.cn/xwtz/xwgg/1299115.htm
[1443] "State Key Laboratory of Micro Nanofabrication Technology" [微米纳米加工技术国家重点实验室], *Caigou* [中国教育装逼采购网], Accessed July 2024, https://web.archive.org/web/20100904161911/https://www.caigou.com.cn/Lab/Detail/lab_4.shtml
[1444] "Flexible Electronics Research Institute went to Shanghai Jiao Tong University to carry out the theme of quality improvement training for young teachers" [柔性电子研究院赴上海交通大学开展青年教师素质提升主题研修], *Northwestern Polytechnical University*, 26 April 2023, https://news.nwpu.edu.cn/info/1003/94389.htm
[1445] "Flexible Electronics Research Institute went to Shanghai Jiao Tong University to carry out the theme of quality improvement training for young teachers" [柔性电子研究院赴上海交通大学开展青年教师素质提升主题研修], *Northwestern Polytechnical University*, 26 April 2023, https://news.nwpu.edu.cn/info/1003/94389.htm
[1446] "Introduction to State Key Laboratory of Micron/Nano Processing Technology and Institute of Microelectronics, Peking University" [微米/纳米加工技术国家重点实验室及北京大学微电子学研究院简介], *szvup,com*, 2 November 2004, https://web.archive.org/web/20081121062551/https://www.szvup.com/html/sys/cyjs/4805836024.html
[1447] "The "Internet of Things Industry Ecological Development Summit Forum" was successfully held in Shijiazhuang City" ["物联网产业生态发展高峰论坛"在石家庄市成功举办], *CICS*, 7 September 2021, https://www.cics-cert.org.cn/web_root/webpage/articlecontent_101001_1437311219659706370.html
[1448] "NU radiation monitoring microsystem key technology project results passed acceptance" [北大辐射监测微系统关键技术项目成果通过验收], *Instruments Online* [仪表网], 6 May 2016, https://www.ybzhan.cn/news/detail-54751.html
[1449] "NU radiation monitoring microsystem key technology project results passed acceptance" [北大辐射监测微系统关键技术项目成果通过验收], *Instruments Online* [仪表网], 6 May 2016, https://www.ybzhan.cn/news/detail-54751.html
[1450] "Chip power plant overturns the traditional path, Shanghai Jiaotong University Professor Hu Zhiyu's energy dream" ["芯片发电厂"颠覆传统路径，上海交大教授胡志宇的能源梦想 ], *Sohu*, 17 January 2021, https://www.sohu.com/a/445134764_334409

[1451] "State Key Laboratory of Micro/Nano Processing Technology (Joint)" [微米/纳米加工技术国家级重点实验室（联合）], *Peking University*, Accessed July 2024, http://www.labpku.cn/sysxx/gjzdsys/15.html
[1452] "Yipeng Lu's group at Peking University is looking for postdoctoral fellows and research assistants in the field of MEMS" [北京大学卢奕鹏课题组诚聘 MEMS 方向博士后与科研助理], *EET China*, 11 August 2022, https://www.eet-china.com/mp/a152877.html
[1453] "State Key Laboratory of Micro/Nano Processing Technology (Joint)" [微米/纳米加工技术国家级重点实验室（联合）], *Peking University*, Accessed July 2024, http://www.labpku.cn/sysxx/gjzdsys/15.html
[1454] "Comprehensive Performance Evaluation Meeting of National Key R&D Program Subjects Held in Tiandiweiye" [国家重点研发计划课题综合绩效评价会在天地伟业召开], *Tiandy*, 25 Novemeber 2021, https://www.tiandy.com/xwzx/gsxw/2305.html
[1455] "National Key Laboratory of Micro Nanofabrication Technology" [微米纳米加工技术全国重点实验室], *Shanghai Jiao Tong University*, 25 October 2023, https://www.seiee.sjtu.edu.cn/kyjd_gjj/85.html
[1456] Yu Tian [于添], Wu Xiaosheng [吴校生], "Structural optimization of A soft jellyfish-like robot with fast pneumatic networks" [快速流动网络仿水母软体机器人的结构优化], *Digital Ocean & Underwater Warfare*, 7 July 2023, http://shuixiagf710.ijournals.cn/szhyysxgf/article/abstract/20230326001
[1457] "Shanghai Jiaotong University team develops ultrafine flexible wearable system for accurate monitoring of sleep and nasal cycle at home throughout the night" [上海交大团队研发超细柔性可穿戴系统，实现居家整夜睡眠和鼻周期的精准监测], *Sina*, 14 July 2023, https://k.sina.cn/article_1738690784_67a250e00190183b4.html?from=science
[1458] "The 4th China MEMS Intelligent Sensor Industry Development Conference and Entrepreneurs Forum was successfully held" [第四届中国 MEMS 智能传感器产业发展大会暨企业家论坛成功召开], *MEMS & NEMS Society of China*, 9 May 2021, http://www.micronano.cn/?v&paged=2
[1459] "Announcement on the Completion of the General Election of the Board of Directors and the Supervisory Committee and the Appointment of Senior Management and Securities Affairs Representatives of Beijing Semiconductor Manufacturing Co." [北京赛微电子股份有限公司关于董事会、监事会完成换届选举及聘任高级管理人员和证券事务代表的公告], *Sohu*, 2023, https://q.stock.sohu.com/newpdf/202355431200.pdf
[1460] "Announcement on the Completion of the General Election of the Board of Directors and the Supervisory Committee and the Appointment of Senior Management and Securities Affairs Representatives of Beijing Semiconductor Manufacturing Co." [北京赛微电子股份有限公司关于董事会、监事会完成换届选举及聘任高级管理人员和证券事务代表的公告], *Sohu*, 2023, https://q.stock.sohu.com/newpdf/202355431200.pdf
[1461] "Flexible Electronics Research Institute went to Shanghai Jiao Tong University to carry out the theme of quality improvement training for young teachers" [柔性电子研究院赴上海交通大学开展青年教师素质提升主题研修], *Northwestern Polytechnical University*, 26 April 2023, https://news.nwpu.edu.cn/info/1003/94389.htm
[1462] "Recruitment - Postdocs for "Micro-Nano Fluidics and Bio-MEMS" in State Key Laboratory of Micro/Nano Processing Technology (Peking University)" [【招聘】微米/纳米加工技术国家级重点实验室（北京大学）"微纳流体与生物微机电系统方向"招收博士后], *Peking University*, 28 February 2019, https://web.archive.org/web/20191028040616/www.ime.pku.edu.cn/xwtz/xwgg/1299115.htm
"Li Hongzhi" [李志宏], *Beijing Institute of Collaborative Innovation*, Accessed July 2024, http://www.bici.org/outstanding_talents/1148.html
[1463] "Fighting the "epidemic" with one heart: SJTU's united front in action" [同心战"疫"：上海交通大学统一战线在行动], *Shanghai Jiao Tong University United Front Work Department*, 31 March 2020, https://tzb.sjtu.edu.cn/index/news/1830-2020-03-31-09-38-01.html\
"Hu Zhiyu" [胡志宇], *Huodongjia* [活动家], Accessed July 2024, https://www.huodongjia.com/guest-07706810705107808408912 0.html
"From nanofires to micro- and nano-chip power generation technologies" [从纳米火到微纳芯片发电技术], *The Institute of Technological Sciences, Wuhan University*, 14 June 2023, http://www.flexcpose.com/info/1026/3251.htm
[1464] Chip power plant overturns the traditional path, Shanghai Jiaotong University Professor Hu Zhiyu's energy dream" ["芯片发电厂"颠覆传统路径，上海交大教授胡志宇的能源梦想 ], *Sohu*, 17 January 2021, https://www.sohu.com/a/445134764_334409

[1465] "Recruitment - Postdocs for "Micro-Nano Fluidics and Bio-MEMS" in State Key Laboratory of Micro/Nano Processing Technology (Peking University)" [【招聘】微米/纳米加工技术国家级重点实验室（北京大学）"微纳流体与生物微机电系统方向"招收博士后], *Peking University*, 28 February 2019, https://web.archive.org/web/20191028040616/www.ime.pku.edu.cn/xwtz/xwgg/1299115.htm
[1466] "The Third Issue of [Zero Distance]: Prof. Xudong Zou, "Thousand Talents Program" Youth from Institute of Electronics, Chinese Academy of Sciences" [【零距离】第三期：中国科学院电子学研究所"千人计划"青年邹旭东教授], *Chinese Students and Scholars Association in Cambridge*, 20 April 2017, https://cssacam.org/2017/04/20/%E3%80%90%E9%9B%B6%E8%B7%9D%E7%A6%BB%E3%80%91%E7%AC%AC%E4%B8%89%E6%9C%9F%EF%BC%9A%E9%82%B9%E6%97%AD%E4%B8%9C%E6%95%99%E6%8E%88/
[1467] "Prof. Luda Wang's group at Peking University is recruiting postdoctoral students/ direct students/ undergraduates in the field of micro and nanoelectronics, nanotechnology, and separation membranes" [北京大学王路达教授课题组招收微纳电子、纳米技术、分离膜方向博后/直博生/本科生], *Sohu*, 21 February 2020, https://www.sohu.com/a/374677815_472924
[1468] "Summary of domestic and foreign companies in the sensor field" [传感器领域的国内外企业汇总], *Elecfans*, 14 January 2019, https://m.elecfans.com/article/849224.html
[1469] "Recruitment - Postdocs for "Micro-Nano Fluidics and Bio-MEMS" in State Key Laboratory of Micro/Nano Processing Technology (Peking University)" [【招聘】微米/纳米加工技术国家级重点实验室（北京大学）"微纳流体与生物微机电系统方向"招收博士后], *Peking University*, 28 February 2019, https://web.archive.org/web/20191028040616/www.ime.pku.edu.cn/xwtz/xwgg/1299115.htm
[1470] "Recruitment - Postdocs for "Micro-Nano Fluidics and Bio-MEMS" in State Key Laboratory of Micro/Nano Processing Technology (Peking University)" [【招聘】微米/纳米加工技术国家级重点实验室（北京大学）"微纳流体与生物微机电系统方向"招收博士后], *Peking University*, 28 February 2019, https://web.archive.org/web/20191028040616/www.ime.pku.edu.cn/xwtz/xwgg/1299115.htm
[1471] "Chip power plant overturns the traditional path, Shanghai Jiaotong University Professor Hu Zhiyu's energy dream" ["芯片发电厂"颠覆传统路径，上海交大教授胡志宇的能源梦想 ], *Sohu*, 17 January 2021, https://www.sohu.com/a/445134764_334409
[1472] "Peking University's post-Moore era micro-nano-electronics intelligence base was approved for the project" [北大后摩尔时代微纳电子引智基地获批立项], *Semi Insights*, 30 January 2018, http://www.semiinsights.com/s/foundry/33/29250.shtml
[1473] "Recruitment - Postdocs for "Micro-Nano Fluidics and Bio-MEMS" in State Key Laboratory of Micro/Nano Processing Technology (Peking University)" [【招聘】微米/纳米加工技术国家级重点实验室（北京大学）"微纳流体与生物微机电系统方向"招收博士后], *Peking University*, 28 February 2019, https://web.archive.org/web/20191028040616/www.ime.pku.edu.cn/xwtz/xwgg/1299115.htm
Institution address can be found at: "Bidding Announcement for the Property of Peking University Micro-Nano Electronics Building" [北京大学微纳电子大厦物业招标公告], *Peking University*, 26 September 2018, https://eecs.pku.edu.cn/xxkxjsxy/info/1026/5222.htm
[1474] "State Key Laboratory of Micron/Nano Processing Technology, Shanghai Jiaotong University" [上海交通大学微米/纳米加工技术国家级重点实验室], *Free Kaoyan*, 16 December 2012, http://school.freekaoyan.com/sh/sjtu/dongtai/20121216/1355665409109186.shtml
[1475] "Literature Review on Structural Design and Frequency Characterization of Large Turning Angle Microphotographs" [大转角微振镜结构设计与频率特性分析文献综述], *Zongsu Net* [综述网[, 25 November 2022, https://www.zongshuwang.com/jixiejidian/jixiegongcheng/9040.html
[1476] "Introduction to State Key Laboratory of Micron/Nano Processing Technology and Institute of Microelectronics, Peking University" [微米/纳米加工技术国家重点实验室及北京大学微电子学研究院简介], *szvup,com*, 2 November 2004, https://web.archive.org/web/20081121062551/https://www.szvup.com/html/sys/cyjs/4805836024.html
[1477] "State Key Laboratory of Micro/Nano Processing Technology (Joint)" [微米/纳米加工技术国家级重点实验室（联合）], *Peking University*, Accessed July 2024, http://www.labpku.cn/sysxx/gjzdsys/15.html

[1478] "National Key Laboratory of Micro Nanofabrication Technology" [微米纳米加工技术全国重点实验室], *Shanghai Jiao Tong University*, 25 October 2023, https://www.seiee.sjtu.edu.cn/kyjd_gjj/85.html
[1479] "Recruitment - Postdocs for "Micro-Nano Fluidics and Bio-MEMS" in State Key Laboratory of Micro/Nano Processing Technology (Peking University)" [【招聘】微米/纳米加工技术国家级重点实验室（北京大学）"微纳流体与生物微机电系统方向"招收博士后*], Peking University*, 28 February 2019, https://web.archive.org/web/20191028040616/www.ime.pku.edu.cn/xwtz/xwgg/1299115.htm
Institution address can be found at: "Bidding Announcement for the Property of Peking University Micro-Nano Electronics Building" [北京大学微纳电子大厦物业招标公告], Peling University, 26 September 2018, https://eecs.pku.edu.cn/xxkxjsxy/info/1026/5222.htm
[1480] "Recruitment Announcement for Project Agent of State Key Laboratory of Micron Nanofabrication Technology" [微米纳米加工技术国家级重点实验室项目代理招聘启示], *Shanghai Jiao Tong University*, Accessed July 2024, https://dmne.sjtu.edu.cn/dmne/7384-2/
Address of the institution found here: "Lab Overview" [实验室概况], S*hanghai Jiao Tong University General Proess MEMS Lab*, Accessed July 2024, https://gpmems.sjtu.edu.cn/
[1481] "National Key Laboratory of New Ceramic Fibres and Composites" [新型陶瓷纤维及其复合材料国家重点实验室], *NUDT* [国防科技大学], 29 June 2010.
https://web.archive.org/web/20150501040729/http://www.nudt.edu.cn/ArticleShow.asp?ID=80 (Chinese) /
https://web.archive.org/web/20130522072903/http://www.nudt.edu.cn/articleshow_eng.asp?id=80 (English)
[1482] "National Key Laboratory of New Ceramic Fibres and Composites" [新型陶瓷纤维及其复合材料国家重点实验室], *NUDT* [国防科技大学], 29 June 2010.
https://web.archive.org/web/20150501040729/http://www.nudt.edu.cn/ArticleShow.asp?ID=80 (Chinese) /
https://web.archive.org/web/20130522072903/http://www.nudt.edu.cn/articleshow_eng.asp?id=80 (English)
[1483] "National Key Laboratory of New Ceramic Fibres and Composites" [新型陶瓷纤维及其复合材料国家重点实验室], *NUDT* [国防科技大学], 29 June 2010.
https://web.archive.org/web/20150501040729/http://www.nudt.edu.cn/ArticleShow.asp?ID=80 (Chinese) /
https://web.archive.org/web/20130522072903/http://www.nudt.edu.cn/articleshow_eng.asp?id=80 (English)
[1484] "National Key Laboratory of New Ceramic Fibres and Composites" [新型陶瓷纤维及其复合材料国家重点实验室], *NUDT* [国防科技大学], 29 June 2010.
https://web.archive.org/web/20150501040729/http://www.nudt.edu.cn/ArticleShow.asp?ID=80 (Chinese) /
https://web.archive.org/web/20130522072903/http://www.nudt.edu.cn/articleshow_eng.asp?id=80 (English)
[1485] "National Key Laboratory of New Ceramic Fibres and Composites" [新型陶瓷纤维及其复合材料国家重点实验室], *NUDT* [国防科技大学], 29 June 2010.
https://web.archive.org/web/20150501040729/http://www.nudt.edu.cn/ArticleShow.asp?ID=80 (Chinese) /
https://web.archive.org/web/20130522072903/http://www.nudt.edu.cn/articleshow_eng.asp?id=80 (English)
"2016' Sol-Gel Symposium of China & International Forum" [2016'中国溶胶－凝胶学术研讨会暨国际论坛], *2016 Sol-Gel Symposium of China & International Forum* [2016'中国溶胶－凝胶学术研讨会暨国际论坛], Accessed 2021, http://www.chinasolgel.com/Assets/userfiles/sys_eb538c1c-65ff-4e82-8e6a-a1ef01127fed/files/2016'中国溶胶－凝胶学术研讨会暨国际论坛会议指南和论文摘要集.pdf
[1486] See, for example, "Ultra-high temperature resistance of Si-B-N wave-transmitting fiber" [Si-BN 透波纤维的耐超高温性能], *Acta Materiae Compositae Sinica* [复合材料学报], 2016,33(09).
https://web.archive.org/web/20210609175556/https://wenku.baidu.com/view/df8d3579df80d4d8d15abe23482fb4daa48d1d09
"Key Issues in Designing and Preparing Hypersonic Missile Radomes" [高超音速导弹天线罩设计与制备中的关键问题分析], *Science & Technology Review* [科技导报], 2006, 24(0608): 28-31.
http://www.kjdb.org/CN/abstract/abstract903.shtml
"Research Progress of Variable Emissivity Materials for Spacecraft Thermal Control" [航天器热控用可变发射率材料研究进展], *2nd Postgraduate Innovation Forum of Hunan Province-Proceedings of the Aerospace and Control Science Sub-forum* [湖南省第二届研究生创新论坛——航空宇航与控制科学分论坛论文集], 1 November 2009 (conference date). https://archive.ph/e8GO9c

“Preparation and properties of 2D C_f/SiC-Cu composites produced by precursor infiltration and pyrolysis” [先驱体转化法制备 2D C_f/SiC-Cu 复合材料及其性能], *New Carbon Materials* [新型炭材料] (2) 2006.
“A Research Status of High-temperature Infrared Low-emissivity Coating” [高温红外低发射率涂层研究现状], *Materials Review* [材料导报], ２０１８年５月第３２卷专辑３1.
https://web.archive.org//web/20210609154257/http://www.mat-rev.com/cldb/ch/reader/create_pdf.aspx?file_no=2018z1084&flag=1&journal_id=cldb&year_id=2018

[1487] “2016' Sol-Gel Symposium of China & International Forum” [2016’中国溶胶－凝胶学术研讨会暨国际论坛], *2016' Sol-Gel Symposium of China & International Forum* [2016’中国溶胶－凝胶学术研讨会暨国际论坛], Accessed 2021, http://www.chinasolgel.com/Assets/userfiles/sys_eb538c1c-65ff-4e82-8e6a-a1ef01127fed/files/2016’中国溶胶－凝胶学术研讨会暨国际论坛会议指南和论文摘要集.pdf
"High Performance Fiber Reinforced Ceramic Matrix Composites" [高性能纤维增强陶瓷基复合材料], *SAMPE China*, 22 April 2021. http://www.sampechina.org/newsinfo/503480.html

[1488] "Ma Qingsong, Director of National Key Laboratory of New Ceramic Fiber and its Composites, National University of Defense Technology, visited School of Materials" [国防科技大学新型陶瓷纤维及其复合材料国家级重点实验室主任马青松一行莅临材料学院交流访问], *NWPU*, 12 May 2021.
https://cailiao.nwpu.edu.cn/info/1140/5373.htm

[1489] "High Performance Fiber Reinforced Ceramic Matrix Composites" [高性能纤维增强陶瓷基复合材料], *SAMPE China*, 22 April 2021. http://www.sampechina.org/newsinfo/503480.html

[1490] “Notice of "The First Academic Conference on Special Powder Metallurgy and Composite Material Preparation/Processing"” [“特种粉末冶金及复合材料制备/加工第一届学术会议”通知], *Non-ferrous technology platform* [有色技术平台], 1 September 2019. http://www.caa2014.com/news/show-3051.html;
“2017 Second Academic Conference on Special Powder Metallurgy and Composite Material Preparation/Processing” [2017 特种粉末冶金及复合材料制备/加工第二届学术会议], *Science Press* [科学出版社], 19 October 2017. https://www.sohu.com/a/198808638_410558;
“The second round of the "2018 3rd Academic Conference on Special Powder Metallurgy and Composite Material Preparation/Processing"” ["2018 特种粉末冶金及复合材料制备/加工第三届学术会议"第二轮通知], *China Metallurgical Nonferrous Technology Network* [中冶有色技术网], 30 November 2018.
https://www.evcana.com/mat/info/1237/6807.htm

[1491] “National Key Laboratory of New Ceramic Fibres and Composites” [新型陶瓷纤维及其复合材料国家重点实验室], *NUDT* [国防科技大学], 29 June 2010.
https://web.archive.org/web/20150501040729/http://www.nudt.edu.cn/ArticleShow.asp?ID=80 (Chinese) /
https://web.archive.org/web/20130522072903/http://www.nudt.edu.cn/articleshow_eng.asp?id=80 (English)

[1492] “National Key Laboratory of New Ceramic Fibres and Composites” [新型陶瓷纤维及其复合材料国家重点实验室], *NUDT* [国防科技大学], 28 June 2010.
https://web.archive.org/web/20150927032502/http://www.nudt.edu.cn/ArticleShow.asp?ID=9
“National Key Laboratory of New Ceramic Fibres and Composites” [新型陶瓷纤维及其复合材料国家重点实验室], *NUDT* [国防科技大学], 29 June 2010.
https://web.archive.org/web/20150501040729/http://www.nudt.edu.cn/ArticleShow.asp?ID=80 (Chinese) /
https://web.archive.org/web/20130522072903/http://www.nudt.edu.cn/articleshow_eng.asp?id=80 (English)

[1493] "Defense Science and Technology Key Laboratory Fund Public Guide Summary" [国防科技重点实验室基金公开指南汇总], *UESTC*, Accessed 2021,
https://www.sre.uestc.edu.cn/local/3/89/3E/6A5DE1ECF8C0A7D6B4FEF7962E8_58840CEB_C03FC.pdf?e=.pdf

[1494] "Key Lab of Nuclear Data" [核数据重点实验室], *China-injier.com*, Accessed 2 June 2023, https://www.china-injier.com/subpage/shiyanshi_5.html

[1495] "Key Lab of Nuclear Data" [核数据重点实验室], *China-injier.com*, Accessed 2 June 2023, https://www.china-injier.com/subpage/shiyanshi_5.html

[1496] "China's first NSF major program in nuclear data research launched" [我国核数据研究领域首个国家自然科学基金重大项目启动], *SASAC*, 7 February 2018,
http://www.sasac.gov.cn/n2588025/n2588119/c8580381/content.html

[1497] "Key Lab of Nuclear Data" [核数据重点实验室], *China-injier.com*, Accessed 2 June 2023, https://www.china-injier.com/subpage/shiyanshi_5.html
"Mystery of nuclear laboratories: this center gives the nuclear world "evidence" to follow" [探秘核实验室：这个中心让核世界有“据”可循], *Sohu*, 22 October 2019, https://www.sohu.com/a/348833680_673510
[1498] "Key Lab of Nuclear Data" [核数据重点实验室], *China-injier.com*, Accessed 2 June 2023, https://www.china-injier.com/subpage/shiyanshi_5.html
[1499] "Mystery of nuclear laboratories: this center gives the nuclear world "evidence" to follow" [探秘核实验室：这个中心让核世界有“据”可循], *Sohu*, 22 October 2019, https://www.sohu.com/a/348833680_673510
[1500] "Researcher Ge Zhigang from China Academy of Atomic Energy Science came to the Academy for exchange of lectures" [中国原子能科学研究院葛智刚研究员来院交流讲学], *Southwest University*, 4 December 2018, http://physics.swu.edu.cn/info/1057/1792.htm
[1501] "Institute Introduction" [院简介], *China Institute of Atomic Energy*, Accessed August 2024, http://www.ciae.ac.cn/zh401/dwgg/yjj/index.html
[1502] "Mystery of nuclear laboratories: this center gives the nuclear world "evidence" to follow" [探秘核实验室：这个中心让核世界有“据”可循], *Sohu*, 22 October 2019, https://www.sohu.com/a/348833680_673510
[1503] "Key Lab of Nuclear Data" [核数据重点实验室], *China-injier.com*, Accessed 2 June 2023, https://www.china-injier.com/subpage/shiyanshi_5.html
[1504] Lu Changing [鲁昌兵] et al., "Feasibility of Fast Neutron Radiography in Weapon Quality Detection" [快中子照相在武器质量检测中的可行性研究], *Chinese Journal of Energetic Materials* [含能材料], 2018, 26(2), https://www.energetic-materials.org.cn/hncl/article/abstract/2017133
[1505] "The Atomic Energy Research Institute (AERI) was awarded the first major project of Natural Science Foundation of China in the field of nuclear data" [原子能院获批我国核数据领域首个自然科学基金重大项目], *Sohu*, 8 December 2017, https://www.sohu.com/a/209236855_313834
[1506] "The Atomic Energy Research Institute (AERI) has been approved as the first major project of the National Natural Science Foundation of China (NSFC) in the field of nuclear data" [原子能院获批我国核数据领域首个国家自然科学基金重大项目], *China Institute of Atomic Energy*, 6 December 2017, http://www.ciae.ac.cn/zh401/xwzx7088/zyzx/1263876/index.html
[1507] "China's first NSF major program in nuclear data research launched" [我国核数据研究领域首个国家自然科学基金重大项目启动], *SASAC*, 7 February 2018, http://www.sasac.gov.cn/n2588025/n2588119/c8580381/content.html
[1508] "Key Laboratory for Nuclear Data Completes Mission to Measure and Evaluate Critical Nuclide Response Cross Sections" [核数据重点实验室完成重要核素反应截面测量与评价任务], *CCNTA*, 21 July 2020, https://www.ccnta.cn/article/2716.html
[1509] "First in the country! IAEA signs cooperation agreement with International Atomic Energy Agency in the field of nuclear data" [国内首个！原子能院与国际原子能机构签署核数据领域合作协议], *China Nuclear Energy Association*, 23 November 2022, https://www.china-nea.cn/site/content/42087.html
[1510] "We never stop exploring the stars" [探索恒星，我们永不止步], *SASTIND*, 9 May 2020, https://www.sastind.gov.cn/n10086205/n10086403/c10255876/content.html
[1511] "Key Lab of Nuclear Data" [核数据重点实验室], *China-injier.com*, Accessed 2 June 2023, https://www.china-injier.com/subpage/shiyanshi_5.html
[1512] "Key Lab of Nuclear Data" [核数据重点实验室], *China-injier.com*, Accessed 2 June 2023, https://www.china-injier.com/subpage/shiyanshi_5.html
[1513] "Special Software" [特色软件], *The Database of Nuclear Physics*, Accessed August 2024, http://www.nuclear.csdb.cn/ytsrj.html
[1514] "Special Software" [特色软件], *The Database of Nuclear Physics*, Accessed August 2024, http://www.nuclear.csdb.cn/ytsrj.html
[1515] "China's first portable neutron generator with high-precision time and angle marking functions successfully developed" [我国首台具有高精度时间和角度标记功能便携式中子发生器研制成功], *Sina*, 1 July 2019, https://news.sina.com.cn/o/2019-07-01/doc-ihytcitk8917201.shtml

[1516] "President Wang Wei and his entourage went to China Academy of Atomic Energy Research for investigation" [王为院长一行赴中国原子能科学研究院调研], *Sun Yat-sen University*, 25 September 2020, https://ifcen.sysu.edu.cn/article/216
[1517] "2019 Annual Academic Conference of the Chinese Nuclear Society" [中国核学会 2019 年学术年会], *Chinese Nuclear Society*, 2019, http://www.csnm.com.cn/uploads/1/file/public/201908/20190817090452_pmhswwdomk.pdf
[1518] "Tea Time Academic Event Series Invited Presentations" [Tea Time 学术活动系列邀请报告], *Huzhou University*, 19 December 2017, http://www.zjhu.edu.cn/2017/1219/c65a6389/page.htm
[1519] "Notification of academic activities: progress and perspectives of nuclear astrophysical reaction experiments" [学术活动通知：核天体反应实验进展与展望], *Shenzhen University*, 8 April 2024, https://iasnes.szu.edu.cn/info/1018/1452.htm
[1520] "The 11th National Seminar on Advanced Gas Detectors" [第十一届全国先进气体探测器研讨会], *USTC*, 12 October 2023, http://cicpi.ustc.edu.cn/indico/conferenceDisplay.py?confId=6366
[1521] "2023 National Nuclear Data Conference and Nuclear Data Macro Parameter Research and Application Conference" [2023 年全国核数据大会暨核数据宏观参数研究与应用会议召开], *National Nuclear Safety Administration*, 27 June 2023, https://nnsa.mee.gov.cn/ywdt/hyzx/202306/t20230627_1034676.html
[1522] "First in the country! IAEA signs cooperation agreement with International Atomic Energy Agency in the field of nuclear data" [国内首个！原子能院与国际原子能机构签署核数据领域合作协议], *China Nuclear Energy Association*, 23 November 2022, https://www.china-nea.cn/site/content/42087.html
[1523] "Special Software" [特色软件], *The Database of Nuclear Physics*, Accessed August 2024, http://www.nuclear.csdb.cn/ytsrj.html
[1524] "The Key Laboratory for Nuclear Data of the Atomic Energy Authority (AEA) participated in the 9th Asian Symposium on Advances in Nuclear Reaction Databases" [原子能院核数据重点实验室参加第九届亚洲核反应数据库进展研讨会], *Energy World* [能源界], 18 December 2018, https://www.nengyuanjie.net/article/21673.html
[1525] "Practice Makes Perfect|Beijing Study Tour Team Visits China Academy of Atomic Energy Sciences" [实践致知|北京访学实践队赴中国原子能科学研究院访学], *Central China Normal University*, 20 July 2024, http://physics.ccnu.edu.cn/info/1092/7725.htm
[1526] "Key Lab of Nuclear Data" [核数据重点实验室], *China-injier.com*, Accessed 2 June 2023, https://www.china-injier.com/subpage/shiyanshi_5.html
[1527] Lu Changing [鲁昌兵] et al., "Feasibility of Fast Neutron Radiography in Weapon Quality Detection" [快中子照相在武器质量检测中的可行性研究], *Chinese Journal of Energetic Materials* [含能材料], 2018, 26(2), https://www.energetic-materials.org.cn/hncl/article/abstract/2017133
[1528] "Company Intro" [公司简介], *51 Job*, 2020. http://campus.51job.com/zd53/about.html
[1529] "Company Intro" [公司简介], *51 Job*, 2020. http://campus.51job.com/zd53/about.html
[1530] "Electrical Science Trends | New changes in science and technology innovation and new opportunities for national key laboratories" [电科动态 | 科技创新新变革新机遇 国家级重点实验室怎么做], *Sohu*, 19 April 2019. https://www.sohu.com/a/309143463_779538
[1531] "China's top ten military centralized enterprise groups for the country!" [中国十大军工央企集团，为国效力！], *NetEase*, 26 November 2020. https://www.163.com/dy/article/FSCE0P580512WI81.html
"Company Intro" [公司简介], *51 Job*, 2020. http://campus.51job.com/zd53/about.html
"About the 53rd Research Institute of China Electronics Technology Group Corporation" [中国电子科技集团公司第五十三研究所简介], *CETC*, Accessed August 2024, http://www.cetc-ss.com/zgdzkj/_300891/_300907/320870/index.html
[1532] "Company Intro" [公司简介], *51 Job*, 2020. http://campus.51job.com/zd53/about.html
"Company Culture" [企业文化], *CETC 53 RI*, Accessed August 2024, http://webcache.googleusercontent.com/search?q=cache%3A53.cetc.com.cn%2F53%2F336302%2F336311%2Findex.html&rlz=1C1CHBD_enUS949US949&oq=cache%3A53.cetc.com.cn%2F53%2F336302%2F336311%2Findex.html&aqs=chrome..69i57j69i58.1167j0j4&sourceid=chrome&ie=UTF-8
[1533] "Company Culture" [企业文化], *CETC 53 RI,* Accessed August 2024, http://webcache.googleusercontent.com/search?q=cache%3A53.cetc.com.cn%2F53%2F336302%2F336311%2Find

ex.html&rlz=1C1CHBD_enUS949US949&oq=cache%3A53.cetc.com.cn%2F53%2F336302%2F336311%2Findex.html&aqs=chrome..69i57j69i58.1167j0j4&sourceid=chrome&ie=UTF-8

[1534] "Optoelectronic Science and Engineering" Frontier Academic Report: How do lasers 'dry' up?" ["光电科学与工程"前沿学术报告：激光器是怎么"燥"起来的？], *Hebei University of Technology* [河北工业大学], 15 May 2019. https://eie.hebut.edu.cn/kxyj/xzdt/72288.htm

[1535] Liu Wanjun [刘万军] et al., "Multi-scale correlation filter tracking algorithm based on occlusion discrimination" [遮挡判别下的多尺度相关滤波跟踪算法], *Journal of Image and Graphics* [中国图象图形学报], 2018, 12, https://gb.oversea.cnki.net/KCMS/detail/detail.aspx?filename=ZGTB201812002&dbcode=CJFQ&dbname=CJFDTEMP

[1536] "Key Laboratory of Electronic Information Control Key Laboratory of Communication Information Control and Security Technology Key Laboratory of Optoelectronic Information Control and Security Technology Call for Papers for 2012 Joint Annual Conference" [电子信息控制重点实验室 通信信息控制和安全技术重点实验室 光电信息控制和安全技术重点实验室 2012 年联合学术年会征文通知], *Zhangqiao Keyan* [掌桥科研], 2012, https://www.zhangqiaokeyan.com/academic-journal-cn_electronic-warfare_thesis/0201239480142.html

[1537] Li Man [李曼], Xu Hong [许宏], "Laser fence detection technology" [激光栅栏探测技术], *SK163*, 2015, http://www.vmtsg.com/qikan/6963899c3420b239dffb1059b462b4be.html

[1538] "News | The 4th Symposium on Computational Imaging Technology and Applications, organized by the Institute, was successfully concluded" [要闻 | 我所主办的第四届计算成像技术与应用专题研讨会圆满落幕], *CETC 53 RI*, 8 December 2020, http://webcache.googleusercontent.com/search?q=cache%3A53.cetc.com.cn%2F53%2F336315%2F336291%2F1636345%2Findex.html&rlz=1C1CHBD_enUS949US949&oq=cache%3A53.cetc.com.cn%2F53%2F336315%2F336291%2F1636345%2Findex.html&aqs=chrome..69i57j69i58.1057j0j4&sourceid=chrome&ie=UTF-8

[1539] Li Haiyu [李宇海], Ding Yu [丁宇], "Development Concept of Intelligent Electro-optical Countermeasure Technology Framework" [智能化光电对抗技术框架发展构想], *Electro-Optic Technology Application* 2018, 6, http://222.198.130.40:81/Qikan/Article/Detail?id=7001235411&from=Qikan_Article_Detail

[1540] Sun Yuxin [孙裕鑫], Li Yuhai [李宇海], Wang Kai [王锴], "Horizon Detection Based on Semantic Segmentation of Infrared Images," [基于语义分割的红外图像天地线检测算法研究], *Electro-Optic Technology Application,* 2020, 6, http://yuxiqbs.cqvip.com/Qikan/Article/Detail?id=7103640106&from=Qikan_Article_Detail

[1541] "Researcher Yan Xiusheng from the 53rd Institute of China Electronics Technology Group (CETG) came to our lab to give an academic report" [中国电子科技集团第 53 所闫秀生研究员来我室做学术报告], *Xi'an Jiaotong University*, 14 April 2014, http://photon.xjtu.edu.cn/info/1010/1071.htmx

[1542] Ding Yu [丁宇], Yan Xiusheng [闫秀生], "Technical Analysis of Intelligent Long-range Anti-ship Missile Capability" [智能化远程反舰导弹能力及技术分析], *Electro-Optic Technology Application* [光电技术应用], 2019, 2, http://kns55.zh.eastview.com/KCMS/detail/detail.aspx?filename=GDYG201902002&dbcode=CJFQ&dbname=CJFD2019

[1543] "2019 National Electronic Warfare Conference [2019 全国电子战大会], *Conference of China Electronic Warfare,* 2019*,* [全国电子战大会], 2019. http://ccew.cie-info.org.cn/

[1544] "News | The 4th Symposium on Computational Imaging Technology and Applications, organized by the Institute, was successfully concluded" [要闻 | 我所主办的第四届计算成像技术与应用专题研讨会圆满落幕], *CETC 53 RI*, 8 December 2020, http://webcache.googleusercontent.com/search?q=cache%3A53.cetc.com.cn%2F53%2F336315%2F336291%2F1636345%2Findex.html&rlz=1C1CHBD_enUS949US949&oq=cache%3A53.cetc.com.cn%2F53%2F336315%2F336291%2F1636345%2Findex.html&aqs=chrome..69i57j69i58.1057j0j4&sourceid=chrome&ie=UTF-8

[1545] "Electrical Science Trends | New changes in science and technology innovation and new opportunities for national key laboratories" [电科动态 | 科技创新新变革新机遇 国家级重点实验室怎么做], *Sohu*, 19 April 2019. https://www.sohu.com/a/309143463_779538

[1546] "Xidian organizes the 27th Annual Electronic Warfare Sanxin Academic Conference" [西电举办第二十七届电子战三新学术年会], *XD Nice* [好网], 16 September 2019, https://www.xdnice.com/portal/article/index/id/710.html

[1547] "Optoelectronic Science and Engineering" Frontier Academic Report: How do lasers 'dry' up?" ["光电科学与工程"前沿学术报告：激光器是怎么"燥"起来的？], *Hebei University of Technology* [河北工业大学], 15 May 2019. https://eie.hebut.edu.cn/kxyj/xzdt/72288.htm
[1548] "Conference Homepage" [会议首页], *The 5th Symposium on Photovoltaic Defense Technology and Applications* [第五届光电防御技术及应用研讨会], 14 September 2020, https://b2b.csoe.org.cn/meeting/FY2020.html
[1549] "Xidian organizes the 27th Annual Electronic Warfare Sanxin Academic Conference" [西电举办第二十七届电子战三新学术年会], *XD Nice* [好网], 16 September 2019, https://www.xdnice.com/portal/article/index/id/710.html
[1550] "2019 National Electronic Warfare Conference" [2019 全国电子战大会], *Conference of China Electronic Warfare* [全国电子战大会], 2019, http://ccew.cie-info.org.cn/
[1551] "Second Summit on Future Space Technology" [第二届未来空间技术高峰论坛], *Ai Shang Yanxiu* [Ai 尚研修], 10 September 2021, http://www.aishangyanxiu.com/p/576
[1552] "Company Culture" [企业文化], *CETC 53 RI*, Accessed August 2024, http://webcache.googleusercontent.com/search?q=cache%3A53.cetc.com.cn%2F53%2F336302%2F336311%2Findex.html&rlz=1C1CHBD_enUS949US949&oq=cache%3A53.cetc.com.cn%2F53%2F336302%2F336311%2Findex.html&aqs=chrome..69i57j69i58.1167j0j4&sourceid=chrome&ie=UTF-8
[1553] "Company Intro" [公司简介], *51 Job*, 2020. http://campus.51job.com/zd53/about.html
[1554] "China Electronics Technology Optoelectronics Research Institute Recruitment 2016" [中电子科技光电研究院 2016 招聘], *Grad Student Hiring Online* [硕博招聘在线], 18 December 2015, http://www.gxzpw.org/jobnav/ky/m/201512187197.html
[1555] Jiang Yong [蒋勇] et al., "Light modulation performance control of the coating on the repaired damage sites in fuzed silica surface" [膜层对熔石英表面损伤修复点光调制性能调控研究], *Chinese Optics* [中国光学], 2021, 14, http://chineseoptics.net.cn/cn/article/doi/10.37188/CO.2020-0110?viewType=HTML
[1556] "State Key Laboratory of Parallel and Distributed Processing" [并行与分布处理国家重点实验室], *TSP Web* [调色盘网], 11 December 2020. https://www.tspweb.com/key/%E5%B9%B6%E8%A1%8C%E4%B8%8E%E5%88%86%E5%B8%83%E5%A4%84%E7%90%86%E5%9B%BD%E5%AE%B6%E9%87%8D%E7%82%B9%E5%AE%9E%E9%AA%8C%E5%AE%A4%E5%9B%BD%E9%98%B2%E7%A7%91%E5%AD%A6%E6%8A%80%E6%9C%AF%E5%A4%A7%E5%AD%A6.html
Xi Qixin [奚启新], Su Kuangshan [苏扩善], "Parallel and Distributed Processing National Key Laboratory Completed in China" [我国建成并行与分布处理国家级重点实验室], *Modern Military* [现代军事] (8) 1998.
[1557] Xi Qixin [奚启新], Su Kuangshan [苏扩善], "Parallel and Distributed Processing National Key Laboratory Completed in China" [我国建成并行与分布处理国家级重点实验室], *Modern Military* [现代军事] (8) 1998.
[1558] "State Key Laboratory of Parallel and Distributed Processing" [并行与分布处理国家重点实验室], *TSP Web* [调色盘网], 11 December 2020. https://www.tspweb.com/key/%E5%B9%B6%E8%A1%8C%E4%B8%8E%E5%88%86%E5%B8%83%E5%A4%84%E7%90%86%E5%9B%BD%E5%AE%B6%E9%87%8D%E7%82%B9%E5%AE%9E%E9%AA%8C%E5%AE%A4%E5%9B%BD%E9%98%B2%E7%A7%91%E5%AD%A6%E6%8A%80%E6%9C%AF%E5%A4%A7%E5%AD%A6.html
[1559] "Higher Education Major: Computer Science and Technology" [高考专业：计算机科学与技术], *Document Home* [文档之家], Accessed 2021, http://webcache.googleusercontent.com/search?q=cache:-t7Is-ZSztEJ:www.doczj.com/doc/5ec209e0dcccda38376baf1ffc4ffe473268fd30.html+&cd=4&hl=en&ct=clnk&gl=us
[1560] "Vice President Wang Hongguang and his delegation investigated "Parallel and Distributed Processing Science and Technology Key Laboratory" [王宏广副院长一行调研"并行与分布处理科技重点实验室"], China Academy of Science and Technology for Development [中国科学技术发展战略研究院] 5 April 2017. http://www.casted.org.cn/channel/newsinfo/6251
[1561] "Introduction to School of Computers" [计算机学院简介], *NUDT* [国防科技大学], Accessed 2021, https://www.nudt.edu.cn/xysz/jsjxy/index.htm

“State Key Laboratory of Parallel and Distributed Processing” [并行与分布处理国家重点实验室], TSP Web [调色盘网], 11 December 2020.
https://www.tspweb.com/key/%E5%B9%B6%E8%A1%8C%E4%B8%8E%E5%88%86%E5%B8%83%E5%A4%84%E7%90%86%E5%9B%BD%E5%AE%B6%E9%87%8D%E7%82%B9%E5%AE%9E%E9%AA%8C%E5%AE%A4%E5%9B%BD%E9%98%B2%E7%A7%91%E5%AD%A6%E6%8A%80%E6%9C%AF%E5%A4%A7%E5%AD%A6.html
“Zhou Xingming” [周兴铭], *National University of Defense Technology*, 10 April 2015.
https://www.nudt.edu.cn/xy/xyfc/372dd25263bb4726bd691395f6ac9957.htm
“Lu Kai” [卢凯], *Cipnet.cn* [创新人才], Accessed 2021, http://expert.irsp.cn/resource/detail/ad2397f2-74df-4824-b014-816146023932
“Parallel I/O Techniques in High Performance Computing” [高性能计算中的并行 I / O 技术], *Computer Science* [计算机科学] (5) 2002. http://www.jsjkx.com/CN/Y2002/V29/I5/1
“"Tianhe-1 Chief Designer Yang Xuejun “ [“天河一号”总设计师 杨学军], *CCTV*, 22 January 2010.
https://tv.cctv.com/2010/01/22/VIDE1359970626549107.shtml
“State Key Laboratory of Parallel and Distributed Processing” [并行与分布处理国家重点实验室], TSP Web [调色盘网], 11 December 2020.
https://www.tspweb.com/key/%E5%B9%B6%E8%A1%8C%E4%B8%8E%E5%88%86%E5%B8%83%E5%A4%84%E7%90%86%E5%9B%BD%E5%AE%B6%E9%87%8D%E7%82%B9%E5%AE%9E%E9%AA%8C%E5%AE%A4%E5%9B%BD%E9%98%B2%E7%A7%91%E5%AD%A6%E6%8A%80%E6%9C%AF%E5%A4%A7%E5%AD%A6.html
“Zhou Xingming” [周兴铭], *National University of Defense Technology*, 10 April 2015.
https://www.nudt.edu.cn/xy/xyfc/372dd25263bb4726bd691395f6ac9957.htm
[1562] “Lu Xicheng” [卢锡城], *Geren Jianli* [个人简历], Accessed 2021,
http://m.gerenjianli.com/Mingren/03/tk4r65p9antk6ke.html
[1563] “Lu Xicheng” [卢锡城], *Geren Jianli* [个人简历], Accessed 2021,
http://m.gerenjianli.com/Mingren/03/tk4r65p9antk6ke.html
[1564] “This Saturday, the Chinese Academy of Engineering Frontiers of Information and Electronic Engineering Forum [No. 4: Convergence of Artificial Intelligence and Computing Systems] will meet you there!” [本周六，中国工程院信息与电子工程前沿论坛【第 4 期：人工智能与计算系统的融合发展】与您不见不散!], *NetEase*, 15 May 2020. https://www.163.com/dy/article/FCMEBVAF0512SE2N.html
“Behind the Research | Tianhe II Design Team: Innovation Creates Supercomputing China Speed” [科研背后 | 天河二号设计团队：创新铸就超算中国速度], *NetEase*, 2 July 2020.
https://www.163.com/dy/article/FGI98ASJ053471BQ.html
[1565] “Lu Xicheng - an expert in computer system architecture and computer networks” [卢锡城--计算机系统结构和计算机网络专家], *Harbin University of Engineering*, 26 November 2012.
http://webcache.googleusercontent.com/search?q=cache%3Axyzh.hrbeu.edu.cn%2F2012%2F1126%2Fc5216a152128%2Fpage.htm&rlz=1C1CHBD_enUS895US895&oq=cache%3Axyzh.hrbeu.edu.cn%2F2012%2F1126%2Fc5216a152128%2Fpage.htm&aqs=chrome..69i57j69i58.1259j0j4&sourceid=chrome&ie=UTF-8
“Lu Xicheng” [卢锡城], *Geren Jianli* [个人简历], Accessed 2021,
http://m.gerenjianli.com/Mingren/03/tk4r65p9antk6ke.html
“This Saturday, the Chinese Academy of Engineering Frontiers of Information and Electronic Engineering Forum [No. 4: Convergence of Artificial Intelligence and Computing Systems] will meet you there!” [本周六，中国工程院信息与电子工程前沿论坛【第 4 期：人工智能与计算系统的融合发展】与您不见不散!], *NetEase*, 15 May 2020. https://www.163.com/dy/article/FCMEBVAF0512SE2N.html
[1566] “Li Dongsheng et al., National University of Defense Technology: A Review of Large-Scale Graph Computing Systems” [国防科技大学李东升等：大规模图计算系统综述], *Sohu*, 1 November 2020.
https://www.sohu.com/a/428832263_613208
[1567] “Invite Report” [邀请报告], *CAEP Software Center for High Performance Numerical Simulation*, 2018.
http://www.caep-scns.ac.cn/HPCMid-2018_696.php

[1568] "Zhou Xingming" [周兴铭], NUDT, 10 April 2015.
https://www.nudt.edu.cn/xy/xyfc/372dd25263bb4726bd691395f6ac9957.htm
[1569] "Professor Peng Yuxing from National University of Defense Technology and Associate Professor Wu Hao from Hunan University visited the Key Laboratory of Intelligent Computing and Language Information Processing in the School of Information Technology" [国防科技大学彭宇行教授、湖南大学吴昊副教授做客信息学院智能计算与语言信息处理重点实验室], *Hunan Normal University* [湖南师范大学], 27 April 2019.
https://iclip.hunnu.edu.cn/info/1048/1050.htm
[1570] "Lu Kai" [卢凯], *Cipnet.cn* [创新人才], Accessed 2021, http://expert.irsp.cn/resource/detail/ad2397f2-74df-4824-b014-816146023932
"Parallel I/O Techniques in High Performance Computing" [高性能计算中的并行 I / O 技术], *Computer Science* [计算机科学] (5) 2002. http://www.jsjkx.com/CN/Y2002/V29/I5/1
[1571] "Upcoming Library Lecture Series | Frontiers in Information and Electronic Engineering Forum: The Convergence of Artificial Intelligence and Computing Systems" [图书馆系列讲座预告 | 信息与电子工程前沿论坛：人工智能与计算系统的融合发展], *North University of China* [中北大学], 15 May 2020.
http://webcache.googleusercontent.com/search?q=cache%3Awww.nuc.edu.cn%2Finfo%2F1354%2F15307.htm&rlz=1C1CHBD_enUS895US895&oq=cache%3Awww.nuc.edu.cn%2Finfo%2F1354%2F15307.htm&aqs=chrome..69i57j69i58.1346j0j4&sourceid=chrome&ie=UTF-8
"This Saturday, the Chinese Academy of Engineering Frontiers of Information and Electronic Engineering Forum [No. 4: Convergence of Artificial Intelligence and Computing Systems] will meet you there!" [本周六，中国工程院信息与电子工程前沿论坛【第 4 期：人工智能与计算系统的融合发展】与您不见不散!], *NetEase*, 15 May 2020. https://www.163.com/dy/article/FCMEBVAF0512SE2N.html
[1572] "Invite Report" [邀请报告], *CAEP Software Center for High Performance Numerical Simulation*, 2018.
http://www.caep-scns.ac.cn/HPCMid-2018_696.php
"The 8th Annual Academic Conference of CAEP" [中物院第八届学术年会], *CAEP* [中国工程物理研究院], 20 August 2012. https://www.caep.cn/meetingsubject/xsnh8/index.shtml
[1573] "The Speech Emotion Computing and Multimodal Interaction team won the second place in the ACM ICMR 2021 Radar Target Detection Challenge, an international flagship conference" [语音情感计算及多模态交互团队荣获 国际旗舰会议 ACM ICMR 2021 雷达目标检测挑战赛亚军], *University of Science and Technology of China*, 13 April 2021, https://nelslip.ustc.edu.cn/2021/0414/c26914a513216/page.htm
[1574] "Upcoming Library Lecture Series | Frontiers in Information and Electronic Engineering Forum: The Convergence of Artificial Intelligence and Computing Systems" [图书馆系列讲座预告 | 信息与电子工程前沿论坛：人工智能与计算系统的融合发展], *North University of China* [中北大学], 15 May 2020.
http://webcache.googleusercontent.com/search?q=cache%3Awww.nuc.edu.cn%2Finfo%2F1354%2F15307.htm&rlz=1C1CHBD_enUS895US895&oq=cache%3Awww.nuc.edu.cn%2Finfo%2F1354%2F15307.htm&aqs=chrome..69i57j69i58.1346j0j4&sourceid=chrome&ie=UTF-8
"This Saturday, the Chinese Academy of Engineering Frontiers of Information and Electronic Engineering Forum [No. 4: Convergence of Artificial Intelligence and Computing Systems] will meet you there!" [本周六，中国工程院信息与电子工程前沿论坛【第 4 期：人工智能与计算系统的融合发展】与您不见不散!], *NetEase*, 15 May 2020. https://www.163.com/dy/article/FCMEBVAF0512SE2N.html
[1575] "State Key Laboratory of Parallel and Distributed Processing" [并行与分布处理国家重点实验室], *TSP Web* [调色盘网], 11 December 2020.
https://www.tspweb.com/key/%E5%B9%B6%E8%A1%8C%E4%B8%8E%E5%88%86%E5%B8%83%E5%A4%84%E7%90%86%E5%9B%BD%E5%AE%B6%E9%87%8D%E7%82%B9%E5%AE%9E%E9%AA%8C%E5%AE%A4%E5%9B%BD%E9%98%B2%E7%A7%91%E5%AD%A6%E6%8A%80%E6%9C%AF%E5%A4%A7%E5%AD%A6.html
[1576] "State Key Laboratory of Parallel and Distributed Processing" [并行与分布处理国家重点实验室], *TSP Web* [调色盘网], 11 December 2020.
https://www.tspweb.com/key/%E5%B9%B6%E8%A1%8C%E4%B8%8E%E5%88%86%E5%B8%83%E5%A4%84%E7%90%86%E5%9B%BD%E5%AE%B6%E9%87%8D%E7%82%B9%E5%AE%9E%E9%AA%8C%E5%AE%A4%E5%9B%BD%E9%98%B2%E7%A7%91%E5%AD%A6%E6%8A%80%E6%9C%AF%E5%A4%A7%E5%AD%A6.html

[1577] "State Key Laboratory of Parallel and Distributed Processing" [并行与分布处理国家重点实验室], *TSP Web* [调色盘网], 11 December 2020. https://www.tspweb.com/key/%E5%B9%B6%E8%A1%8C%E4%B8%8E%E5%88%86%E5%B8%83%E5%A4%84%E7%90%86%E5%9B%BD%E5%AE%B6%E9%87%8D%E7%82%B9%E5%AE%9E%E9%AA%8C%E5%AE%A4%E5%9B%BD%E9%98%B2%E7%A7%91%E5%AD%A6%E6%8A%80%E6%9C%AF%E5%A4%A7%E5%AD%A6.html

[1578] "Announcing the address for receiving graduate student files" [公布研究生档案接收地址], *NUDT*, 5 June 2020. http://yjszs.nudt.edu.cn/pubweb/homePageList/detailed.view?keyId=717

[1579] "Inventory! 20 "National Key Laboratories" at Tsinghua University" [盘点！清华大学 20 个"全国重点实验室"], *Netease*, 26 December 2024, https://www.163.com/dy/article/JKBHP1GI0536A3D8.html "Government-approved institutions" [政府批建机构], *Tsinghua University*, 31 March 2024, https://www.rd.tsinghua.edu.cn/kyjg/zfpjjg.htm

[1580] "Institute of Physical and Chemical Engineering of the Nuclear Industry" [核工业理化工程研究院], *National Center for Information Counseling and Career Guidance for Students of Higher Education Institutions* [全国高等学校学生信息咨询与就业指导中心], Accessed August 2021, https://yz.chsi.com.cn/sch/schoolInfo--schId-367940,categoryId-446580.dhtml

[1581] "Tan Rongqing" [谭荣清], *cqvip*, Accessed August 2021, http://webcache.googleusercontent.com/search?q=cache%3A60.171.75.82%3A82%2Fwriter%2Farticle.aspx%3Fid%3D100000013512901&rlz=1C1CHBD_enUS949US949&oq=cache%3A60.171.75.82%3A82%2Fwriter%2Farticle.aspx%3Fid%3D100000013512901&aqs=chrome..69i57j69i58.1521j0j4&sourceid=chrome&ie=UTF-8

[1582] "Successful conclusion of Advanced Laser Technology and Application Symposium and the 4th Photoelectric Defense Technology and Application Symposium" [先进激光技术及应用研讨会 暨第四届光电防御技术及应用研讨会顺利闭幕], *Chinese Society for Optical Engineering* [中国光学工程学会], 30 September 2018, https://www.csoe.org.cn/html/xhgg/gjjl/3207.html

[1583] Wang Chao [江超], "Failure Analysis of Fiber Composite Pipe under Constant Load" [恒定载荷下纤维复合材料圆管失效分析], *Atomic Energy Science and Technology* [原子能科学技术], 2019, 3, http://www.cglhub.com/auto/db/detail.aspx?db=190716&rid=73000823&agfi=0&cls=0&uni=True&cid=0&showgp=True&prec=False&md=93&pd=6&msd=93&psd=6&mdd=93&pdd=6&count=10&reds=%E6%A8%A1%E6%80%81%E5%BA%94%E5%8F%98%E8%83%BD%E6%B3%95

[1584] "We held the 4th National Symposium on Frontiers of Intense Lasers and Particle Beams in 2024" [我校召开2024 年第四届全国强激光与粒子束前沿学术研讨会], *Wenzhou University*, 24 April 2024, https://www.wzu.edu.cn/info/1320/64277.htm

[1585] "Fifth Academic Committee Meeting of Key Laboratory of Plasma Physics" [等离子体物理重点实验室召开第五届学术委员会会议], *China Academy of Engineering Physics*, 14 May 2013, https://web.archive.org/web/20190926031247/http://www.caep.ac.cn/kxjsnew/xsjl/xxkxydzgc/14978.shtml

[1586] "Fifth Academic Committee Meeting of Key Laboratory of Plasma Physics" [等离子体物理重点实验室召开第五届学术委员会会议], *China Academy of Engineering Physics*, 14 May 2013, https://web.archive.org/web/20190926031247/http://www.caep.ac.cn/kxjsnew/xsjl/xxkxydzgc/14978.shtml

[1587] Zhou Weimin [周维民], *Scholarmate*, Accessed June 2024, https://www.scholarmate.com/P/3a2iqe? "Progress in High Energy Density Physics at State Key Laboratory of Plasma Physics" [等离子体物理国家重点实验室高能量密度物理研究进展], *Hunan University*, 1 March 2023, https://spe.hnu.edu.cn/info/1082/7669.htm

[1588] "About Laser Fusion Research Center" [激光聚变研究中心简介], *China Academy of Engineering Physics*, Accessed June 2024, https://zpxx.caep.cn/zrpage/job/deptPostInfo.jsp?deptCode=9008lf

[1589] Zhou Weimin [周维民], *Scholarmate*, Accessed June 2024, https://www.scholarmate.com/P/3a2iqe?

[1590] "Youth Forum "Nuclear Science and Technology" - Dr. Jingjing Li" ["核科学与技术"青年论坛——李晶晶博士], *Lanzhou University*, 13 May 2024, https://snst.lzu.edu.cn/xueshujiaoliu/2024/0513/269409.html

[1591] "Plasma Physics National Key Laboratory Governing Unit Awarding Ceremony Held in Our University" [等离子体物理全国重点实验室理事单位授牌仪式在我校举行], *Wenzhou University*, 31 October 2023, https://www.wzu.edu.cn/info/1320/47516.htm

[1592] "Progress in High Energy Density Physics at State Key Laboratory of Plasma Physics" [等离子体物理国家重点实验室高能量密度物理研究进展], *Hunan University*, 1 March 2023, https://spe.hnu.edu.cn/info/1082/7669.htm
[1593] "Qiaobin's group in the School of Physics and collaborators successfully carried out laser-driven three-dimensional simultaneous proton photography experiments and verified a new mechanism for the origin of the celestial magnetic field" [物理学院乔宾课题组与合作者成功开展激光驱动三维同步质子照相实验并验证天体磁场起源新机制], *ebiotrade*, 23 April 2024, https://m.ebiotrade.com/newsf/2024-4/20240423064041742.htm
"Qiaobin's group and collaborators propose new laser-driven short-pulse neutron source scheme" [乔宾课题组与合作者提出激光驱动的新型短脉冲中子源方案], *Peking University*, 15 July 2023, http://sklnpt.pku.edu.cn/info/1122/2814.htm
[1594] "Department of Plasma Physics--Zhu Shaoping" [等离子体物理教研室--朱少平], *Institute of Applied Physics and Computational Mathematics*, Accessed June 2024, http://www.iapcm.ac.cn/teams_head_con_238.html
[1595] "Summer Camp Notice of 2021 Summer Camp for Outstanding Undergraduates of Graduate School of China Academy of Engineering Physics (Headquarters)" [【夏令营】2021 年中国工程物理研究院研究生院（本部）优秀大学生暑期夏令营活动通知], *Sohu*, 22 May 2021, https://www.sohu.com/a/467952938_121124036
[1596] "Report Title: Micro- and Nano-fabrication in Thermonuclear Fusion Targets" [报告题目：热核聚变靶中的微纳制造技术], *Dalian University of Technology*, 18 December 2020, http://institution.dlut.edu.cn/mnstlab/zh_CN/article/1107814/content/3838.htm
[1597] "Plasma Physics National Key Laboratory Governing Unit Awarding Ceremony Held in Our University" [等离子体物理全国重点实验室理事单位授牌仪式在我校举行], *Wenzhou University*, 31 October 2023, https://www.wzu.edu.cn/info/1320/47516.htm
[1598] "Research Project on Laser Plasma Tail Wave Acceleration Mechanism and Its Technology" [激光等离子体尾波加速机制及其技术研究项], *Academic Leading Group* [学术领导小组], Acessed July 2024, https://lwfa.sjtu.edu.cn/Web/Teacher/2
[1599] "Key Laboratory of Plasma Physics Holds HEDP Seminar" [等离子体物理重点实验室召开 HEDP Seminar], *Chinese Academy of Engineering Physics*, 18 July 2016, https://www.caep.cn/doc/2020/01/06/363.shtml
[1600] "Conference Introduction" [会议介绍], 4*th National Symposium on the Frontiers of Strong Laser and Particle Beam* [第四届全国强激光与粒子束前沿学术研讨会], 2024, https://hplpb2024.hplpb.com.cn/Page
[1601] "Sixth International Conference on Matter and Radiation in Extreme Conditions (ICMRE2023) Notice of First Round of Meetings" [第六届极端条件下的物质与辐射国际会议(ICMRE2023) 第一轮会议通知], *Weixin*, 17 February 2023, https://mp.weixin.qq.com/s/j7UmRNEsDkdoJhRxYPdyqA
[1602] "Key Laboratory of Plasma Physics Holds HEDP Seminar" [等离子体物理重点实验室召开 HEDP Seminar], *Chinese Academy of Engineering Physics*, 18 July 2016, https://www.caep.cn/doc/2020/01/06/363.shtml
[1603] "Progress in High Energy Density Physics at State Key Laboratory of Plasma Physics" [等离子体物理国家重点实验室高能量密度物理研究进展], *Hunan University*, 1 March 2023, https://spe.hnu.edu.cn/info/1082/7669.htm
[1604] "Key Laboratory of Plasma Physics Holds HEDP Seminar" [等离子体物理重点实验室召开 HEDP Seminar], *Chinese Academy of Engineering Physics*, 15 January 2021, https://www.caep.cn/doc/2021/03/29/2899.shtml
[1605] "Forwarding: Notice on the Application of the State Key Laboratory of Plasma Physics for Opening to the Public in 2005" [转发：等离子体物理国家级重点实验室 2005 年度对外开放课题申请的通知], *Peking University*, 24 December 2004, https://www.research.pku.edu.cn/tzgg/1215043.htm
[1606] "China's ultra-high-power femtosecond laser device successfully operated" [我国超高功率飞秒激光装置成功运行], *Chinese Academy of Sciences*, https://www.cas.cn/xw/kjsm/gndt/200906/t20090608_647200.shtml
[1607] Lian Hongfei [连红飞] et al., "Multi domain joint modulation waveform for automotive radar" [汽车雷达多域联合调制波形], *Journal of Systems Engineering and Electronics* [系统工程与电子技术], 45(11), 2023, https://www.sys-ele.com/CN/10.12305/j.issn.1001-506X.2023.11.05
[1608] "ATR "Spring Rain" Postdoctoral Fellowship Guidelines" [ATR“春雨”博士后联合基金指南], *Pianshen* [程序员大本营], Accessed 2021, https://www.pianshen.com/article/36111417052/
"ATR Key Laboratory of Defense Science and Technology, Shenzhen University, Shenzhen" [深圳大学 ATR 国防科技重点实验室], *Shenzhen University* [深圳大学], Accessed 2021, https://it.szu.edu.cn/xgxy/info/1017/1300.htm

[1609] "Strengthen the research and development of major core technologies to provide strong scientific and technological support for advancing the cause of a strong military in the new era" [加强重大核心技术研究攻关为推进新时代强军事业提供强大科技支撑], *Sichuan News* [四川新闻网], 17 March 2021. http://www.sc-028.com/html/life/194508.html

[1610] "ATR "Spring Rain" Postdoctoral Fellowship Guidelines" [ATR“春雨”博士后联合基金指南], *Pianshen* [程序员大本营], Accessed 2021, https://www.pianshen.com/article/36111417052/

"Introduction to Xiamen University Postdoctoral Station - Control Science and Engineering" [厦门大学博士后流动站简介——控制科学与工程], *Xiamen University*, 24 December 2013. http://webcache.googleusercontent.com/search?q=cache%3Ahttps%3A%2F%2Frsc.xmu.edu.cn%2F2013%2F0228%2Fc3199a60518%2Fpage.htm&rlz=1C1CHBD_enUS895US895&oq=cache%3Ahttps%3A%2F%2Frsc.xmu.edu.cn%2F2013%2F0228%2Fc3199a60518%2Fpage.htm&aqs=chrome..69i57j69i58.1513j0j4&sourceid=chrome&ie=UTF-8

"ATR Key Laboratory of Defense Science and Technology, Shenzhen University, Shenzhen" [深圳大学 ATR 国防科技重点实验室], *Shenzhen University* [深圳大学], Accessed 2021, https://it.szu.edu.cn/xgxy/info/1017/1300.htm

[1611] "ATR "Spring Rain" Postdoctoral Fellowship Guidelines" [ATR“春雨”博士后联合基金指南], *Pianshen* [程序员大本营], Accessed 2021, https://www.pianshen.com/article/36111417052/

"Introduction to Xiamen University Postdoctoral Station - Control Science and Engineering" [厦门大学博士后流动站简介——控制科学与工程], *Xiamen University*, 24 December 2013. http://webcache.googleusercontent.com/search?q=cache%3Ahttps%3A%2F%2Frsc.xmu.edu.cn%2F2013%2F0228%2Fc3199a60518%2Fpage.htm&rlz=1C1CHBD_enUS895US895&oq=cache%3Ahttps%3A%2F%2Frsc.xmu.edu.cn%2F2013%2F0228%2Fc3199a60518%2Fpage.htm&aqs=chrome..69i57j69i58.1513j0j4&sourceid=chrome&ie=UTF-8

"ATR Key Laboratory of Defense Science and Technology, Shenzhen University, Shenzhen" [深圳大学 ATR 国防科技重点实验室], *Shenzhen University* [深圳大学], Accessed 2021, https://it.szu.edu.cn/xgxy/info/1017/1300.htm

"Shenzhen University ATR Key Laboratory of National Defense Science and Technology is looking for post-docs in 2017" [深圳大学 ATR 国防科技重点实验室智能信息处理方向 2017 年诚招博士后], *Northwest University*, 27 September 2017. http://jiuye.nwu.edu.cn/website/news_show.aspx?id=8444

[1612] "National University of Defense Technology, College of Electronic Science ATR-3 Laboratory Recruitment Announcement" [国防科技大学电子科学学院 ATR-3 实验室招聘公告], *NUDT*, 17 August 2017. https://www.nudt.edu.cn/rczp/5dbf9f576a8a406f9626035aad231e45.htm

[1613] "ATR Key Laboratory, School of Electronic Science and Engineering, Target Characterization and Identification Group Recruitment Announcement" [电子科学与工程学院 ATR 重点实验室目标特性与识别课题组招聘公告], *NUDT*, 17 August 2016. https://web.archive.org/web/20190523071431/http:/www.nudt.edu.cn/Articleshow.asp?id=6921

[1614] "ATR Key Laboratory of Defense Science and Technology, Shenzhen University, Shenzhen" [深圳大学 ATR 国防科技重点实验室], *Shenzhen University* [深圳大学], Accessed 2021, https://it.szu.edu.cn/xgxy/info/1017/1300.htm

[1615] Dong Xiaohu [董小虎] et al., "Detection and Tracking of Small Infrared Targets Adaptively in Complex Background" [复杂背景下红外小目标自适应检测跟踪], *Aero Weaponry* [航空兵器] (6) 2019. http://www.aeroweaponry.avic.com/CN/10.12132/ISSN.1673-5048.2019.0233

[1616] Fang Jiao [方娇] et al., "Defense scientists to forge the great weapon "super brain"" [国防科大人这样锻造大国利器“超强大脑”], *81.cn*, 12 August 2020. http://www.81.cn/dy/2020-08/12/content_9880299.htm

[1617] Fang Jiao [方娇] et al., "Defense scientists to forge the great weapon "super brain"" [国防科大人这样锻造大国利器“超强大脑”], *81.cn*, 12 August 2020. http://www.81.cn/dy/2020-08/12/content_9880299.htm

[1618] "ATR "Spring Rain" Postdoctoral Fellowship Guidelines" [ATR“春雨”博士后联合基金指南], *Pianshen* [程序员大本营], Accessed 2021, https://www.pianshen.com/article/36111417052/

[1619] "ATR "Spring Rain" Postdoctoral Fellowship Guidelines" [ATR“春雨”博士后联合基金指南], *Pianshen* [程序员大本营], Accessed 2021, https://www.pianshen.com/article/36111417052/

[1620] "Shenzhen University ATR Key Laboratory of National Defense Science and Technology is looking for post-docs in 2017" [深圳大学 ATR 国防科技重点实验室智能信息处理方向 2017 年诚招博士后], *Northwest University*, 27 September 2017. http://jiuye.nwu.edu.cn/website/news_show.aspx?id=8444
[1621] "Leaning on the sky with a sharp sword like a rainbow - close to a technical innovation team in the key laboratory of automatic target recognition of the National Defense University of Science and Technology" [倚天利剑气如虹——走近国防科大自动目标识别重点实验室某技术创新团队], *Voice of China*, 28 June 2018. http://webcache.googleusercontent.com/search?q=cache%3Ahunan.voc.com.cn%2Farticle%2F201806%2F201806280712154621.html&rlz=1C1CHBD_enUS895US895&oq=cache%3Ahunan.voc.com.cn%2Farticle%2F201806%2F201806280712154621.html&aqs=chrome..69i57j69i58.5384j0j4&sourceid=chrome&ie=UTF-8
Fang Jiao [方娇] et al., "Defense scientists to forge the great weapon "super brain"" [国防科大人这样锻造大国利器“超强大脑”], *81.cn*, 12 August 2020. http://www.81.cn/dy/2020-08/12/content_9880299.htm
"Dongfeng 100 missile "comes with a brain": can improvise, decide on its own maneuver to change trajectory" [东风 100 导弹“自带大脑”：可以随机应变，自己决定机动变轨], *kknews*, 22 August 2020. https://kknews.cc/zh-cn/military/e5yk23r.html
[1622] "Leaning on the sky with a sharp sword like a rainbow - close to a technical innovation team in the key laboratory of automatic target recognition of the National Defense University of Science and Technology" [倚天利剑气如虹——走近国防科大自动目标识别重点实验室某技术创新团队], *Voice of China*, 28 June 2018. http://webcache.googleusercontent.com/search?q=cache%3Ahunan.voc.com.cn%2Farticle%2F201806%2F201806280712154621.html&rlz=1C1CHBD_enUS895US895&oq=cache%3Ahunan.voc.com.cn%2Farticle%2F201806%2F201806280712154621.html&aqs=chrome..69i57j69i58.5384j0j4&sourceid=chrome&ie=UTF-8
Fang Jiao [方娇] et al., "Defense scientists to forge the great weapon "super brain"" [国防科大人这样锻造大国利器“超强大脑”], *81.cn*, 12 August 2020. http://www.81.cn/dy/2020-08/12/content_9880299.htm
"Dongfeng 100 missile "comes with a brain": can improvise, decide on its own maneuver to change trajectory" [东风 100 导弹“自带大脑”：可以随机应变，自己决定机动变轨], *kknews*, 22 August 2020. https://kknews.cc/zh-cn/military/e5yk23r.html
[1623] "A share of tomorrow's wind: 8 ministries issued opinions to strengthen the standardization of express green packaging" [A 股明日风口：8 部委发布意见加强快递绿色包装标准化工作], *Sina*, 9 August 2020. https://finance.sina.cn/stock/ywgg/2020-08-09/detail-iivhvpwy0099562.d.html?vt=4&cid=76524&node_id=76524
[1624] “Guo Guirong” [郭桂蓉], *Beijing Sihai Changxin Consulting Center* [北京四海昌信咨询中心], Accessed 2021, http://www.shcxaa.com/tuijianzhuanjia/zhengzhijushoukezhuanjia/20110610530.html
[1625] "Governor Su Shulin Visited Xiamen University ATR Lab" [苏树林省长莅临厦门大学 ATR 实验室参观考察], *Xiamen University* [厦门大学], 13 June 2014. https://wscec.xmu.edu.cn/info/1006/1024.htm
[1626] "Shenzhen University ATR Key Laboratory of National Defense Science and Technology is looking for post-docs in 2017" [深圳大学 ATR 国防科技重点实验室智能信息处理方向 2017 年诚招博士后], *Northwest University*, 27 September 2017. http://jiuye.nwu.edu.cn/website/news_show.aspx?id=8444
[1627] "Yaxun network academician expert workstation successfully awarded" [雅迅网络院士专家工作站成功授牌[, *Tencent*, 30 November 2019. https://new.qq.com/omn/20191130/20191130A0NUYX00.html
[1628] "Millimeter-wave sensing technology and industrialized application" [毫米波感知技术及产业化应用], *Beihang University*, 20 March 2024, https://www.bhpocc.com/achievement/32-32
[1629] "Chapter 1: A Long History" [第一章 悠久历史], *Xinhua*, Accessed 2021, http://www.fj.xinhuanet.com/dszx/nazx/najg.htm
Fang Jiao [方娇] et al., "Defense scientists to forge the great weapon "super brain"" [国防科大人这样锻造大国利器“超强大脑”], *81.cn*, 12 August 2020. http://www.81.cn/dy/2020-08/12/content_9880299.htm
Regarding Zhuang Zhaowen’s rank, photos are inconclusive. For example, the photo at https://www.baike.com/wiki/%E5%BA%84%E9%92%8A%E6%96%87?view_id=2z9it9kxao7myo shows Zhuang with a Major General rank, but the (likely more recent) photo at https://www.sohu.com/a/499440607_121124017 shows what looks like the six-pointed flower of a civilian cadre.
[1630] "The second "Air and Space Cup" national innovation and creativity competition final held in Chang" [第二届“空天杯”全国创新创意大赛决赛在长举行], *Wenlu News* [文旅头条], 28 August 2019. http://www.wenlvnews.com/p/158880.html

[1631] "Guo Guirong" [郭桂蓉], *Beijing Sihai Changxin Consulting Center* [北京四海昌信咨询中心], Accessed 2021, http://www.shcxaa.com/tuijianzhuanjia/zhengzhijushoukezhuanjia/20110610530.html
"Yaxun network academician expert workstation successfully awarded" [雅迅网络院士专家工作站成功授牌], *Tencent*, 30 November 2019. https://new.qq.com/omn/20191130/20191130A0NUYX00.html
[1632] "Strengthen the research and development of major core technologies to provide strong scientific and technological support for advancing the cause of a strong military in the new era" [加强重大核心技术研究攻关为推进新时代强军事业提供强大科技支撑], *Sichuan News* [四川新闻网], 17 March 2021. http://www.sc-028.com/html/life/194508.html
[1633] "The Second "Air and Space Cup" National Innovation and Creativity Competition Presentation" [第二届"空天杯"全国创新创意大赛宣讲会], *Peking University*, 6 May 2019. https://scc.pku.edu.cn/jobfair_ff8080816a594ad7016a8c0cfd600af3_1.html
[1634] "Yaxun network academician expert workstation successfully awarded" [雅迅网络院士专家工作站成功授牌], *Tencent*, 30 November 2019. https://new.qq.com/omn/20191130/20191130A0NUYX00.html
[1635] "Chapter 1: A Long History" [第一章 悠久历史], *Xinhua*, Accessed 2021, http://www.fj.xinhuanet.com/dszx/nazx/najg.htm
[1636] "ATR Key Laboratory of Defense Science and Technology, Shenzhen University, Shenzhen" [深圳大学 ATR 国防科技重点实验室], *Shenzhen University* [深圳大学], Accessed 2021, https://it.szu.edu.cn/xgxy/info/1017/1300.htm
[1637] "ATR Key Laboratory of Defense Science and Technology, Shenzhen University, Shenzhen" [深圳大学 ATR 国防科技重点实验室], *Shenzhen University* [深圳大学], Accessed 2021, https://it.szu.edu.cn/xgxy/info/1017/1300.htm
[1638] "ATR Key Laboratory of Defense Science and Technology, Shenzhen University, Shenzhen" [深圳大学 ATR 国防科技重点实验室], *Shenzhen University* [深圳大学], Accessed 2021, https://it.szu.edu.cn/xgxy/info/1017/1300.htm
"Shenzhen University ATR Key Laboratory of National Defense Science and Technology is looking for post-docs in 2017" [深圳大学 ATR 国防科技重点实验室智能信息处理方向 2017 年诚招博士后], *Northwest University*, 27 September 2017. http://jiuye.nwu.edu.cn/website/news_show.aspx?id=8444
[1639] "National University of Defense Technology, College of Electronic Science ATR-3 Laboratory Recruitment Announcement" [国防科技大学电子科学学院 ATR-3 实验室招聘公告], *NUDT*, 17 August 2017. https://www.nudt.edu.cn/rczp/5dbf9f576a8a406f9626035aad231e45.htm
[1640] "Shenzhen University ATR Key Laboratory of National Defense Science and Technology is looking for post-docs in 2017" [深圳大学 ATR 国防科技重点实验室智能信息处理方向 2017 年诚招博士后], *Northwest University*, 27 September 2017. http://jiuye.nwu.edu.cn/website/news_show.aspx?id=8444
[1641] "Wang Zhongjin" [王忠金], *Harbin Institute of Technology*, Accessed 2021, http://homepage.hit.edu.cn/wangzhongjin
[1642] "No.036 National Key Lab for Precision Hot Processing of Metals" [NO.036 金属精密热加工国家重点实验室], *Changzhou Military-Civil Fusion Public Service Platform*, 14 June 2016. http://www.czjmrh.com/content/?1099.html
[1643] "No.036 National Key Lab for Precision Hot Processing of Metals" [NO.036 金属精密热加工国家重点实验室], *Changzhou Military-Civil Fusion Public Service Platform*, 14 June 2016. http://www.czjmrh.com/content/?1099.html
[1644] "HIT School of Materials Science and Engineering Graduate Advisor Profile – Sun Jianfei" [哈尔滨工业大学材料科学与工程学院研究生考研导师简介-孙剑飞], *FreeKaoyan.com*, 25 May 2019, http://school.freekaoyan.com/heilongjiang/hit/daoshi/2019/05-25/1558762406963686.shtml
"Sun Shen visited Professor Yuan Shijian, an expert in service" [孙珅看望联系服务专家苑世剑教授], *Sohu*, 23 October 2018. https://www.sohu.com/a/270639903_807006
[1645] "Qu Dazhuang, deputy general manager of State Nuclear Power Technology Corporation, and his delegation came to the university to discuss cooperation" [国家核电技术公司副总经理曲大庄一行来校洽谈合作], *China Nuclear Power Information Online* [中国核电信息网], 21 September 2020, http://www.heneng.net.cn/index.php?mod=news&category_id=9&action=show&article_id=5283

[1646] "No.036 National Key Lab for Precision Hot Processing of Metals" [NO.036 金属精密热加工国家重点实验室], *Changzhou Military-Civil Fusion Public Service Platform*, 14 June 2016. http://www.czjmrh.com/content/?1099.html
[1647] "Profile of Professor Yuan Shijian, a distinguished representative of our outstanding alumni and a Changjiang Scholar" [我校优秀校友的杰出代表、长江学者苑世剑教授简介], *Dalian Jiaotong University* [大连交通大学], Accessed 2021, http://smse.djtu.edu.cn/cn/_infolist/info_1.asp?f_id=19&f_menu_id=795
[1648] "Professor Su Yanqing, a National Outstanding Youth and Changjiang Scholar of the Ministry of Education, visited the university for academic exchange" [国家杰青、教育部长江学者苏彦庆教授来校进行学术交流], *Jiangsu University of Science and Technology* [江苏科技大学], 16 November 2020, https://cailiao.just.edu.cn/2020/1116/c4164a271978/page.htm
[1649] "Notice on the declaration of open topics of the State Key Laboratory of Comprehensive Utilization of Vanadium and Titanium Resources for 2019" [关于申报钒钛资源综合利用国家重点实验室 2019 年度开放课题申报通知], *Harbin Institute of Technology*, 13 November 2019. http://webcache.googleusercontent.com/search?q=cache%3Apre.hitwh.edu.cn%2F2019%2F1113%2Fc1607a114497%2Fpage.htm&rlz=1C1CHBD_enUS895US895&oq=cache%3Apre.hitwh.edu.cn%2F2019%2F1113%2Fc1607a114497%
[1650] "Shen Hongxian" [沈红先], *Harbin Institute of Technology*, Accessed 2021, http://homepage.hit.edu.cn/shenhongxian
[1651] Kong Fantao [孔凡涛] et al., "Advances in the research of metal-intermetallic compound laminated composites" [金属-金属间化合物叠层复合材料研究进展], *Journal of Aviation Materials* [航空材料学报] 4 (2018).
[1652] "National Key Laboratory for Precision Hot Processing of Metals" [金属精密热加工国家级重点实验室], *Harbin Institute of Technology*, 1 May 2010. http://mse.hit.edu.cn/2010/0501/c3766a99689/page.htm
[1653] "HIT Graduate Advisor Profile – Sun Jianfei" [哈尔滨工业大学研究生导师简介-孙剑飞*], FreeKaoyan.com*, 1 April 2016, http://school.freekaoyan.com/heilongjiang/hit/daoshi/2016/04-01/1459455759546674.shtml
[1654] "Shen Hongxian" [沈红先], *Harbin Institute of Technology*, Accessed 2021, http://homepage.hit.edu.cn/shenhongxian
[1655] "The Science Association of Electrical College organized students to visit the key laboratory of radar signal processing" [电院科协组织学生参观雷达信号处理重点实验室], *Xidian University*, 8 December 2011. https://see.xidian.edu.cn/html/news/4981.html
"Homepage," *National Lab of Radar Signal Processing* [雷达信号处理国家重点实验室], Accessed 2021, https://rsp.xidian.edu.cn/index.html. English version at https://rsp.xidian.edu.cn/html/english/
"Welcome to the new website of State Key Laboratory of Radar Signal Processing (Institute of Electronics)" [欢迎访问雷达信号处理国家重点实验室(电子所)新网站], *Xidian University*, 1 December 2008. https://www.xidian.edu.cn/info/1063/2313.htm
"Discipline research direction" [学科研究方向], National Key Laboratory of Radar Signal Processing, Accessed October 2024, https://rsp.xidian.edu.cn/info/1019/1525.htm
[1656] "Discipline research direction" [学科研究方向], *National Key Laboratory of Radar Signal Processing*, Accessed October 2024, https://rsp.xidian.edu.cn/info/1019/1525.htm
[1657] "The Science Association of Electrical College organized students to visit the key laboratory of radar signal processing" [电院科协组织学生参观雷达信号处理重点实验室], *Xidian University*, 8 December 2011. https://see.xidian.edu.cn/html/news/4981.html
"Homepage," *National Lab of Radar Signal Processing* [雷达信号处理国家重点实验室], Accessed 2021, https://rsp.xidian.edu.cn/index.html. English version at https://rsp.xidian.edu.cn/html/english/
"Welcome to the new website of State Key Laboratory of Radar Signal Processing (Institute of Electronics)" [欢迎访问雷达信号处理国家重点实验室(电子所)新网站], *Xidian University*, 1 December 2008. https://www.xidian.edu.cn/info/1063/2313.htm
"Discipline research direction" [学科研究方向], National Key Laboratory of Radar Signal Processing, Accessed October 2024, https://rsp.xidian.edu.cn/info/1019/1525.htm

[1658] "Introduction of National Key Laboratory of Radar Signal Processing" [雷达信号处理全国重点实验室简介], *National Key Laboratory of Radar Signal Processing*, Accessed April 2025, https://rsp.xidian.edu.cn/sysgk/sysjj.htm
[1659] "(Original) Enrolling in the Key Laboratory of Radar Signal Processing is your firm and wise choice" [(原创)报考雷达信号处理重点实验室是你坚定明智的选择], Jianshu [简书], 28 June 2019. https://www.jianshu.com/p/77b38b785417
"Homepage," National Lab of Radar Signal Processing [雷达信号处理国家重点实验室], Accessed 2021, https://rsp.xidian.edu.cn/index.html. English version at https://rsp.xidian.edu.cn/html/english/
[1660] "Homepage," National Lab of Radar Signal Processing [雷达信号处理国家重点实验室], Accessed 2021, https://rsp.xidian.edu.cn/index.html. English version at https://rsp.xidian.edu.cn/html/english/
"(Original) Enrolling in the Key Laboratory of Radar Signal Processing is your firm and wise choice" [(原创)报考雷达信号处理重点实验室是你坚定明智的选择], *Jianshu* [简书], 28 June 2019. https://www.jianshu.com/p/77b38b785417
"Alumni Person of the Year 丨 Polishing the "clairvoyance" of national defense! He is an expert in the field of radar signal processing!" [校友年度人物 丨 擦亮国防的"千里眼"！他是雷达信号处理领域专家!], *Dalian University of Technology*, 20 January 2021. http://alumni.dlut.edu.cn/info/1041/5514.htm
[1661] "Homepage," *National Lab of Radar Signal Processing* [雷达信号处理国家重点实验室], Accessed 2021, https://rsp.xidian.edu.cn/index.html. English version at https://rsp.xidian.edu.cn/html/english/
[1662] "Homepage," *National Lab of Radar Signal Processing* [雷达信号处理国家重点实验室], Accessed 2021, https://rsp.xidian.edu.cn/index.html. English version at https://rsp.xidian.edu.cn/html/english/
"On-campus coy flower search" [校内嗲花查询], *Xidian University*, Accessed 2021, https://tel.xidian.cc/search.php?Dpid=73
[1663] "Introduction of National Key Laboratory of Radar Signal Processing" [雷达信号处理全国重点实验室简介], *National Key Laboratory of Radar Signal Processing*, Accessed April 2025, https://rsp.xidian.edu.cn/sysgk/sysjj.htm
[1664] "Xidians's first national local joint engineering research center was officially approved for construction" [西电首个国家地方联合工程研究中心正式获批建设], 西 *Xidian University*, 15 March 2019. https://rsp.xidian.edu.cn/html/news/allnews/2019/0315/398.html
[1665] "Discipline research direction" [学科研究方向], *National Key Laboratory of Radar Signal Processing*, Accessed October 2024, https://rsp.xidian.edu.cn/info/1019/1525.htm
[1666] "Homepage," *National Lab of Radar Signal Processing* [雷达信号处理国家重点实验室], Accessed 2021, https://rsp.xidian.edu.cn/index.html. English version at https://rsp.xidian.edu.cn/html/english/
[1667] "Homepage," *National Lab of Radar Signal Processing* [雷达信号处理国家重点实验室], Accessed 2021, https://rsp.xidian.edu.cn/index.html. English version at https://rsp.xidian.edu.cn/html/english/
"Bao Zheng: A "referee" for the radar" [保铮： 雷达界的"裁判长"], *ScienceDirect* [科学导报], 17 November 2020. http://www.kxdb.com/index.php/News/news/articleId/29222.html
"Alumni Person of the Year 丨 Polishing the "clairvoyance" of national defense! He is an expert in the field of radar signal processing!" [校友年度人物 丨 擦亮国防的"千里眼"！他是雷达信号处理领域专家!], *Dalian University of Technology*, 20 January 2021. http://alumni.dlut.edu.cn/info/1041/5514.htm
[1668] "Leaning on the sky with a sharp sword like a rainbow - close to a technical innovation team in the key laboratory of automatic target recognition of the National Defense University of Science and Technology" [倚天利剑气如虹——走近国防科大自动目标识别重点实验室某技术创新团队], *Voice of China*, 28 June 2018. http://webcache.googleusercontent.com/search?q=cache%3Ahunan.voc.com.cn%2Farticle%2F201806%2F201806280712154621.html&rlz=1C1CHBD_enUS895US895&oq=cache%3Ahunan.voc.com.cn%2Farticle%2F201806%2F201806280712154621.html&aqs=chrome..69i57j69i58.5384j0j4&sourceid=chrome&ie=UTF-8
Fang Jiao [方娇] et al., "Defense scientists to forge the great weapon "super brain"" [国防科大人这样锻造大国利器"超强大脑"], *81.cn*, 12 August 2020. http://www.81.cn/dy/2020-08/12/content_9880299.htm
"Dongfeng 100 missile "comes with a brain": can improvise, decide on its own maneuver to change trajectory" [东风 100 导弹"自带大脑"：可以随机应变，自己决定机动变轨], *kknews*, 22 August 2020. https://kknews.cc/zh-cn/military/e5yk23r.html

[1669] "Leaning on the sky with a sharp sword like a rainbow - close to a technical innovation team in the key laboratory of automatic target recognition of the National Defense University of Science and Technology" [倚天利剑气如虹——走近国防科大自动目标识别重点实验室某技术创新团队], *Voice of China*, 28 June 2018. http://webcache.googleusercontent.com/search?q=cache%3Ahunan.voc.com.cn%2Farticle%2F201806%2F201806280712154621.html&rlz=1C1CHBD_enUS895US895&oq=cache%3Ahunan.voc.com.cn%2Farticle%2F201806%2F201806280712154621.html&aqs=chrome..69i57j69i58.5384j0j4&sourceid=chrome&ie=UTF-8
Fang Jiao [方娇] et al., "Defense scientists to forge the great weapon "super brain"" [国防科大人这样锻造大国利器"超强大脑"], *81.cn*, 12 August 2020. http://www.81.cn/dy/2020-08/12/content_9880299.htm
"Dongfeng 100 missile "comes with a brain": can improvise, decide on its own maneuver to change trajectory" [东风 100 导弹"自带大脑"：可以随机应变，自己决定机动变轨], *kknews*, 22 August 2020. https://kknews.cc/zh-cn/military/e5yk23r.html
[1670] "A share of tomorrow's wind: 8 ministries issued opinions to strengthen the standardization of express green packaging" [A 股明日风口：8 部委发布意见加强快递绿色包装标准化工作], *Sina*, 9 August 2020. https://finance.sina.cn/stock/ywgg/2020-08-09/detail-iivhvpwy0099562.d.html?vt=4&cid=76524&node_id=76524
[1671] "Guo Guirong" [郭桂蓉], *Beijing Sihai Changxin Consulting Center* [北京四海昌信咨询中心], Accessed 2021, http://www.shcxaa.com/tuijianzhuanjia/zhengzhijushoukezhuanjia/20110610530.html
[1672] "Governor Su Shulin Visited Xiamen University ATR Lab" [苏树林省长莅临厦门大学 ATR 实验室参观考察], *Xiamen University* [厦门大学], 13 June 2014. https://wscec.xmu.edu.cn/info/1006/1024.htm
[1673] "Shenzhen University ATR Key Laboratory of National Defense Science and Technology is looking for post-docs in 2017" [深圳大学 ATR 国防科技重点实验室智能信息处理方向 2017 年诚招博士后], *Northwest University*, 27 September 2017. http://jiuye.nwu.edu.cn/website/news_show.aspx?id=8444
[1674] "Yaxun network academician expert workstation successfully awarded" [雅迅网络院士专家工作站成功授牌[, *Tencent*, 30 November 2019. https://new.qq.com/omn/20191130/20191130A0NUYX00.html
[1675] "Introduction of National Key Laboratory of Radar Signal Processing" [雷达信号处理全国重点实验室简介], *National Key Laboratory of Radar Signal Processing*, Accessed April 2025, https://rsp.xidian.edu.cn/sysgk/sysjj.htm
[1676] "Chapter 1: A Long History" [第一章 悠久历史], *Xinhua*, Accessed 2021, http://www.fj.xinhuanet.com/dszx/nazx/najg.htm
Fang Jiao [方娇] et al., "Defense scientists to forge the great weapon "super brain"" [国防科大人这样锻造大国利器"超强大脑"], *81.cn*, 12 August 2020. http://www.81.cn/dy/2020-08/12/content_9880299.htm
Regarding Zhuang Zhaowen's rank, photos are inconclusive. For example, the photo at https://www.baike.com/wiki/%E5%BA%84%E9%92%8A%E6%96%87?view_id=2z9it9kxao7myo shows Zhuang with a Major General rank, but the (likely more recent) photo at https://www.sohu.com/a/499440607_121124017 shows what looks like the six-pointed flower of a civilian cadre.
[1677] "The second "Air and Space Cup" national innovation and creativity competition final held in Chang" [第二届"空天杯"全国创新创意大赛决赛在长举行], *Wenlu News* [文旅头条], 28 August 2019. http://www.wenlvnews.com/p/158880.html
[1678] "Guo Guirong" [郭桂蓉], *Beijing Sihai Changxin Consulting Center* [北京四海昌信咨询中心], Accessed 2021, http://www.shcxaa.com/tuijianzhuanjia/zhengzhijushoukezhuanjia/20110610530.html
"Yaxun network academician expert workstation successfully awarded" [雅迅网络院士专家工作站成功授牌[, *Tencent*, 30 November 2019. https://new.qq.com/omn/20191130/20191130A0NUYX00.html
[1679] "Homepage," *National Lab of Radar Signal Processing* [雷达信号处理国家重点实验室], Accessed 2021, https://rsp.xidian.edu.cn/index.html. English version at https://rsp.xidian.edu.cn/html/english/
[1680] Zhang Linrng [张林让], *Beijing Gunxue Technology Co.* [北京衮雪科技有限公司], Accessed 2021, https://www.x-mol.com/university/faculty/214491
[1681] Zhang Linrng [张林让], *Beijing Gunxue Technology Co.* [北京衮雪科技有限公司], Accessed 2021, https://www.x-mol.com/university/faculty/214491
[1682] "Ph.D. Admission, Radar Signal Processing Laboratory, School of Information Technology, Xiamen University," [厦门大学信息学院雷达信号处理实验室博士招生], Southeast University, 4 November 2015, https://radio.seu.edu.cn/2015/1104/c19216a227410/page.htm

[1683] "Radar Signal Processing Lab Hosts 2012 Annual Graduate Student Conference" [雷达信号处理实验室举办2012年研究生学术年会], *Microwave RF King* [微波射频王], 29 November 2012, http://www.mwrf.net/news/zhbd/2012/8866.html
[1684] "Homepage," *National Lab of Radar Signal Processing* [雷达信号处理国家重点实验室], Accessed 2021, https://rsp.xidian.edu.cn/index.html. English version at https://rsp.xidian.edu.cn/html/english/
[1685] "Homepage," *National Lab of Radar Signal Processing* [雷达信号处理国家重点实验室], Accessed 2021, https://rsp.xidian.edu.cn/index.html. English version at https://rsp.xidian.edu.cn/html/english/
[1686] "Tesla face retrofit 4D millimeter wave radar, is it a real "god"?" [特斯拉打脸加装的4D毫米波雷达，是真"神人"？], *DaaS-Auto*, 23 February 2023, https://www.daas-auto.com/hot_news/news_detail/news/15256.html
[1687] Zhang Lei [张磊], "A New Method of Anti-FM Slope Mismatch Jamming for Single Channel Synthetic Aperture Radar" [单通道合成孔径雷达抗调频斜率失配干扰新方法], *Journal of Electronics & Information Technology* [电子与信息学报], 9, 2020, gb.oversea.cnki.net/KCMS/detail/detail.aspx?filename=DZY
[1688] "Homepage," *National Lab of Radar Signal Processing* [雷达信号处理国家重点实验室], Accessed 2021, https://rsp.xidian.edu.cn/index.html. English version at https://rsp.xidian.edu.cn/html/english/
[1689] "The 4th Electronic Information Young Scholars Forum was successfully held in Xidian" [第四届电子信息青年学者论坛在西电圆满召开], *Xidian University*, 8 November 2019. https://rsp.xidian.edu.cn/html/news/allnews/2019/1108/422.html
[1690] "Inauguration of the Joint Research Center for Cognitive Signal Processing of Xidian and University of Pisa and the 2nd International Symposium on Intelligent Learning and Processing of Signals and Information" [西电-比萨大学认知信号处理联合研究中心揭牌仪式暨第二届信号与信息智能学习与处理国际研讨会], *QQ*, 18 July 2019, https://page.om.qq.com/page/OIntp1jj85PAgCy_R5E5beJQ0
[1691] "Syracuse University Establishes International Center on Information Fusion with China's Xidian University," *Syracuse University*, 11 July 2018. https://news.syr.edu/blog/2018/07/11/syracuse-university-establishes-international-center-on-information-fusion-with-chinas-xidian-university/
[1692] "Inauguration of the Joint Research Center for Cognitive Signal Processing of Xidian and University of Pisa and the 2nd International Symposium on Intelligent Learning and Processing of Signals and Information" [西电-比萨大学认知信号处理联合研究中心揭牌仪式暨第二届信号与信息智能学习与处理国际研讨会], *QQ*, 18 July 2019, https://page.om.qq.com/page/OIntp1jj85PAgCy_R5E5beJQ0
[1693] "Alumni Person of the Year 丨 Polishing the "clairvoyance" of national defense! He is an expert in the field of radar signal processing!" [校友年度人物 丨 擦亮国防的"千里眼"！他是雷达信号处理领域专家!], *Dalian University of Technology*, 20 January 2021. http://alumni.dlut.edu.cn/info/1041/5514.htm
[1694] "Recent Radar Experimental Results," *National Key Laboratory of Radar Signal Processing*, 2 July 2023, https://rsp.xidian.edu.cn/info/1026/1942.htm
[1695] "Successful CIE International Radar Conference 2021" [2021年CIE国际雷达会议成功举办], *Xidian University*, 29 December 2021, https://see.xidian.edu.cn/html/news/11191.html
[1696] "Lan Lan: Polishing the "fiery eyes" of the informationization battlefield" [兰岚：擦亮信息化战场的"火眼金睛"], *Sina*, 18 March 2023, https://finance.sina.cn/2023-03-18/detail-imymhzxu4157792.d.html
[1697] "Dr. Xin Yuan from Bell Labs visited Xidian to talk about the latest research progress of compressed sensing technology," [贝尔实验室袁鑫博士访问西电 讲述压缩感知技术的最新研究进展], *kkNews*, 1 April 2016. https://kknews.cc/zh-my/other/4zmrrg.html
[1698] "Mr. CHEVALIER from THALES France came to our university for a lecture visit" [法国THALES公司CHEVALIER先生来我校讲学访问], *Xidian University*, 12 December 2007. https://rsp.xidian.edu.cn/html/news/all/2016/1127/125.html
[1699] "(Original) Enrolling in the Key Laboratory of Radar Signal Processing is your firm and wise choice" [(原创)报考雷达信号处理重点实验室是你坚定明智的选择], *Jianshu* [简书], 28 June 2019. https://www.jianshu.com/p/77b38b785417
[1700] "Homepage," *National Lab of Radar Signal Processing* [雷达信号处理国家重点实验室], Accessed 2021, https://rsp.xidian.edu.cn/index.html. English version at https://rsp.xidian.edu.cn/html/english/
[1701] "Homepage," *National Lab of Radar Signal Processing* [雷达信号处理国家重点实验室], Accessed 2021, https://rsp.xidian.edu.cn/index.html. English version at https://rsp.xidian.edu.cn/html/english/

[1702] "Homepage," *National Lab of Radar Signal Processing* [雷达信号处理国家重点实验室], Accessed 2021, https://rsp.xidian.edu.cn/index.html. English version at https://rsp.xidian.edu.cn/html/english/
[1703] "Homepage," *National Lab of Radar Signal Processing* [雷达信号处理国家重点实验室], Accessed 2021, https://rsp.xidian.edu.cn/index.html. English version at https://rsp.xidian.edu.cn/html/english/
[1704] "Equipment and Facilities" [仪器设备], *National Key Laboratory of Radar Signal Processing*, Accessed May 2024, https://rsp.xidian.edu.cn/
[1705] "Dr. Xin Yuan from Bell Labs visited Xidian to talk about the latest research progress of compressed sensing technology," [贝尔实验室袁鑫博士访问西电 讲述压缩感知技术的最新研究进展], kkNews, 1 April 2016. https://kknews.cc/zh-my/other/4zmrrg.html
[1706] "Xi'an University of Electronic Science and Technology, No.2 South Tai Bai Road, Yanta District, Xi'an, Shaanxi Province" [陕西省西安市雁塔区太白南路 2 号西安电子科技大学], *Youbianku*, Accessed 2021, https://www.youbianku.com/%E9%99%95%E8%A5%BF%E7%9C%81%E8%A5%BF%E5%AE%89%E5%B8%82%E9%9B%81%E5%A1%94%E5%8C%BA%E5%A4%AA%E7%99%BD%E5%8D%97%E8%B7%AF2%E5%8F%B7%E8%A5%BF%E5%AE%89%E7%94%B5%E5%AD%90%E7%A7%91%E6%8A%80%E5%A4%A7%E5%AD%A6
[1707] "Brief Introduction to Sponsors," *The 12th International Symposium on Antennas, Propagation and EM Theory*, Accessed 2021, http://www.rpsoc.cn/isape2018/index.php/site/singlePage/35
[1708] "Brief Introduction to Sponsors," *The 12th International Symposium on Antennas, Propagation and EM Theory*, Accessed 2021, http://www.rpsoc.cn/isape2018/index.php/site/singlePage/35
"Chapter II Scientific Research Institutions" [第二章 科研机构], *Qingdao City Affairs Network* [青岛市情网], Accessed 2021, http://qdsq.qingdao.gov.cn/n15752132/n30400816/n30400892/n30485315/151215041304282305.html
"State Key Laboratory" [国家重点实验室], *State Key Laboratory of Radio Environment Characteristics and Modeling Technology* [电波环境特性及模化技术国家重点实验室], Accessed 2021, https://web.archive.org/web/20071017121411/http://leme.ac.cn/sysgk.htm
[1709] "Company Profile" [企业简介], CETC 22nd RI [中国电子科技集团公司第二十二研究所], Accessed 2021, https://web.archive.org/web/20161120010447/http://www.crirp.ac.cn/22/338987/338975/index.html
[1710] "State Key Laboratory" [国家重点实验室], *State Key Laboratory of Radio Environment Characteristics and Modeling Technology* [电波环境特性及模化技术国家重点实验室], Accessed 2021, https://web.archive.org/web/20071017121411/http://leme.ac.cn/sysgk.htm
[1711] "Introduction to the laboratory" [实验室简介], State Key Laboratory of Radio Environment Characteristics and Modeling Technology [电波环境特性及模化技术国家重点实验室], Accessed 2021, https://web.archive.org/web/20080409182755/http://leme.ac.cn/
"State Key Laboratory" [国家重点实验室], *State Key Laboratory of Radio Environment Characteristics and Modeling Technology* [电波环境特性及模化技术国家重点实验室], Accessed 2021, https://web.archive.org/web/20071017121411/http://leme.ac.cn/sysgk.htm
[1712] "State Key Laboratory" [国家重点实验室], *State Key Laboratory of Radio Environment Characteristics and Modeling Technology* [电波环境特性及模化技术国家重点实验室], Accessed 2021, https://web.archive.org/web/20071017121411/http://leme.ac.cn/sysgk.htm
[1713] "Brief Introduction to Sponsors," *The 12th International Symposium on Antennas, Propagation and EM Theory*, Accessed 2021, http://www.rpsoc.cn/isape2018/index.php/site/singlePage/35
"Introduction to the laboratory" [实验室简介], *State Key Laboratory of Radio Environment Characteristics and Modeling Technology* [电波环境特性及模化技术国家重点实验室], Accessed 2021, https://web.archive.org/web/20080409182755/http://leme.ac.cn/
"State Key Laboratory" [国家重点实验室], *State Key Laboratory of Radio Environment Characteristics and Modeling Technology* [电波环境特性及模化技术国家重点实验室], Accessed 2021, https://web.archive.org/web/20071017121411/http://leme.ac.cn/sysgk.htm
[1714] "Introduction to the laboratory" [实验室简介], *State Key Laboratory of Radio Environment Characteristics and Modeling Technology* [电波环境特性及模化技术国家重点实验室], Accessed 2021, https://web.archive.org/web/20080409182755/http://leme.ac.cn/

"State Key Laboratory" [国家重点实验室], *State Key Laboratory of Radio Environment Characteristics and Modeling Technology* [电波环境特性及模化技术国家重点实验室], Accessed 2021, https://web.archive.org/web/20071017121411/http://leme.ac.cn/sysgk.htm
"Scientific and technological achievements" [科技成果], *State Key Laboratory of Radio Environment Characteristics and Modeling Technology* [电波环境特性及模化技术国家重点实验室], Accessed 2021, https://web.archive.org/web/20071017121341/http://leme.ac.cn/kjcg.htm
[1715] "Scientific and technological achievements" [科技成果*], State Key Laboratory of Radio Environment Characteristics and Modeling Technology* [电波环境特性及模化技术国家重点实验室], Accessed 2021, https://web.archive.org/web/20071017121341/http://leme.ac.cn/kjcg.htm
"Real Time Estimation of Electromagnetic Wave Refraction Bending Angles with Singular Ground-Based GPS" [单站地基 GPS 实时估计电波折射弯曲角], *Geomatics and Information Science of Wuhan University* [武汉大学学报-信息科学版] (37)2012. http://ch.whu.edu.cn/article/id/231
"Non-ambiguity capture algorithm based on correlation shift BOC(n,n)" [基于相关移位 BOC(n,n)无模糊度捕获算法], *Journal of Beijing Institute of Technology* [北京理工大学学报], (3) 2020.
[1716] "Scientific and technological achievements" [科技成果], *State Key Laboratory of Radio Environment Characteristics and Modeling Technology* [电波环境特性及模化技术国家重点实验室], Accessed 2021, https://web.archive.org/web/20071017121341/http://leme.ac.cn/kjcg.htm
[1717] "Researcher Wu Jian, Distinguished Alumni of Our School" [我院杰出校友吴健研究员], *School of Physics and Electronic Engineering, Fuyang Normal University* [阜阳师范大学物理与电子工程学院], 25 October 2018. https://archive.is/ts9rD
[1718] "Our school signed a strategic cooperation agreement with the China Institute of Radio Communication" [我校与中国电波传播研究所签订战略合作协议], *Hangzhou Dianzi University* [杭州电子科技大学], 16 May 2018. https://archive.is/Zx667
[1719] "Application of Wideband Delphi Technology in Software Estimation" [Wideband_Delphi 技术在软件估算中的应用], Electronics Quality [电子质量] (10) 2017. https://www.cqvip.com/qk/90112x/201710/7000342453.html
"Channel Analysis and Application of Troposphere Duct over Sea" [海洋大气波导信道特性分析与应用], Radio Engineering [无线电工程] (43) 2013. http://ir.nsfc.gov.cn/paperDownload/1000015076237.pdf
[1720] "Introduction to the laboratory" [实验室简介], *State Key Laboratory of Radio Environment Characteristics and Modeling Technology* [电波环境特性及模化技术国家重点实验室], Accessed 2021, https://web.archive.org/web/20080409182755/http://leme.ac.cn/
"Brief Introduction to Sponsors," *The 12th International Symposium on Antennas, Propagation and EM Theory*, Accessed 2021, http://www.rpsoc.cn/isape2018/index.php/site/singlePage/35
[1721] "Brief Introduction to Sponsors," *The 12th International Symposium on Antennas, Propagation and EM Theory*, Accessed 2021, http://www.rpsoc.cn/isape2018/index.php/site/singlePage/35
[1722] "Introduction to the laboratory" [实验室简介*], State Key Laboratory of Radio Environment Characteristics and Modeling Technology* [电波环境特性及模化技术国家重点实验室], Accessed 2021, https://web.archive.org/web/20080409182755/http://leme.ac.cn/
[1723] "Brief Introduction to Sponsors," T*he 12th International Symposium on Antennas, Propagation and EM Theory*, Accessed 2021, http://www.rpsoc.cn/isape2018/index.php/site/singlePage/35
"Welcome to ISAPE2010," *Xidian University*, Accessed 2021, https://see.xidian.edu.cn/conference/isape2010/
"The 11th National Annual Conference on Radio Wave Propagation The first round of call for papers (please post)" [第十一届全国电波传播学术讨论年会 第一轮征文通知（请张贴）], [2011 年第十一届全国电波传播学术讨论年会], 25 May 2011.
"VHF radar observations of the PMSE over Norway," *CHINESE JOURNAL OF RADIO SCIENCE*, Vol. 28, No.1 February, 2013. https://www.sloc.com.cn/index/download/pid/30625
"The 13th National Radio Wave Propagation Academic Annual Conference and Academician Lu Baowei's Centennial Birthday Commemoration Meeting was successfully held" [第十三届全国电波传播学术年会暨吕保维院士百年华诞纪念会胜利召开], *CAS Institute of Electronics* [中国科学院电子学研究所], 23 October 2015. http://www.ie.cas.cn/gzdt2016/201510/t20151023_4444421.html

"Notice of Call for Papers for the 14th National Conference on Radio Wave Propagation" [第十四届全国电波传播学术讨论年会征文通知], *Journal of Radio Science* [电波科学学报], 2017 年 3 期. http://www.dptsg.com/qikan/98d114c1c59e76f4f9509a4de872d5a0.html
CNSRP2019-The 15th National Annual Conference on Radio Wave Propagation" [CNSRP2019-第十五届全国电波传播学术讨论年会], *China Research Institute of Radio Wave Propagation* [中国电波传播研究所], accessed April 2021. https://web.archive.org/web/20210426181038/http://www.rpsoc.cn/cnsrp2019/index.php
"CNSRP2020-The 16th National Annual Conference on Radio Wave Propagation" [CNSRP2020-第十六届全国电波传播学术讨论年会], *China Research Institute of Radio Wave Propagation* [中国电波传播研究所], accessed April 2021. http://www.rpsoc.cn/cnsrp2020/
[1724] "Chapter II Scientific Research Institutions" [第二章 科研机构], *Qingdao City Affairs Network* [青岛市情网], Accessed 2021, http://qdsq.qingdao.gov.cn/n15752132/n30400816/n30400892/n30485315/151215041304282305.html
[1725] "State Key Laboratory" [国家重点实验室], *State Key Laboratory of Radio Environment Characteristics and Modeling Technology* [电波环境特性及模化技术国家重点实验室], Accessed 2021, https://web.archive.org/web/20071017121411/http://leme.ac.cn/sysgk.htm
[1726] "State Key Laboratory" [国家重点实验室], *State Key Laboratory of Radio Environment Characteristics and Modeling Technology* [电波环境特性及模化技术国家重点实验室], Accessed 2021, https://web.archive.org/web/20071017121411/http://leme.ac.cn/sysgk.htm
[1727] "The 36th China Simulation Conference was successfully held in Yangzhou" [第三十六届中国仿真大会在扬州顺利召开], *China Simulation Federation*, 18 October 2024, http://www.csf-sim.org.cn/showNewsDetail.asp?nsId=1487
"Prof. Quan Qiquan gave a lecture at Beijing Strength Environment Institute" [全齐全教授在北京强度环境研究所作学术报告], *Aerospace Mechanism Testing*, 3 December 2024, http://www.amthit.org/cn/?p=8151
[1728] "Introduction to the Sub-Laboratory of Beijing Institute of Satellite Environmental Engineering, State Key Laboratory of Reliability and Environmental Engineering Technology" ["可靠性与环境工程技术"国家科技重点实验室北京卫星环境工程研究所分实验室简介], *China Aerospace Journal Platform* [中国航天期刊平台], Accessed 2021, http://new.zghtqk.com/cn/simple_view_abstract.aspx?pcid=26FCEE7E0C06EA5863D91553F1CAF79C693AA6D910AD699D&cid=433C7FE4A4A0ED97&jid=F7CC4DF28BBCB8CEA6443EC43C69F841&aid=23065F6483C9B2B5FBC7B2133F895263&yid=9377ED8094509821&iid=CA4FD0336C81A37A&sid=0B39A22176CE99FB&eid=76AC9483E38F6FA0&referenced_num=0&reference_num=0
"Key Laboratory of Reliability and Environmental Engineering Technology for National Defense" [可靠性与环境工程技术国防科技重点实验室], *Capital Science and Technology Condition Platform* [首都科技条件平台], Accessed 2021, https://www.sdtjpt.cn/sites/sdtjpt/lab.html?id=1125&searchkey=
"Yanlin Xu, Reliability and Environmental Engineering Technology Key Laboratory News" [徐焱林, 可靠性与环境工程技术"重点实验室动态], *iXueshu*, Accessed 2021, https://www.ixueshu.com/h5/document/8170b4f9a3ae16f2318947a18e7f9386.html
[1729] "Experts tell you what "reliability" is" [专家告诉你什么是"可靠性"], *Sohu*, 25 June 2018. https://www.sohu.com/a/237646938_492541
"We welcome all the talented people from all over the world, and we have a lot of fruits" [迎新专栏 | 海纳百川迎四方英杰，桃李芬芳结硕果累累], *Sohu*, 31 August 2017. https://www.sohu.com/a/168727575_816163
[1730] "Introduction to the Sub-Laboratory of Beijing Institute of Satellite Environmental Engineering, State Key Laboratory of Reliability and Environmental Engineering Technology" ["可靠性与环境工程技术"国家科技重点实验室北京卫星环境工程研究所分实验室简介], *China Aerospace Journal Platform* [中国航天期刊平台], Accessed 2021, http://new.zghtqk.com/cn/simple_view_abstract.aspx?pcid=26FCEE7E0C06EA5863D91553F1CAF79C693AA6D910AD699D&cid=433C7FE4A4A0ED97&jid=F7CC4DF28BBCB8CEA6443EC43C69F841&aid=23065F6483C9B2B5FBC7B2133F895263&yid=9377ED8094509821&iid=CA4FD0336C81A37A&sid=0B39A22176CE99FB&eid=76AC9483E38F6FA0&referenced_num=0&reference_num=0

"Beijing Institute of Spacecraft Environment Engineering" [北京卫星环境工程研究所], *CAST*, 21 April 2016. https://www.cast.cn/news/4077

[1731] "Beijing Institute of Strength and Environment" [北京强度环境研究所], *CALT*, Accessed 2021, http://m.calt.com/n1689/n1713/c13698/content.html

[1732] U.S. Entity List – Annotated China Section, *Wisconsin Project on Nuclear Arms Control*, 1 April 2008. https://www.wisconsinproject.org/u-s-entity-list-annotated-china-section/

[1733] "Key Laboratory of Reliability and Environmental Engineering Technology for National Defense" [可靠性与环境工程技术国防科技重点实验室], *Capital Science and Technology Condition Platform* [首都科技条件平台], Accessed 2021, https://www.sdtjpt.cn/sites/sdtjpt/lab.html?id=1125&searchkey=

[1734] "Beijing University of Aeronautics and Astronautics ladies invite you to volunteer" [北京航空航天大学小姐姐们邀你填志愿], *NetEase*, 1 July 2017. https://edu.163.com/photoview/3Q0N0029/2236185.html#p=CO8CF9LD3Q0N0029

"Application Tips |2017 Beihang enrollment full analysis I: engineering experimental class (aerospace class)" [报考秘籍 |2017 北航招生全解析 I：工科试验班类(航空航天类)], *Xuehua* [雪花新闻], 24 June 2018. https://www.xuehua.us/a/5eb7263d86ec4d3b436545b6

"Members of the research group participated in the 3rd Aerospace Engineering and High Performance Materials Requirements and Application Technology Exchange" [研究组成员参加第三届航天工程和高性能材料需求与应用技术交流会], *Extreme Environment Powder Metallurgy Materials Research Team* [极端环境粉末冶金材料研究团队], 28 September 2015. http://spm-abs.com/newsshow.asp?id=362

[1735] "Key Laboratory of Reliability and Environmental Engineering Technology for National Defense" [可靠性与环境工程技术国防科技重点实验室], *Capital Science and Technology Condition Platform* [首都科技条件平台], Accessed 2021, https://www.sdtjpt.cn/sites/sdtjpt/lab.html?id=1125&searchkey=

[1736] "Key Laboratory of Reliability and Environmental Engineering Technology for National Defense" [可靠性与环境工程技术国防科技重点实验室], *Capital Science and Technology Condition Platform* [首都科技条件平台], Accessed 2021, https://www.sdtjpt.cn/sites/sdtjpt/lab.html?id=1125&searchkey=

[1737] "Introduction of System Engineering Tutor in School of Reliability and Systems Engineering, Beihang University: Lv Chen" [北航可靠性与系统工程学院系统工程导师介绍：吕琛], *China Kaoyan*, 11 September 2015. http://www.chinakaoyan.com/graduate/info/nid/90954/schoolID/87.shtml

[1738] "Upcoming Lectures | Into the Key Laboratory of Reliability" [讲座预告 | 走进可靠性重点实验室], *Sohu*, 1 November 2019. https://www.sohu.com/a/350984026_816163

[1739] "The group successfully held the 8th Equipment Vibration and Noise Control Youth Forum and Workshop on Mechanical Metamaterials/Structures Theory and Applications" [课题组成功举办第八届装备振动与噪声控制青年论坛暨力学超材料/结构理论与应用研讨会], *National University of Defense Technology* [国防科技大学], 23 November 2020. http://vag.nudt.edu.cn/index.php/home/index/detail/id/302.html

[1740] "16th International Conference on Reliability, Maintainability and Safety" [ 第十六届国际可靠性维修性安全性会议, 学术会议在线], *ICRMS*, Accessed January 2025, https://www.icrms.cn/#/

[1741] "The 6th China Simulation Technology Application Conference and Tianjin (Ninghe) Low Altitude Industry Development Summit held in Tianjin" [第六届中国仿真技术应用大会暨天津（宁河）低空产业发展峰会在津隆重举行], *China Automative News*, 8 November 2024, http://www.cnautonews.com/zhinengwl/2024/11/08/detail_20241108369531.html

[1742] "Yanlin Xu, Reliability and Environmental Engineering Technology Key Laboratory News" [徐焱林, 可靠性与环境工程技术"重点实验室动态], *iXueshu*, Accessed 2021, https://www.ixueshu.com/h5/document/8170b4f9a3ae16f2318947a18e7f9386.html

[1743] "Beijing Institute of Spacecraft Environment Engineering" [北京卫星环境工程研究所], *CAST*, 21 April 2016. https://www.cast.cn/news/4077

"General Assembly and Environmental Engineering Department" [总装与环境工程部], *China Aerospace Talent Network* [中国航天人才网], Accessed 2021, http://gaoxiao.spacetalent.com.cn/wapA/dw_x.aspx?id=54

[1744] Yan Wang, "Remanufacturing Mission to China," *University of Brighton*, 24 May 2016. https://1stdirectory.co.uk/_assets/files_comp/b956bdf6-2918-459f-8b32-da13e2c572cb.pdf.

[1745] "Key Laboratory of National Defense Technology for Equipment Remanufacturing Technology," [装备再制造技术国防科技重点实验室], *Capital Science and Technology Condition Platform* [首都科技条件平台], Accessed 2021, https://www.sdtjpt.cn/sites/sdtjpt/lab.html?id=392

[1746] "Wang Yupu academician and his party visited the key laboratory of national defense science and technology of equipment remanufacturing technology" [王玉普院士一行到装备再制造技术国防科技重点实验室参观指导], *Chinese Academy of Engineering* [中国工程院], 1 April 2014. https://www.cae.cn/cae/html/main/col147/2014-04/01/20140401092655361786699_1.html

"Key Laboratory of National Defense Science and Technology for Equipment Remanufacturing Technology" [装备再制造技术国防科技重点实验室], *INSTITUTE OF REMANUFACTURING INDUSTRY TECHNOLOGY, JING-JIN-JI* [京津冀再制造产业技术研究院], 3 December 2019. https://www.irit-jjj.com/newsinfo/1942961.html?templateId=1133604

[1747] "Academician Xu Binshi: China's remanufacturing industry is still to be standardized" [徐滨士院士：中国再制造产业尚待规范化], *d1cm*, 29 August 2011. https://news.d1cm.com/2011/08/29/082911560318094.shtml

"Laser Additive Remanufacturing Technology and Applications" [激光增材再制造技术及应用], *Nanjixiong 3D* [南极熊], 15 February 2019. https://www.nanjixiong.com/thread-132330-1-1.html

"Key Laboratory of National Defense Science and Technology for Equipment Remanufacturing Technology" [装备再制造技术国防科技重点实验室], *INSTITUTE OF REMANUFACTURING INDUSTRY TECHNOLOGY, JING-JIN-JI* [京津冀再制造产业技术研究院], 3 December 2019. https://www.irit-jjj.com/newsinfo/1942961.html?templateId=1133604

[1748] "Management issues in the development of remanufacturing industry" [再制造产业发展过程中的管理问题], *Engineering.org.cn*, 2012. http://www.engineering.org.cn/ch/article/20120906001

"Wang Yupu academician and his party visited the key laboratory of national defense science and technology of equipment remanufacturing technology" [王玉普院士一行到装备再制造技术国防科技重点实验室参观指导], *Chinese Academy of Engineering* [中国工程院], 1 April 2014. https://www.cae.cn/cae/html/main/col147/2014-04/01/20140401092655361786699_1.html

"Equipment remanufacturing technology national defense science and technology key laboratory introduction" [装备再制造技术国防科技重点实验室简介], *Sina*, 17 January 2011. http://finance.sina.com.cn/roll/20110117/08293579943.shtml

[1749] "Key Laboratory of National Defense Technology for Equipment Remanufacturing Technology," [装备再制造技术国防科技重点实验室], *Capital Science and Technology Condition Platform* [首都科技条件平台], Accessed 2021, https://www.sdtjpt.cn/sites/sdtjpt/lab.html?id=392

[1750] "To investigate equipment remanufacturing technology at the Armored Forces Engineering College" [赴装甲兵工程学院调研装备再制造技术工作], *Zhengzhou Machinery Network* [郑州机械网], 30 March 2021. http://www.zzjxwa.com/w4ntw7/81116.html

"Laser Additive Remanufacturing Technology and Applications" [激光增材再制造技术及应用], *Nanjixiong 3D* [南极熊], 15 February 2019. https://www.nanjixiong.com/thread-132330-1-1.html

"Equipment remanufacturing technology national defense science and technology key laboratory introduction" [装备再制造技术国防科技重点实验室简介], *Sina*, 17 January 2011. http://finance.sina.com.cn/roll/20110117/08293579943.shtml

"Innovation and development of civil-military fusion remanufacturing technology to significantly improve the maintenance and security capacity of weapons and equipment" [创新发展军民融合再制造技术 显著提升武器装备维修保障能力], *Sanming City Science and Technolgoy Bureau* [三明市科学技术局], 8 January 2021. http://smkj.sm.gov.cn/kjxx_22745/lszzzcyzt/202101/t20210108_1613553.htm

[1751] Li Fei [李飞], Wang Yao [王瑶], "Our military equipment remanufacturing technology successfully used in tank engines" [我军装备再制造技术成功用于坦克发动机], *81.cn*, 8 November 2014. http://www.81.cn/jmywyl/2014-11/08/content_6217954.htm

""Tank nanny" Xu Binshi: iron armor flows and casts military soul " ["坦克保姆"徐滨士：铁甲流金铸军魂], *Sina*, 19 November 2004. http://tech.sina.com.cn/d/2004-11-19/1551462152.shtml

[1752] Xu Binshi [徐滨士], "Development and application of anti-wear lubricants for military vehicle engines" [军用车辆发动机抗磨润滑剂的研制与应用], *Acta Armamentarii* [兵工学报] (26) 2005. https://www.mianfeiwendang.com/doc/5a5b265b0724c324a6b383be
"Innovation and development of civil-military fusion remanufacturing technology to significantly improve the maintenance and security capacity of weapons and equipment" [创新发展军民融合再制造技术 显著提升武器装备维修保障能力], *Sanming City Science and Technology Bureau* [三明市科学技术局], 8 January 2021. http://smkj.sm.gov.cn/kjxx_22745/lszzzcyzt/202101/t20210108_1613553.htm
[1753] "Innovation and development of civil-military fusion remanufacturing technology to significantly improve the maintenance and security capacity of weapons and equipment" [创新发展军民融合再制造技术 显著提升武器装备维修保障能力], *Sanming City Science and Technology Bureau* [三明市科学技术局], 8 January 2021. http://smkj.sm.gov.cn/kjxx_22745/lszzzcyzt/202101/t20210108_1613553.htm
"Air Force aero-engine remanufacturing technology application research and development center was set up" [空军航空发动机再制造技术应用研发中心挂牌成立], *China News*, 19 April 2013. http://www.chinanews.com/mil/2013/04-19/4745473.shtml
Huang Xuanmin [黄选民] et al., "Performance of engine blade after nanoparticle composite electrobrush plating" [发动机叶片纳米颗粒复合电刷镀后的性能], *Material Protection* [材料保护] (3) 2010. http://www.yatsg.com/qikan/a7280db3ed7ff7714c173e40969d806d.html
[1754] "Wang Yupu academician and his party visited the key laboratory of national defense science and technology of equipment remanufacturing technology" [王玉普院士一行到装备再制造技术国防科技重点实验室参观指导], *Chinese Academy of Engineering* [中国工程院], 1 April 2014. https://www.cae.cn/cae/html/main/col147/2014-04/01/20140401092655361786699_1.html
"Army Armor College, Beijing Alumni Association of Military Engineering College" [陆军装甲兵学院简介, 军事工程学院(哈军工)], *Beijing Alumni Association* [北京校友会], 25 September 2018. https://www.hjgbj.com/site/portal/item/frontnode/NDcwX2FydGljbGVfaGpnYmoueml4aWFodS5jb20=
[1755] "Army Armor College, Beijing Alumni Association of Military Engineering College" [陆军装甲兵学院简介, 军事工程学院(哈军工)], *Beijing Alumni Association* [北京校友会], 25 September 2018. https://www.hjgbj.com/site/portal/item/frontnode/NDcwX2FydGljbGVfaGpnYmoueml4aWFodS5jb20=
"2017 China Construction Machinery Repair and Remanufacturing Technology Matching Exchange will be held grandly " [2017 中国工程机械维修与再制造技术对接交流会盛大召开], *HC360* [智聪网], 13 April 2017. http://info.cm.hc360.com/2017/04/131505668679.shtml
[1756] "To investigate equipment remanufacturing technology at the Armored Forces Engineering College" [赴装甲兵工程学院调研装备再制造技术工作], *Zhengzhou Machinery Network* [郑州机械网], 30 March 2021. http://www.zzjxwa.com/w4ntw7/81116.html
"China Runda Remanufacturing" [中润达再制造], *SPT* [中润大], Accessed 2021, www.spt56.com/productinfo/905092.html
"Army Armor College, Beijing Alumni Association of Military Engineering College" [陆军装甲兵学院简介, 军事工程学院(哈军工)], *Beijing Alumni Association* [北京校友会], 25 September 2018. https://www.hjgbj.com/site/portal/item/frontnode/NDcwX2FydGljbGVfaGpnYmoueml4aWFodS5jb20=
[1757] Li Fei [李飞], Wang Yao [王瑶], "Our military equipment remanufacturing technology successfully used in tank engines" [我军装备再制造技术成功用于坦克发动机], *81.cn*, 8 November 2014. http://www.81.cn/jmywyl/2014-11/08/content_6217954.htm
[1758] "Mining machinery repair and remanufacturing equipment" [矿山机械修复与再制造设备 2013], *AceTop* [领峰重工科技] Accessed 2021, https://www.thisandthatreuse.com/85487/2014-06-27.html
[1759] "500,000 yuan in research funding " [50 万元科研经费], *Information Meets Future* [信息预见未来], 9 October 2020. http://zjkskjxxs.org.cn/UserDemandView.asp?id=6
[1760] "China Runda Remanufacturing" [中润达再制造], *SPT* [中润大], Accessed 2021, www.spt56.com/productinfo/905092.html
[1761] "Management issues in the development of remanufacturing industry" [再制造产业发展过程中的管理问题], *Engineering.org.cn*, 2012. http://www.engineering.org.cn/ch/article/20120906001

[1762] “China's equipment parts remanufacturing industry alliance was established” [我国设备零部件再制造产业联盟成立], *Huainan Hongbaoxiang Machinery Co.* [淮南市宏宝祥机械有限公司], 22 July 2017. http://www.hnhbx.com/content/?176.html
[1763] “Beijing, Tianjin and Hebei remanufacturing industry technology research institute was built in Hefei” [京津冀再制造产业技术研究院在河间建成], *Cangzhou People’s Government* [沧州市人民政府], 10 April 2018. http://www.cangzhou.gov.cn/zjcz/tzcz/jjsd/522373.shtml
[1764] "About Us“ [关于我们], *Furui Group*, Accessed April 2025, https://www.furuigroup.com/history.html
[1765] “State Key Laboratory of Remanufacturing Technology” [再制造技术国家重点实验室], *Science Net*, 31 August 2011. https://m.sciencenet.cn/blog-399664-481504.html
[1766] Yan Wang, “Remanufacturing Mission to China,” *University of Brighton*, 24 May 2016. https://1stdirectory.co.uk/_assets/files_comp/b956bdf6-2918-459f-8b32-da13e2c572cb.pdf.
“China-UK Green Manufacturing and Remanufacturing Summit (March 2018)”, *Brighton University*, March 2018. https://blogs.brighton.ac.uk/responsible/events/previous-events/china-uk-green-manufacturing-and-remanufacturing-summit-march-2018/
[1767] "2024 China Materials Conference E09-Materials Surface Engineering Forum was successfully held" [2024 中国材料大会 E09-材料表面工程论坛圆满召开], *Specialized Committee on Metal Surface Treatment Technology of Guangdong Machine Quality Association* [粤机质协金属表面处理技术专委会], 2024, http://pc-mstt.com/nd.jsp?id=58
[1768] State Key Laboratory of Remanufacturing Technology” [再制造技术国家重点实验室], *Science Net*, 31 August 2011. https://m.sciencenet.cn/blog-399664-481504.html
[1769] “Key Laboratory of National Defense Technology for Equipment Remanufacturing Technology,” [装备再制造技术国防科技重点实验室], *Capital Science and Technology Condition Platform* [首都科技条件平台], Accessed 2021, https://www.sdtjpt.cn/sites/sdtjpt/lab.html?id=392
[1770] "Honor the Military: China's original noise-reducing stealth technology enhances stealth of 093B nuclear submarine" [『崇军尚武』中国独创降噪隐身技术 093B 核潜艇隐蔽性增强], *Zhikan Luozhu* [只看楼主网], 31 March 2016, https://zhikanlouzhu.com/post/tieba/%E5%B4%87%E5%86%9B%E5%B0%9A%E6%AD%A6/163247/1.html
[1771] "Ship hydroacoustic defense leader, endogenous and exogenous double-wheel drive" [舰船水声防务龙头,内生外延双轮驱动], *Zheshang Seucrities Co.* [浙商证券股份有限公司], 7 February 2021, https://pdf.dfcfw.com/pdf/H3_AP202202081545678276_1.pdf?1644326407000.pdf
“Current status and development of research on acoustic scattering characteristics of targets in water” [水中目标声散射特性研究现状与发展], *Jiangsu University of Science and Technology*, 6 November 2019, https://www.just.edu.cn/2019/1106/c7655a257072/page.htm
[1772] “Because of his contribution to the Chinese submarine was "hidden", this year was elected academician of the Academy of Engineering deservedly” [由于他的贡献中国潜艇被“藏”起来，今年当选工程院院士实至名归], *kknews*, 28 Novemeber 2017, https://kknews.cc/military/qo5neo8.html
"China's nuclear submarines welcome super steel: 200% stronger than U.S. and Russian submarine steel" [中国核潜艇迎来超级钢：强度比美俄潜艇钢提升 200%], *Sina*, 19 March 2018, https://mil.sina.cn/sd/2018-03-19/detail-ifyskeua9425333.d.html
[1773] "Ship hydroacoustic defense leader, endogenous and exogenous double-wheel drive" [舰船水声防务龙头,内生外延双轮驱动], *Zheshang Seucrities Co.* [浙商证券股份有限公司], 7 February 2021, https://pdf.dfcfw.com/pdf/H3_AP202202081545678276_1.pdf?1644326407000.pdf
[1774] “15 CFR Part 744,” *Federal Register Vol. 85, No. 246*, 22 December, 2020. https://www.govinfo.gov/content/pkg/FR-2020-12-22/pdf/2020-28031.pdfx
[1775] “2020 Maneuvering Institute's 702nd Institute Employment Leadership Social Practice” [2020 机动学院第 702 研究所就业引领社会实践], *Shanghai Jiao Tong University*, 4 May 2021, https://me.sjtu.edu.cn/xsgz/sj010/1573.html
[1776] “Because of his contribution to the Chinese submarine was "hidden", this year was elected academician of the Academy of Engineering deservedly” [由于他的贡献中国潜艇被“藏”起来，今年当选工程院院士实至名归], *kknews*, 28 November 2017, https://kknews.cc/military/qo5neo8.html

"China's nuclear submarines welcome super steel: 200% stronger than U.S. and Russian submarine steel" [中国核潜艇迎来超级钢：强度比美俄潜艇钢提升 200%], *Sina*, 19 March 2018, https://mil.sina.cn/sd/2018-03-19/detail-ifyskeua9425333.d.html

[1777] "IMO Approves Draft Revisions to Shipboard Noise Level Rules" [IMO 批准《船上噪声等级规则》修订草案], *Dalian Maritime University*, 29 June 2012, https://imcrc.dlmu.edu.cn/info/1060/1495.htm

[1778] "Forwarding the "Guidelines for 2020 Open Fund Project Declaration of the Key Laboratory of Hydrodynamics, the Key Laboratory of Ship Vibration and Noise, and the Provincial Key Laboratory of Green Ship Technology" of the 702nd RI of CSSC" [转发中船集团第七〇二研究所《关于水动力学重点实验室、船舶振动噪声重点实验室和省绿色船舶技术重点实验室 2020 年开放基金项目申报指南》], *Hubei Military-Civil Fusion* [湖北军民融合], 22 June 2020, https://www.hbjmrh.gov.cn/gk/xxgk/tzgg/23606.htm

[1779] "Because of his contribution to the Chinese submarine was "hidden", this year was elected academician of the Academy of Engineering deservedly" [由于他的贡献中国潜艇被"藏"起来，今年当选工程院院士实至名归], *kknews*, 28 Novemeber 2017, https://kknews.cc/military/qo5neo8.html

"China's nuclear submarines welcome super steel: 200% stronger than U.S. and Russian submarine steel" [中国核潜艇迎来超级钢：强度比美俄潜艇钢提升 200%], *Sina*, 19 March 2018, https://mil.sina.cn/sd/2018-03-19/detail-ifyskeua9425333.d.html

[1780] "He Lin" [何琳], *The Ho Leung Ho Lee Foundation*, Accessed March 2024, http://www.hlhl.org.cn/news/findnews/showsub.asp?id=1299

"The submarine expert honored by President Xi's twice-signed orders was elected to the Academy of Engineering" [习主席两次签署通令记功的这位潜艇专家当选工程院院士], *Big Wuhan* [大武汉], 27 November 2017, http://www.app.dawuhanapp.com/p/6458.html

[1781] "He Lin" [何琳], *The Ho Leung Ho Lee Foundation*, Accessed March 2024, http://www.hlhl.org.cn/news/findnews/showsub.asp?id=1299

"The submarine expert honored by President Xi's twice-signed orders was elected to the Academy of Engineering" [习主席两次签署通令记功的这位潜艇专家当选工程院院士], *Big Wuhan* [大武汉], 27 November 2017, http://www.app.dawuhanapp.com/p/6458.html

[1782] "Ocean and Information Technology Knowledge Forum" ["海洋与信息技术"知名教授论坛], *Shanghai Maritime University College of Information Engineering* [上海海事大学信息工程学院], 11 November 2014, https://cie.shmtu.edu.cn/2014/1108/c7227a59062/page.htm

[1783] "Weng Zhenping" [翁震平], *Shanghai Jiao Tong University Institute of Marine Equipment* [上海交通大学海洋装备研究院], Accessed April 2024, https://ime.sjtu.edu.cn/info/1001/1048.htm

[1784] "Detection method for transient signal under low SNR condition based on cepstrum analysis" [基于倒谱分析的低信噪比瞬态声信号检测方法], *Journal of Naval University of Engineering* [海军工程大学学报], 2019, 5, http://cnki.cqgmy.edu.cn/KCMS/detail/detailall.aspx?filename=hjgx201905012&dbcode=CJFQ&dbname=CJFD2019

[1785] "Prof. Wen Huabing was invited to participate in the 18th National Symposium on Underwater Noise from Ships" [我院温华兵教授应邀参加第十八届全国船舶水下噪声学术讨论会], *Jiangsu University of Science and Technology*, 7 October 2021, https://sepe.just.edu.cn/2021/1007/c4654a294888/page.htm

[1786] "The group will organize the 7th Youth Forum on Equipment Vibration and Noise Control" [课题组将举办第七届装备振动与噪声控制青年论坛], *BIT Laboratory of Wave Mechanics*, 12 October 2019, http://www.micromechanics.cn/archives/915

[1787] "Key Laboratory of Ship Vibration and Noise organizes exchange meeting on dynamic force measurement technology" [船舶振动噪声重点实验室举办动态力测量技术交流会], *China Ship Scientific Research Center* [中国船舶科学研究中心], 13 April 2015, http://www.cssrc.com.cn/wnewsx/wdetail/685.html

[1788] Bai Zhenguo [白振国], "Sound scattering characteristics of three underwater paralleling flexible cylindrical shells" [水下三弹性柱壳耦合声散射特性研究], Acta Acustica [声学学报], 2019, 44(6), https://jac.ac.cn/cn/article/doi/10.15949/j.cnki.0371-0025.2019.06.005?viewType=citedby-info

"Key Laboratory of Ship Vibration and Noise organizes exchange meeting on dynamic force measurement technology" [船舶振动噪声重点实验室举办动态力测量技术交流会], China SHip Scientific Research Center [中国船舶科学研究中心], 13 April 2015, http://www.cssrc.com.cn/wnewsx/wdetail/685.html

[1789] Zhang Shihui [张世辉], "Design of wireless smart sensing tag based on radio frequency technology" [基于射频技术的无线智能传感标签设计], *Transducer and Microsystem Technology* [传感器与微系统], 2015, 6, https://www.alljournals.cn/view_abstract.aspx?pcid=5B3AB970F71A803DEACDC0559115BFCF0A068CD97DD29835&cid=8240383F08CE46C8B05036380D75B607&jid=C5F1B9AAEC2187FF8E36A04A12A6DD75&aid=6CA257CADDB7EFE456E8261BF85FBA74&yid=FFD10F7019FAA9EC
[1790] "The 15th National Explosive Mechanics Conference First Round Notice" [第十五届全国爆炸力学学术会议第一轮通知], *thepaper.cn*, 10 February 2025, https://m.thepaper.cn/newsDetail_forward_30126113
[1791] Tan Hua [谭华], "Introduction to State Key Laboratory of Shock Wave Physics and Explosion Physics" [冲击波物理与爆轰物理国家级重点实验室简介], *Physics* [物理], 1998, 12, http://www.alljournals.cn/view_abstract.aspx?pcid=6E709DC38FA1D09A4B578DD0906875B5B44D4D294832BB8E&cid=47EA7CFDDEBB28E0&jid=D3DCC9D6F2F39F6E31CD40B3E78928FE&aid=E0B8ADFD01466CDE65F748A60AE8416A&yid=8CAA3A429E3EA654
[1792] Tan Hua [谭华], "Introduction to State Key Laboratory of Shock Wave Physics and Explosion Physics" [冲击波物理与爆轰物理国家级重点实验室简介], *Physics* [物理], 1998, 12, http://www.alljournals.cn/view_abstract.aspx?pcid=6E709DC38FA1D09A4B578DD0906875B5B44D4D294832BB8E&cid=47EA7CFDDEBB28E0&jid=D3DCC9D6F2F39F6E31CD40B3E78928FE&aid=E0B8ADFD01466CDE65F748A60AE8416A&yid=8CAA3A429E3EA654
[1793] Tan Hua [谭华], "Introduction to State Key Laboratory of Shock Wave Physics and Explosion Physics" [冲击波物理与爆轰物理国家级重点实验室简介], *Physics* [物理], 1998, 12, http://www.alljournals.cn/view_abstract.aspx?pcid=6E709DC38FA1D09A4B578DD0906875B5B44D4D294832BB8E&cid=47EA7CFDDEBB28E0&jid=D3DCC9D6F2F39F6E31CD40B3E78928FE&aid=E0B8ADFD01466CDE65F748A60AE8416A&yid=8CAA3A429E3EA654
[1794] "Dr. Chen Liliang and Dr. Meng Chuanmin from China Academy of Engineering Physics visited our university on December 25, 2014 and gave an academic lecture" [中国工程物理研究院陈黎亮博士、孟川民博士于 2014 年 12 月 25 日来我校访问并做学术报告], *Hebei Institute of Technology*, 25 December 2014, https://clxy.hebut.edu.cn/kxyj/xzhd/99391.htm
[1795] Tan Hua [谭华], "Introduction to State Key Laboratory of Shock Wave Physics and Explosion Physics" [冲击波物理与爆轰物理国家级重点实验室简介], *Physics* [物理], 1998, 12, http://www.alljournals.cn/view_abstract.aspx?pcid=6E709DC38FA1D09A4B578DD0906875B5B44D4D294832BB8E&cid=47EA7CFDDEBB28E0&jid=D3DCC9D6F2F39F6E31CD40B3E78928FE&aid=E0B8ADFD01466CDE65F748A60AE8416A&yid=8CAA3A429E3EA654
[1796] "Chinese Academy of Engineering Physics Dedicated to National Prosperity," *Engineering Science* [中国工程科学], 2001, 3(8), https://www.engineering.org.cn/en/article/24871/detail
[1797] "Academician Jing Fuqian" [经福谦院士], *Chinese Academy of Sciences*, Accessed January 2024, http://casad.cas.cn/zt2022/mhys/2012/201505/t20150512_4683171.html
"Jing Fuqian" [谦院士], *CAE Academician Library*, Accessed January 2024, https://ysg.ckcest.cn/share/1000114/baseInfo (downloads pdf)
[1798] "Dr. Chen Liliang and Dr. Meng Chuanmin from China Academy of Engineering Physics visited our university on December 25, 2014 and gave an academic lecture" [中国工程物理研究院陈黎亮博士、孟川民博士于 2014 年 12 月 25 日来我校访问并做学术报告], *Hebei Institute of Technology*, 25 December 2014, https://clxy.hebut.edu.cn/kxyj/xzhd/99391.htm
[1799] Tan Hua [谭华], "Introduction to State Key Laboratory of Shock Wave Physics and Explosion Physics" [冲击波物理与爆轰物理国家级重点实验室简介], *Physics* [物理], 1998, 12, http://www.alljournals.cn/view_abstract.aspx?pcid=6E709DC38FA1D09A4B578DD0906875B5B44D4D294832BB8E&cid=47EA7CFDDEBB28E0&jid=D3DCC9D6F2F39F6E31CD40B3E78928FE&aid=E0B8ADFD01466CDE65F748A60AE8416A&yid=8CAA3A429E3EA654
[1800] Zeng Daipeng [曾代朋] et al., "Experimental and Numerical Calculation Study on Shock Sensitivity of Aluminum Explosive" [含铝炸药冲击波感度的实验和数值计算研究], *Chinese Journal of Energetic Materials*, 2010, 18(2), http://www.energetic-materials.org.cn/hncl/article/abstract/2009166?st=search

[1801] Xu Weisen [徐维森] et al., "Experimental research on the damage features of vehicle under explosion" [汽车爆炸毁伤特征的实验研究], *Journal of Sichuan University (Natural Science Edition)*, 2021, 58(5), https://science.scu.edu.cn/jsunature_cn/article/abstract/y210050
[1802] "Postdoctoral Recruitment in Key Laboratory of Shock Wave Physics and Blast Physics, Institute of Fluid Physics" [中物院流体物理研究所冲击波物理与爆轰物理重点实验室博后招聘], *Xiao Muchong*, Accessed January 2024, https://muchong.com/html/201009/2376021.html
[1803] "China's Laser Interferometric Velocimetry Technology Makes Major Breakthroughs" [我国激光干涉测速技术取得重大突破], *PRC Central People's Government*, 25 April 2007, https://www.gov.cn/govweb/fwxx/kp/2007-04/25/content_595053.htm
[1804] "Notable Individual Forum (2016-5)" [名家论坛（2016-5）], *State Key Laboratory of Geological Processes and Mineral Resources*, 14 June 2016, https://gpmr.cug.edu.cn/info/1027/1268.htm
[1805] "Weekly Report of Women's Federation (September 21-30, 2019)" [妇联工作周报（2019 年 9 月 21-30 日）], *thepaper.cn*, 8 October 2019, https://m.thepaper.cn/newsDetail_forward_4618514
[1806] "China's "two bombs and one satellite" merit Chen Junxiang to our school to give a special lecture" [我国“两弹一星”功勋陈俊祥来我校作专题讲座], *Netease*, 4 November 2020, https://m.163.com/dy/article/FQHUDM4O0514MPJ8.html?spss=adap_pc
[1807] "China's Laser Interferometric Velocimetry Technology Makes Major Breakthroughs" [我国激光干涉测速技术取得重大突破], *PRC Central People's Government*, 25 April 2007, https://www.gov.cn/govweb/fwxx/kp/2007-04/25/content_595053.htm
[1808] "The 12th National Conference on Explosive Mechanics co-organized by our Key Laboratory was held in Tongxiang City" [我重点实验室协办的第十二届全国爆炸力学学术会议在桐乡市召开], *CAS Key Laboratory of Mechanical Behavior and Design of Materials*, 12 November 2018, https://lmbd.ustc.edu.cn/2018/1112/c10217a351821/page.htm
[1809] “12th National Conference on Explosive Mechanics Second Round Notification”[第十二届全国爆炸力学学术会议第二轮通知], *Beijing Institute of Technology*, 2018, https://shock.bit.edu.cn/docs/2018-04/20180402083901632032.pdf
[1810] "Bilateral Symposium on Numerical Simulation and Computational Physics of Chongqing University - Institute of Fluid Physics, CIFM, held by School of Physics" [物理学院召开重庆大学-中物院流体物理研究所数值模拟与计算物理双边学术研讨会], *Chongqing News*, Accessed January 2024, https://news.cqu.edu.cn/archives/notice/content/2018/12/07/4c87e5e9fc1a564781c398618687a2f5cad0abb8.html
[1811] “Impact loading pressure of three-stage gun ultra-high-speed launching technology made significant research progress in the Chinese Academy of Materials (CAM)” [中物院三级炮超高速发射技术取得重大研究进展的冲击加载压力], *Sciencenet*, 5 June 2014, https://wap.sciencenet.cn/blog-528739-800721.html?mobile=1
[1812] "Chinese Academy of Engineering Physics Dedicated to National Prosperity," *Engineering Science* [中国工程科学], 2001, 3(8), https://www.engineering.org.cn/en/article/24871/detail
[1813] "Postdoctoral Recruitment in Key Laboratory of Shock Wave Physics and Blast Physics, Institute of Fluid Physics" [中物院流体物理研究所冲击波物理与爆轰物理重点实验室博后招聘], *Xiao Muchong*, Accessed January 2024, https://muchong.com/html/201009/2376021.html
[1814] “State Key Labs,” *NWPU*, Accessed 2021, https://en.nwpu.edu.cn/Research1/CentersandInstitutions.htm
[1815] "National Key Laboratory of Solid Propulsion held a working meeting" [固体推进全国重点实验室召开工作会], *Northwestern Polytechnical University*, 2 September 2024, https://hangtian.nwpu.edu.cn/info/1804/33071.htm
[1816] “Defense S&T Key Laboratory of Solid Rocket Engine Combustion, Thermal Structure, and Inner Flow Field” [燃烧、热结构与内流场重点实验室], *NWPU*, 2018. http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=359
“No.021 Defense S&T Key Laboratory of Solid Rocket Engine Combustion, Thermal Structure, and Inner Flow Field” [No.021 燃烧、热结构与内流场重点实验室], *Changzhou Military-Civil Fusion Service Platform*, 14 June 2016. http://www.czjmrh.com/content/?1036.html
“Key Laboratory of Solid Rocket Engine Combustion, Thermal Structure, and Inner Flow Field” [燃烧、热结构与内流场重点实验室], *Propulsion Frontier* [动力前沿], 14 September 2019. http://www.srmcad.com/?p=815

[1817] "Defense S&T Key Laboratory of Solid Rocket Engine Combustion, Thermal Structure, and Inner Flow Field" [燃烧、热结构与内流场重点实验室], NWPU, 2018. http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=359

[1818] "Xi'an Aerospace Power Research Institute: only asked Zhang Xiaoping back to go declassification procedures, the rumors are not true" [西安航天动力研究所：只是要求张小平回来走脱密程序 传闻失实], *Sohu*, 27 September 2018. https://www.sohu.com/a/256521956_313745

"Spaceflight Institute develops solid rocket engine" [航天四院研制出固体火箭发动机], *SGST* [上海研发公共服务平套], 17 May 2007. http://webcache.googleusercontent.com/search?q=cache%3Awww.sgst.cn%2Fxwdt%2Fshsd%2F200705%2Ft20070517_67191.html&rlz=1C1CHBD_enUS895US895&oq=cache%3Awww.sgst.cn%2Fxwdt%2Fshsd%2F200705%2Ft20070517_67191.html&aqs=chrome..69i57j69i58.1282j0j4&sourceid=chrome&ie=UTF-8

"CASC 41st RI strives to achieve leapfrog development by inheriting innovation and overcoming difficulties" [航天 41 所继承创新攻坚克难努力实现跨越式发展], *CASC*, 26 November 2014. http://www.spacechina.com/n25/n2014789/n2014809/c784479/content.html

"Recruitment Notice of the 41st Research Institute of the 4th Research Academy of China Aerospace Science and Technology Corporation" [中国航天科技集团公司第四研究院第四十一研究所招聘通知], *NWPU*, 11 September 2014. https://hangtian.nwpu.edu.cn/info/1386/8290.htm

"Xi'an Aerospace Power Technology Research Institute 2021 Campus Recruitment" [西安航天动力技术研究所 2021 届校园招聘], *Peking University* [北京大学], 22 September 2020. https://scc.pku.edu.cn/employment_22e9034574b371d40174b55f8392041f_0.html

[1819] "Defense S&T Key Laboratory of Solid Rocket Engine Combustion, Thermal Structure, and Inner Flow Field" [燃烧、热结构与内流场重点实验室], *NWPU*, 2018. http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=359

[1820] "Our university "solid rocket engine combustion, thermal structure and internal flow field" national defense science and technology key laboratory to expand and improve construction project， successfully passing acceptance" [我校"固体火箭发动机燃烧、热结构与内流场"国防科技重点实验室拓展提高建设项目顺利通过验收], *NWPU*, 30 June 2010. http://webcache.googleusercontent.com/search?q=cache%3Ahttps%3A%2F%2Fnews.nwpu.edu.cn%2Finfo%2F1003%2F40100.htm&rlz=1C1CHBD_enUS895US895&oq=cache%3Ahttps%3A%2F%2Fnews.nwpu.edu.cn%2Finfo%2F1003%2F40100.htm&aqs=chrome.0.69i59j69i58j69i60l2.1137j0j4&sourceid=chrome&ie=UTF-8

[1821] "The aerospace science and technology four institutions to develop instantaneous high thrust special solid engine" [航天科技四院研制瞬时大推力特种固体发动机], *Sina*, 14 February 2006. http://mil.news.sina.com.cn/2006-02-14/1033350762.html

[1822] "Institute of Space Power Technology held a meeting with new master's degree students of class 2024" [空天动力技术研究所召开 2024 级硕士研究生新生见面会], *Northwestern Polytechnical University*, 12 September 2024, https://hangtian.nwpu.edu.cn/info/1804/33601.htm

[1823] "Defense S&T Key Laboratory of Solid Rocket Engine Combustion, Thermal Structure, and Inner Flow Field" [燃烧、热结构与内流场重点实验室], *NWPU*, 2018. http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=359

[1824] "Defense S&T Key Laboratory of Solid Rocket Engine Combustion, Thermal Structure, and Inner Flow Field" [燃烧、热结构与内流场重点实验室], *NWPU*, 2018. http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=359

[1825] "Discussing the JL-2 missile R&D, capable of hitting all of Russia from China's near seas" [深度：浅谈中国巨浪 2 导弹研发 从我近海或可打击俄全境], *Sina*, 26 January 2015. https://mil.news.sina.com.cn/2015-01-26/1037819483.html

[1826] Wang Yinghong [王英红] et al., "Improvement of multi-residue fuel-rich propellant burn rate tester" [多残渣富燃料推进剂燃速测试仪的改进], *Solid Rocket Technology* [固体火箭技术] (3) 2010. http://www.cqvip.com/qk/96831x/201003/34380192.html

[1827] "Frequent accidents, are the P5 intercontinental missiles still reliable? Chinese researchers have come to an important conclusion" [频频出事，五常的洲际导弹还靠得住吗？中国科研人员得出重要结论], *Tencent*, 10 December 2024, https://news.qq.com/rain/a/20241210A025HC00

[1828] "Chinese universities helped! Shen XVIII succeeded!" [中国高校助力！神十八成功!], *Tenent*, 26 April 2024, https://news.qq.com/rain/a/20240426A08K8P00
[1829] "Northwestern Polytechnical University's Solid-Liquid Hybrid Sounding Rocket Again Points at the Sky" [西北工业大学固液混合探空火箭再次剑指苍穹], *Northwestern Polytechnical University*, 3 August 2023, https://hangtian.nwpu.edu.cn/info/1804/23441.htm
[1830] "He Guoqiang" [何国强], *Shaanxi Province Aerospace and Astronautics Propulsion Research Institute* [陕西空天动力研究院], Accessed 2021, http://sn-aapri.com/hgq/index.jhtml
[1831] "National Key Laboratory of Solid Propulsion held a working meeting" [固体推进全国重点实验室召开工作会], *Northwestern Polytechnical University*, 2 September 2024, https://hangtian.nwpu.edu.cn/info/1804/33071.htm
"School of Energetics and Dynamics Held Rocket Propulsion Technology Exchange Meeting and Launching Ceremony of Rocket Club" [能动学院举行火箭推进技术交流会暨"火箭社团"启动仪式], *Shandong University*, 11 November 2024, https://www.epe.sdu.edu.cn/info/1002/11284.htm
[1832] "National Key Laboratory of Solid Propulsion held a working meeting" [固体推进全国重点实验室召开工作会], *Northwestern Polytechnical University*, 2 September 2024, https://hangtian.nwpu.edu.cn/info/1804/33071.htm
[1833] "Defense S&T Key Laboratory of Solid Rocket Engine Combustion, Thermal Structure, and Inner Flow Field" [燃烧、热结构与内流场重点实验室], *NWPU*, 2018. http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=359
[1834] "Chinese universities helped! Shen XVIII succeeded!" [中国高校助力！神十八成功!], *Tencent*, 26 April 2024, https://news.qq.com/rain/a/20240426A08K8P00
[1835] "China Aerospace Third Professional Information Network 37th Technical Exchange Conference and 1st Joint Conference on Air and Space Dynamics Call for Papers" [中国航天第三专业信息网第三十七届技术交流会暨第一届空天动力联合会议征文通知], *Dalian University of Technology* [大连理工大学], 1 June 2016. https://aa.dlut.edu.cn/info/1005/1657.htm
[1836] "The First China Air and Space Propulsion Technology Forum Call for Papers" [首届中国空天推进技术论坛征文通知], *Sohu*, 4 April 2018. https://www.sohu.com/a/227212261_607269
[1837] "Company Profile" [公司简介], *Xi'an Bell Petrochemical Co.* [西安贝尔石油化工科技有限责任公司], Accessed 2021, http://www.bellstim.com/list.asp?D_CataID=A0005
[1838] "The 2019 International Symposium on Space Propulsion Technology was successfully held in Xi'an " [2019 年空间推进技术国际研讨会在西安顺利召开], *NWPU*, 23 September 2019. https://news.nwpu.edu.cn/info/1003/65292.htm
"Speakers", *International Workshop on Space Propulsion*, 2018. http://iwsp2018.scievent.com/speakers/
[1839] "Defense S&T Key Laboratory of Solid Rocket Engine Combustion, Thermal Structure, and Inner Flow Field" [燃烧、热结构与内流场重点实验室], *NWPU*, 2018. http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=359
"No.021 Defense S&T Key Laboratory of Solid Rocket Engine Combustion, Thermal Structure, and Inner Flow Field" [No.021 燃烧、热结构与内流场重点实验室], *Changzhou Military-Civil Fusion Service Platform*, 14 June 2016. http://www.czjmrh.com/content/?1036.html
[1840] "Gong Xianyi" [宫先仪], *Marine Professional Knowledge Service System* [海洋专业知识服务系统], Accessed 2021, http://ocean.ckcest.cn/web/expert_new_detail.view?id=14fb1b8017b24b9dbd7ff670dfefd45c
"Visiting the Defense S&T Key Lab of Sonar Technology" [访声纳技术国防科技重点实验室], *Sina*, 18 May 2006. http://tech.sina.com.cn/d/2006-05-18/1103943707.shtml
"State Key Laboratory and Science and Technology Industry R&D Center Construction Project Public Statement of Environmental Protection Acceptance Opinions for Completion" [七一五所国家重点实验室及科技产业研发中心建设项目竣工环境保护验收意见公开说明], *CSSC 715th RI*, 12 September 2018. https://www.715.com.cn/Public/AttachFile/201810/20181018636754991097397501754 3708.pdf
[1841] "Gong Xianyi" [宫先仪], *Marine Professional Knowledge Service System* [海洋专业知识服务系统], Accessed 2021, http://ocean.ckcest.cn/web/expert_new_detail.view?id=14fb1b8017b24b9dbd7ff670dfefd45c
[1841] "Visiting the Defense S&T Key Lab of Sonar Technology" [访声纳技术国防科技重点实验室], *Sina*, 18 May 2006. http://tech.sina.com.cn/d/2006-05-18/1103943707.shtml

[1842] "Company Profile" [企业简介], *CSSC 715 RI*, Accessed 2021, https://www.715.com.cn/About.aspx?InfoID=3&ModuleID=21&PageID=1
"CSSC 715 Research Institute" [中国船舶集团第七一五研究所], *Zhejiang University*, Accessed 2021, http://www.career.zju.edu.cn/jyxt/sczp/zpztgl/ckZpgwList.zf?dwxxid=761C0E1553F324AFE055000000000001
[1843] "Addition of Entities to the Entity List, Revision of Entry on the Entity List, and Removal of Entities From the Entity List," *Federal Register*, 22 December 2020. https://www.federalregister.gov/documents/2020/12/22/2020-28031/addition-of-entities-to-the-entity-list-revision-of-entry-on-the-entity-list-and-removal-of-entities
[1844] "Company Profile" [企业简介], *CSSC 715 RI*, Accessed 2021, https://www.715.com.cn/About.aspx?InfoID=3&ModuleID=21&PageID=1
[1845] "National Key Laboratory of Sonar Technology Open Fund Project" [国家声纳技术重点实验室开放基金项目], *Project Details* [项目详情], 10 May 2019. https://m.feibaos.com/zz/product/info/86294.html
"Visiting the Defense S&T Key Lab of Sonar Technology" [访声纳技术国防科技重点实验室], *Sina*, 18 May 2006. http://tech.sina.com.cn/d/2006-05-18/1103943707.shtml
[1846] "Visiting the Defense S&T Key Lab of Sonar Technology" [访声纳技术国防科技重点实验室], *Sina*, 18 May 2006. http://tech.sina.com.cn/d/2006-05-18/1103943707.shtml
[1847] "CSIC has developed another latest achievement, the chief engineer says an almost impossible task" [中船重工又研制出一项最新成果，总师：是一项几乎不可能完成的任务], *Sohu*, 12 May 2019. https://www.sohu.com/a/313508379_100271904
"It took 5 years to build the submarine nemesis! CSIC's latest masterpiece for China" [耗时 5 年打造潜艇克星！中船重工最新力作中国], *Sohu*, 8 May 2019. https://www.sohu.com/a/312538853_207533
[1848] "Gong Xianyi" [宫先仪], *Ocean Research Center of Zhoushan Zhejiang University* [浙江大学舟山海洋研究中心], 30 August 2018. https://zoceanc.zju.edu.cn/2018/0830/c54896a2222748/page.htm
"Gong Xianyi" [宫先仪], *Chinese Academy of Engineering*, Accessed 2021, https://www.cae.cn/cae/html/main/colys/37509876.html
"054A can effectively deal with U.S. nuclear submarines " [054A 能有效对付美军的核潜艇], *cjdby.net*, 7 May 2021. http://webcache.googleusercontent.com/search?q=cache%3Ahttps%3A%2F%2Fwww.b7pu.com%2Fnews%2F1594403&rlz=1C1CHBD_enUS949US949&oq=cache%3Ahttps%3A%2F%2Fwww.b7pu.com%2Fnews%2F1594403&aqs=chrome..69i57j69i58.2068j0j4&sourceid=chrome&ie=UTF-8
[1849] "Xia Tiejian" [夏铁坚] et al., "An underwater acoustic communication and alarm method and its apparatus" [一种水下声通信和报警方法及其装置], *Google Patents*, 19 August 2009. https://patents.google.com/patent/CN101101700A/pt
[1850] "Notice | The first batch of academic committee members and bases of Zhijiang Science and Technology Think Tank are all listed here" [通知 | 之江科技智库首批学术委员会委员和基地全部名单来啦], *Home of Science and Technology Workers* [科技工作者之家], 30 April 2020. https://www.scimall.org.cn/article/detail?id=1459615
[1851] "Academician Yang Desen of Harbin Engineering gave an educational report on the theme of promoting the spirit of patriotic struggle" [哈工程杨德森院士作弘扬爱国奋斗精神主题教育报告], *Sohu*, 11 November 2018. https://www.sohu.com/a/274564353_100253932
[1852] "Visiting the Defense S&T Key Lab of Sonar Technology" [访声纳技术国防科技重点实验室], *Sina*, 18 May 2006. http://tech.sina.com.cn/d/2006-05-18/1103943707.shtml
"Gong Xianyi" [宫先仪], *Marine Professional Knowledge Service System* [海洋专业知识服务系统], Accessed 2021, http://ocean.ckcest.cn/web/expert_new_detail.view?id=14fb1b8017b24b9dbd7ff670dfefd45c
"Gong Xianyi" [宫先仪], *Ocean Research Center of Zhoushan Zhejiang University* [浙江大学舟山海洋研究中心], 30 August 2018. https://zoceanc.zju.edu.cn/2018/0830/c54896a2222748/page.htm
"Gong Xianyi" [宫先仪], *Chinese Academy of Engineering*, Accessed 2021, https://www.cae.cn/cae/html/main/colys/37509876.html
"President Zhou Ji and Secretary Li Xiaohong congratulate Academician Gong Xian Yi on his 80th birthday" [周济院长、李晓红书记祝贺宫先仪院士八十寿辰贺信], *Chinese Academy of Engineering*, 12 January 2018. https://www.cae.cn/cae/html/main/col43/2018-01/12/20180112165041309956732_1.html

"054A can effectively deal with U.S. nuclear submarines " [054A 能有效对付美军的核潜艇], *cjdby.net*, 7 May 2021. http://webcache.googleusercontent.com/search?q=cache%3Ahttps%3A%2F%2Fwww.b7pu.com%2Fnews%2F1594403&rlz=1C1CHBD_enUS949US949&oq=cache%3Ahttps%3A%2F%2Fwww.b7pu.com%2Fnews%2F1594403&aqs=chrome..69i57j69i58.2068j0j4&sourceid=chrome&ie=UTF-8

[1853] "Visiting the Defense S&T Key Lab of Sonar Technology" [访声纳技术国防科技重点实验室], *Sina*, 18 May 2006. http://tech.sina.com.cn/d/2006-05-18/1103943707.shtml
"IEEE/OES Symposium on Ocean Acoustics in China" [IEEE/OES 中国海洋声学研讨会], *AConf.org*, 9 November 2016. https://www.aconf.org/conf_81725.IEEE/OES%E4%B8%AD%E5%9B%BD%E6%B5%B7%E6%B4%8B%E5%A3%B0%E5%AD%A6%E7%A0%94%E8%AE%A8%E4%BC%9A.html

[1854] "Visiting the Defense S&T Key Lab of Sonar Technology" [访声纳技术国防科技重点实验室], *Sina*, 18 May 2006. http://tech.sina.com.cn/d/2006-05-18/1103943707.shtml

[1855] "Visiting the Defense S&T Key Lab of Sonar Technology" [访声纳技术国防科技重点实验室], *Sina*, 18 May 2006. http://tech.sina.com.cn/d/2006-05-18/1103943707.shtml

[1856] "IEEE/OES Symposium on Ocean Acoustics in China " [IEEE/OES 中国海洋声学研讨会], *AConf.org*, 9 November 2016. https://www.aconf.org/conf_81725.IEEE/OES%E4%B8%AD%E5%9B%BD%E6%B5%B7%E6%B4%8B%E5%A3%B0%E5%AD%A6%E7%A0%94%E8%AE%A8%E4%BC%9A.html
"2021 IEEE/OES International Conference on Ocean Acoustics in China " [2021 IEEE/OES 中国海洋声学国际会议], *COA 2021*, 14 July 2021. http://www.chinaoceanacoustics.cn/COA2021/index.asp

[1857] "Company Profile" [企业简介], *CSSC 715 RI*, Accessed 2021, https://www.715.com.cn/About.aspx?InfoID=3&ModuleID=21&PageID=1
"CSSC 715 Research Institute" [中国船舶集团第七一五研究所], *Zhejiang University*, Accessed 2021, http://www.career.zju.edu.cn/jyxt/sczp/zpztgl/ckZpgwList.zf?dwxxid=761C0E1553F324AFE055000000000001

[1858] "State Key Laboratory and Science and Technology Industry R&D Center Construction Project Public Statement of Environmental Protection Acceptance Opinions for Completion" [七一五所国家重点实验室及科技产业研发中心建设项目竣工环境保护验收意见公开说明], *CSSC 715th RI*, 12 September 2018. https://www.715.com.cn/Public/AttachFile/201810/20181018636754991097397501754370 8.pdf

[1859] "CSSC 715 Research Institute" [中国船舶集团第七一五研究所], *Zhejiang University*, Accessed 2021, http://www.career.zju.edu.cn/jyxt/sczp/zpztgl/ckZpgwList.zf?dwxxid=761C0E1553F324AFE055000000000001

[1860] "Xiangyang's first state-level key laboratory" [襄阳首设国家级重点实验室], *Hubei People's Government*, 25 May 2018, http://www.hubei.gov.cn/hbfb/szsm/201805/t20180525_1547781.shtml

[1861] "42nd RI" [四十二所], *CASC Talent* [中国航天人才网], Accessed January 2024, https://www.spacetalent.com.cn/jituan_xx.html?id=29&childDeptId=31
"The 42nd Institute of the Fourth Academy of Aerospace Science and Technology has been approved to set up a key laboratory for national defense" [航天科技四院 42 所获批成立国防重点实验室], *CASC*, 3 May 2018, https://www.spacechina.com/n25/n2014789/n2014809/c1847627/content.html
"The entire Fourth Academy earnestly studies and implements the spirit of the Seventh Working Conference of the Group and endeavors to build an international first-class aerospace high-tech company with the integration and development of the military and the people" [四院上下认真学习贯彻集团公司第七次工作会精神 努力建设军民融合发展的国际一流航天高科技公司], *Sohu*, 5 September 2018, https://www.sohu.com/a/252154012_660250
"Open Fund Guidelines for the Aerospace Chemical Power Technology Key Laboratory" [航天化学动力技术重点实验室开放基金指南], *Keyan Pro*, 31 May 2022, http://webcache.googleusercontent.com/search?client=firefox-b-1-d&q=cache%3Ahttps%3A%2F%2Fwww.keyanpro.com%3A5000%2Fget_project%3Fmd5_new%3D029df7e42d19f313557b

[1862] "The entire Fourth Academy earnestly studies and implements the spirit of the Seventh Working Conference of the Group and endeavors to build an international first-class aerospace high-tech company with the integration and development of the military and the people" [四院上下认真学习贯彻集团公司第七次工作会精神 努力建设军民融合发展的国际一流航天高科技公司], *Sohu*, 5 September 2018, https://www.sohu.com/a/252154012_660250

[1863] "2018 International Defense Technology Conference held in Beijing" [2018 国际防务技术大会在京召开], SASAC, 26 October 2018, https://www.sastind.gov.cn/n10086200/n10086344/c10173397/content.html "1st International Conference on Defense Technology" [第一届国际防务技术会暨征文通知], *China Armaments Society*, 2018, https://www.cup.edu.cn/kjc/docs/20180523091353019433.pdf and "The 13th International Autumn Symposium on Propellant, Explosives and Pyrotechnics Technology and the 95th Anniversary of the Birth of Mr. Ding Wang Successfully Held" [第 13 届国际推进剂、炸药、烟火技术秋季研讨会暨丁儆先生诞辰 95 周年纪念会成功举行], *Beijing Institute of Technology*, 17 October 2019, http://webcache.googleusercontent.com/search?client=firefox-b-1-d&q=cache%3Arenshichu.kjc.czpxzs.com%2Fxww%2Fxzw%2Fxydt2%2Fa177459.htm

[1864] "42nd RI" [四十二所], *CASC Talent* [中国航天人才网], Accessed January 2024, https://www.spacetalent.com.cn/jituan_xx.html?id=29&childDeptId=31

[1865] "Open Fund Guidelines for the Aerospace Chemical Power Technology Key Laboratory" [航天化学动力技术重点实验室开放基金指南], *Keyan Pro*, 31 May 2022, http://webcache.googleusercontent.com/search?client=firefox-b-1-d&q=cache%3Ahttps%3A%2F%2Fwww.keyanpro.com%3A5000%2Fget_project%3Fmd5_new%3D029df7e42d19f313557b

[1866] "Xiangyang's first state-level key laboratory" [襄阳首设国家级重点实验室], *Hubei People's Government*, 25 May 2018, http://www.hubei.gov.cn/hbfb/szsm/201805/t20180525_1547781.shtml

[1867] "Notice of the Xiangyang Municipal People's Government on the Issuance of the 14th Five-Year Plan for New Infrastructure Construction in Xiangyang City" [襄阳市人民政府关于印发襄阳市新型基础设施建设“十四五”规划的通知], *eChinagov*, 24 March 2022, http://www.echinagov.com/info/320557

[1868] “Sending warmth into the hearts of experts and talents” [将温暖送进专家人才心窝里], *Chang Jiang Net* [长江网], 9 September 2022, http://news.cjn.cn/hbpd_19912/xy_19928/202209/t4248401.htm

[1869] "Beihang Spray Combustion Laboratory Spring Semester 2021 Offline Lecture - Hubei Institute of Aerospace Chemical Technology Wang Fang" [北航喷雾燃烧实验室 2021 春季学期线下讲座 ——湖北航天化学技术研究所 王芳], *Beihang University*, 3 June 2021, http://webcache.googleusercontent.com/search?client=firefox-b-1-d&q=cache%3Ahttps%3A%2F%2Fteacher.buaa.edu.cn%2Ffuqingfei%2Fzh_CN%2Farticle%2F49480%2Fcontent%2F1328.htm

[1870] "Open Fund Guidelines for the Aerospace Chemical Power Technology Key Laboratory" [航天化学动力技术重点实验室开放基金指南], *Keyan Pro*, 31 May 2022, http://webcache.googleusercontent.com/search?client=firefox-b-1-d&q=cache%3Ahttps%3A%2F%2Fwww.keyanpro.com%3A5000%2Fget_project%3Fmd5_new%3D029df7e42d19f313557b

[1871] "Profile of Candidates for Membership " [理事候选人简介], *Chinese Chemical Society*, Accessed January 2024, https://www.chemsoc.org.cn/meeting/12thMember/candidate538.html

[1872] “Sending warmth into the hearts of experts and talents” [将温暖送进专家人才心窝里], *Chang Jiang Net* [长江网], 9 September 2022, http://news.cjn.cn/hbpd_19912/xy_19928/202209/t4248401.htm

[1873] "Beihang Spray Combustion Laboratory Spring Semester 2021 Offline Lecture - Hubei Institute of Aerospace Chemical Technology Wang Fang" [北航喷雾燃烧实验室 2021 春季学期线下讲座 ——湖北航天化学技术研究所 王芳], *Beihang University*, 3 June 2021, http://webcache.googleusercontent.com/search?client=firefox-b-1-d&q=cache%3Ahttps%3A%2F%2Fteacher.buaa.edu.cn%2Ffuqingfei%2Fzh_CN%2Farticle%2F49480%2Fcontent%2F1328.htm

[1874] "Beihang Spray Combustion Laboratory Spring Semester 2021 Offline Lecture - Hubei Institute of Aerospace Chemical Technology Wang Fang" [北航喷雾燃烧实验室 2021 春季学期线下讲座 ——湖北航天化学技术研究所 王芳], *Beihang University*, 3 June 2021, http://webcache.googleusercontent.com/search?client=firefox-b-1-d&q=cache%3Ahttps%3A%2F%2Fteacher.buaa.edu.cn%2Ffuqingfei%2Fzh_CN%2Farticle%2F49480%2Fcontent%2F1328.htm

[1875] "Notice of the Fifth China Air and Space Propulsion Technology Forum (second round)" [第五届中国空天推进技术论坛通知（第二轮）], *Dalian University of Technology*, 12 April 2022, https://aa.dlut.edu.cn/info/1036/1434.htm

[1876] "Notice of Conference "Fire Explosives Technology Annual Conference 2023" (Third Round)" ["2023 年火炸药技术学术年会" 会议通知（第三轮）]， *Wenzhou University*, 24 October 2023, http://webcache.googleusercontent.com/search?client=firefox-b-1-d&q=cache%3Ahttps%3A%2F%2Fwww.tjthyg.com%2Finfo%2F2599%2F41343.htm
[1877] "The 13th International Autumn Symposium on Propellant, Explosives and Pyrotechnics Technology and the 95th Anniversary of the Birth of Mr. Ding Wang Successfully Held" [第 13 届国际推进剂、炸药、烟火技术秋季研讨会暨丁儆先生诞辰 95 周年纪念会成功举行], *Beijing Institute of Technology*, 17 October 2019, http://webcache.googleusercontent.com/search?client=firefox-b-1-d&q=cache%3Arenshichu.kjc.czpxzs.com%2Fxww%2Fxzw%2Fxydt2%2Fa177459.htm
[1878] "2018 International Defense Technology Conference held in Beijing" [2018 国际防务技术大会在京召开], SASAC, 26 October 2018, https://www.sastind.gov.cn/n10086200/n10086344/c10173397/content.html
"1st International Conference on Defense Technology" [第一届国际防务技术会暨征文通知], *China Armaments Society*, 2018, https://www.cup.edu.cn/kjc/docs/2018052309135301943 3.pdf
"Laboratory members participated in the "2022 International Defense Technology Conference" and gave invited presentations" [实验室成员参加"2022 国际防务技术大会"并做邀请报告], *Nanjing University of Science and Technology Smart Computational Imaging Lab*, 3 September 2022, https://scilaboratory.com/h-nd-321.html
[1879] "English College Volunteer Team Shines at International Defense Technology Conference" [英文学院志愿者团队闪耀"国际防务技术大会"], *Xi'an Fanyi University*, 30 September 2024, https://www.xafy.edu.cn/info/1090/205411.htm
我校组织团队参加 2024 国际防务技术大会, Shenyang Ligong University, 26 September 2024, https://www.sylu.edu.cn/info/1003/26942.htm
[1880] "2024 International Conference on Defence Technology," *Journal of Physics*, Conference Series 2891, 2024, https://iopscience.iop.org/article/10.1088/1742-6596/2891/1/011001/pdf
[1881] "Conference Report" [大会报告人], *ICDT 2024*, Accessed February 2025, https://www.bagevent.com/event/8767410/p/539007
Linkedin Post by Murali Mohan Cheepu, Linkedin, November 2024, https://www.linkedin.com/posts/murali-mohan-cheepu-47b12320_i-am-glad-to-receive-an-official-invitation-activity-7262837753954873344-MBze/
[1882] "Dr Raja Munusamy Represents Alliance University at ICDT 2024, Xi'an, China," *Alliance University*, 25 September 2024, https://www.alliance.edu.in/news/dr-raja-munusamy-represents-alliance-university-at-icdt-2024-xian-china
[1883] Instagram Post, *RIT India*, 25 September 2024, https://www.instagram.com/ritindiaedu/p/DAV01htsCAJ/?img_index=1
[1884] "Academic Committee" [学术委员会], *2024 International Conference on Defence Technology*, Accessed February 2025, https://www.bagevent.com/event/8767410/p/542175
[1885] "National Key Laboratory of Space Environment and Material Effects" [空间环境与物质作用全国重点实验室], *Harbin Institute of Technology*, 8 May 2023, https://mse.hit.edu.cn/2023/0508/c16913a305817/page.htm
[1886] "Defense S&T Key Laboratory of Space Environmental Materials Behavior and Evaluation Technology" [空间环境材料行为及评价技术国家级重点实验室], *Harbin Institute of Technology*, 1 May 2010. http://mse.hit.edu.cn/2015/0708/c3817a99883/page.htm
"National Key Laboratory of Space Environmental Materials Behavior and Evaluation Technology" [空间环境材料行为与评价技术国家级重点实验室], *Harbin Institute of Technology*, 1 May 2010. https://web.archive.org/web/20190517062804/http://mse.hit.edu.cn/2010/0501/c3766a99691/page.htm. This appears to be an older version of the homepage with some additional information.
"No.035 No.035 State Key Laboratory of Space Environmental Materials Behavior and Evaluation Technology" [空间环境材料行为及评价技术国家重点实验], *Changzhou Military-Civil Fusion Public Service Platform*, 14 June 2016. http://www.czjmrh.com/content/?1097.html
[1887] "510 RI: building the most valuable research institute in aerospace industry" [五一〇研究所：打造航天最有价值研究所], *Sina*, 17 April 2018, https://k.sina.cn/article_2810373291_a782e4ab02000gaw7.html
"Notification of taking the course "Introduction to Astronautics and Space Spirit" [关于选修《宇航概论与航天精神》课程的通知], *Lanzhou University*, 11 September 2020, https://ge.lzu.edu.cn/peiyanggongzuo/jiaoxueguanli/jiaoxueanpai/2020/1223/158903.html

[1888] "National Key Laboratory of Space Environment and Material Effects" [空间环境与物质作用全国重点实验室], *Harbin Institute of Technology*, 8 May 2023, http://mse.hit.edu.cn/2023/0508/c16913a305817/page.htm
[1889] Zhao Chengxuan [赵呈选] et al., "Analysis of Typical Plasma Environment and Terrain Shielding Effect near the Lunar Polar Regions" [月球极区附近典型的月面等离子体环境及地形的遮挡效应分析], *Vacuum and Cryogenics* [真空与低温], 2023, 29(6), http://www.vaccryjour.cn/cn/article/doi/10.3969/j.issn.1006-7086.2023.06.003?viewType=HTML
"China Academy of Space Technology (510 RI) 2024 Master's Degree Enrollment Transfer Notice" [中国空间技术研究院(510 所)2024 年硕士研究生招生调剂通知], *iQihang* [启航教育], 16 April 2024, http://m-jixun.iqihang.com/zixun/tiaoji/2024402662.html
[1890] "Introduction" [本所简介], *Lanzhou Institute of Physics*, Accessed June 2024, http://www.lipcast.cn/channels/channel_10074_1.html
"Lanzhou Institute of Physics" [兰州空间技术物理研究所], *Beidou.org*, Accessed June 2024, https://www.beidou.org/exhibitordetail_256.html
[1891] Zhang Chenguang [张晨光] et al., "Pulsed laser simulation of single-particle effect study" [脉冲激光模拟单粒子效应研究], *Nuclear Technology* [核技术] 43 (2020).
"[Recruitment] The Fifth Research Academy of China Aerospace Science and Technology Corporation 510 Research Institute Recruitment" [[招聘信息]中国航天科技集团公司第五研究院第五一○研究所招聘], *Lanzhou University*, 7 November 2014. http://msen.lzu.edu.cn:8080/xsfz/jycy/2016/04/06/1617141048.html
[1892] "2024 Open Fund Guidelines for the National Key Laboratory of Space Environment and Role of Matter" [2024 年度空间环境与物质作用全国重点实验室开放基金指南], *Harbin Institute of Technology*, 25 April 2024, http://today.hit.edu.cn/article/2024/04/25/112569
[1893] "National Key Laboratory of Space Environment and Material Effects" [空间环境与物质作用全国重点实验室], *Harbin Institute of Technology*, 8 May 2023, http://mse.hit.edu.cn/2023/0508/c16913a305817/page.htm
[1894] "Defense S&T Key Laboratory of Space Environmental Materials Behavior and Evaluation Technology" [空间环境材料行为及评价技术国家级重点实验室], Harbin Institute of Technology, 1 May 2010. http://mse.hit.edu.cn/2015/0708/c3817a99883/page.htm
[1895] "Defense S&T Key Laboratory of Space Environmental Materials Behavior and Evaluation Technology" [空间环境材料行为及评价技术国家级重点实验室], Harbin Institute of Technology, 1 May 2010. http://mse.hit.edu.cn/2015/0708/c3817a99883/page.htm
[1896] "2024 Open Fund Guidelines for the National Key Laboratory of Space Environment and Role of Matter" [2024 年度空间环境与物质作用全国重点实验室开放基金指南], *Harbin Institute of Technology*, 25 April 2024, http://today.hit.edu.cn/article/2024/04/25/112569
[1897] "2024 Open Fund Guidelines for the National Key Laboratory of Space Environment and Role of Matter" [2024 年度空间环境与物质作用全国重点实验室开放基金指南], *Harbin Institute of Technology*, 25 April 2024, http://today.hit.edu.cn/article/2024/04/25/112569
[1898] "Some basic scientific problems and research platforms for spacecraft space environment effect research" [航天器空间环境效应研究若干基础科学问题与研究平台], Inner Mongolia University of Technology [内蒙古工业大学], 20 July 2018. https://www.imut.edu.cn/info/1004/4223.htm
[1899] "HIT Grad Student Adviser Profile – Li Chundong" [哈尔滨工业大学研究生导师简介-李春东*], Free Kaoyan*, 1 April 2016. http://school.freekaoyan.com/heilongjiang/hit/daoshi/2016/04-01/1459456092547042.shtml
[1900] "Qin Wei" [秦伟], *Chongqing Smart Park Public Service Platform* [重庆市智慧园区公共服务平台], Accessed 2021, https://www.cqsmartpark.cn/expert/show.php?itemid=5523
[1901] "Li Xingji [李兴冀], *Harbin Institute of Technology*, Accessed 2021, http://homepage.hit.edu.cn/lxj0218
[1902] "Hunan Aerospace Co., Ltd. and Harbin Institute of Technology signed Strategic Cooperation Framework Agreement" [湖南航天有限责任公司与哈尔滨工业大学 签订战略合作框架协议], *Sohu*, 17 October 2017. https://www.sohu.com/a/198801834_241477
[1903] "Summary of the 3rd National Conference on Hypervelocity Collision" [第三届全国超高速碰撞学术会议总结], *Chinese Society of Theoretic and Applied Mechanics* [中国力学学会], 27 November 2019. https://www.cstam.org.cn/article/201829.html

[1904] "Defense S&T Key Laboratory of Space Environmental Materials Behavior and Evaluation Technology" [空间环境材料行为及评价技术国家级重点实验室], Harbin Institute of Technology, 1 May 2010. http://mse.hit.edu.cn/2015/0708/c3817a99883/page.htm
[1905] "National Key Laboratory of Space Environmental Materials Behavior and Evaluation Technology" [空间环境材料行为与评价技术国家级重点实验室], Harbin Institute of Technology, 1 May 2010. https://web.archive.org/web/20190517062804/http://mse.hit.edu.cn/2010/0501/c3766a99691/page.htm
[1906] HIT Grad Student Adviser Profile – Li Chundong" [哈尔滨工业大学研究生导师简介-李春东*], Free Kaoyan*, 1 April 2016. http://school.freekaoyan.com/heilongjiang/hit/daoshi/2016/04-01/1459456092547042.shtml
[1907] "State Key Labs," *NWPU*, Accessed 2021, https://en.nwpu.edu.cn/Research1/CentersandInstitutions.htm
[1908] "Defense S&T Key Laboratory of Space Flight Dynamics Technology" [航天飞行动力学技术重点实验室], *NWPU*, 2018. http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=315
"No.025 Key Lab of Space Flight Dynamics Technology" [No.025 航天飞行动力学技术重点实验室], *Changzhou Military-Civil Fusion Service Platform* [常规军民融合公共服务平台], 14 June 2017. http://www.czjmrh.com/content/?1067.html
"Key Laboratory of Aerospace Flight Dynamics Technology Passes Trial Operation Evaluation" [航天飞行动力学技术重点实验室通过试运行评估], *NetEase*, 24 October 2012. https://war.163.com/12/1024/18/8EJP1IRV00014OMD.html
[1909] "Defense S&T Key Laboratory of Space Flight Dynamics Technology" [航天飞行动力学技术重点实验室], NWPU, 2018. http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=315
[1910] Mark Stokes at al., China's Space and Counterspace Capabilities and Activities, *Project 2049 Institute*, 30 March 2020. http://www.spaceflightfans.cn/wp-content/uploads/2020/10/China_Space_and_Counterspace_Activities.pdf
[1911] "Defense S&T Key Laboratory of Space Flight Dynamics Technology" [航天飞行动力学技术重点实验室], *NWPU*, 2018. http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=315
Wang Jingyu [王靖宇] et al, "Small UAV Target Detection Model Based on Deep Neural Network" [基于深度神经网络的低空弱小无人机目标检测研究], *Journal of Northwestern Polytechnical University* [西北工业大学学报] (2) 2018. https://www.jnwpu.org/articles/jnwpu/pdf/2018/02/jnwpu2018362p258.pdf
Yang Wenjun [杨文骏] et al., "LESO-Based Dynamic Surface Control for a Hypersonic Flight Vehicle" [含 LESO 的高超声速飞行器动态面控制*], Journal of Astronautics* [宇航学报] (8) 2017.
[1912] "Tiangong-1 flight control work is a long way to go" [天宫一号飞控工作任重道远], *China.com*, 30 September 2011. fangtan.china.com.cn/2011-09/30/content_23529759.htm
"Experts explain the Tiangong docking orbit control strategy: accuracy is the key to success" [专家解读天宫对接轨控策略：精度是成功关键], *China News* [中国新闻网], 3 November 2011. http://www.chinanews.com/gn/2011/11-03/3435509.shtml
[1913] "Researcher Tang Geshi from Beijing Space Flight Control Center came to the hospital for exchange" [北京航天飞行控制中心唐歌实研究员来院交流], *NUAA* [南京航空航天大学], 6 September 2017. https://astro.nuaa.edu.cn/2017/0906/c2092a65843/page.htm
[1914] "No.025 Key Lab of Space Flight Dynamics Technology" [No.025 航天飞行动力学技术重点实验室], *Changzhou Military-Civil Fusion Service Platform* [常规军民融合公共服务平台], 14 June 2017. http://www.czjmrh.com/content/?1067.html
Wang Tao [王涛], Wang Xiang [王祥], "Multi-dimensional assessment method for infrared missile anti-interference capability" [红外导弹抗干扰能力多维度评估方法], *Infrared Technology* [红外技术] (7) 2014. http://en.nvt.com.cn/oa/pdfdow.aspx?Sid=201404006 (CAUTION: opens pdf)
[1915] "Defense S&T Key Laboratory of Space Flight Dynamics Technology" [航天飞行动力学技术重点实验室], *NWPU*, 2018. http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=315
[1916] "Defense S&T Key Laboratory of Space Flight Dynamics Technology" [航天飞行动力学技术重点实验室], *NWPU*, 2018. http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=315
[1917] "Key Laboratory of Aerospace Flight Dynamics Technology Passes Trial Operation Evaluation" [航天飞行动力学技术重点实验室通过试运行评估], NetEase, 24 October 2012. https://war.163.com/12/1024/18/8EJP1IRV00014OMD.html

[1918] "Key Laboratory of Aerospace Flight Dynamics Technology" [航天飞行动力学技术重点实验室], Collaborative Innovation Center of Future Aerospace Vehicle [未来飞行区协同创新中心], Accessed 2021, https://hangkong.nwpu.edu.cn/info/1204/2622.htm
[1919] "Defense S&T Key Laboratory of Space Flight Dynamics Technology" [航天飞行动力学技术重点实验室], NWPU, 2018. http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=315
[1920] "Our laboratory participated in the signing ceremony of the strategic cooperation agreement between the Institute of Remote Sensing and the Beijing Space Flight Control Center" [我实验室参加遥感地球所与北京航天飞行控制中心战略合作协议签订仪式], *Planetary Mapping and Remote Sensing Laboratory* [行星制图摇杆实验室], 26 May 2016. http://www.pmrslab.cn/news/zhanluehezuo.html
[1921] Song Xingguang [宋星光], "The Sixth National Symposium on Aerospace Flight Dynamics Technology was successfully completed" [第六届全国航天飞行动力学技术研讨会圆满完成], *81.cn*, 11 October 2018. http://www.81.cn/jwsj/2018-10/11/content_9308946.htm
[1922] "Defense S&T Key Laboratory of Space Flight Dynamics Technology" [航天飞行动力学技术重点实验室], NWPU, 2018. http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=315
[1923] "Defense S&T Key Laboratory of Space Flight Dynamics Technology" [航天飞行动力学技术重点实验室], NWPU, 2018. http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=315
[1924] "Defense S&T Key Laboratory of Space Flight Dynamics Technology" [航天飞行动力学技术重点实验室], NWPU, 2018. http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=315
[1925] Sun Lingfeng [孙凌峰], "Comparison between ionospheric character parameters retrieved from FORMOSAT3 measurement and ionosonde observation over China" [中国区域电离层垂测仪探测参量与 COSMIC 掩星反演结果比较研究], *Chinese Journal of Geophysics* [地球物理学报] (11) 2014. 4
[1926] "Different Thrust Maneuvers Detection of Uncooperative Space Objects" [不同推力下的非合作空间目标轨道机动检测], *Journal of Astronautics* [宇航学报] (3) 2016.
[1927] "Defense S&T Key Laboratory of Space Flight Dynamics Technology" [航天飞行动力学技术重点实验室], NWPU, 2018. http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=315
[1928] "Defense S&T Key Laboratory of Space Flight Dynamics Technology" [航天飞行动力学技术重点实验室], NWPU, 2018. http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=315
[1929] "Defense S&T Key Laboratory of Space Flight Dynamics Technology" [航天飞行动力学技术重点实验室], NWPU, 2018. http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=315
"Northwestern Polytechnic University National Key Laboratory of Aerospace Flight Dynamics Technology Recruitment" [西北工业大学 航天飞行动力学技术国家级重点实验室招聘启事], *Muchong.com* [小木虫], 2021. http://muchong.com/html/202012/14554329.html
[1930] "A Laboratory of 1st Academy Won the First Place in the Evaluation of State-level Key Laboratories" [火箭院一实验室在集团公司国家级重点实验室考评中荣获第一名], *China Academy of Launch Vehicle Technology*, 1 June 2023, http://www.calt.com/n481/n497/n853/c27594/content.html
[1931] "Key Lab of Missile Guidance and Control established" [导弹制导与控制技术重点实验室成立], *Research and Development* [高校科技], 20 March 2006. https://www.edu.cn/ke_yan_yu_fa_zhan/gao_xiao_cheng_guo/ke_yan_ji_gou/200603/t20060320_168287.shtml
"'Key Laboratory of Aerospace Intelligent Control Technology" won the first place in the assessment of group companies, " ["宇航智能控制技术重点实验室"获集团公司考核第一名], *CALT*, 3 June 2019. http://www.calt.com/n689/c15234/content.html
[1932] "Key Lab of Missile Guidance and Control established" [导弹制导与控制技术重点实验室成立], *Research and Development* [高校科技], 20 March 2006. https://www.edu.cn/ke_yan_yu_fa_zhan/gao_xiao_cheng_guo/ke_yan_ji_gou/200603/t20060320_168287.shtml
[1933] "A CALT Lab Won the First Place in the Evaluation of State-level Key Laboratories of Group Companies" [火箭院一实验室在集团公司国家级重点实验室考评中荣获第一名], *China Academy of Launch Vehicle Technology*, 1 June 2023, http://www.calt.com/n481/n497/n853/c27594/content.html

[1934] "The Twelve Institute of Aeronautics and Astronautics 2014 master's degree transfer admission instructions" [航天十二所 2014 年硕士研究生调剂招生说明], *Shanghai Jiaotong University* [上海交通大学], 3 April 2014. https://xsb.seiee.sjtu.edu.cn/yjwb0/info/7428.htm
[1935] "Aerospace intelligence technology has an "innovation base"" [航天智能技术有了"创新根据地"], *CALT*, 13 March 2018. http://calt.spacechina.com/n689/c11370/content.html
[1936] "Six projects of Rocket Academy won awards in the "BAACI Cup" Aerospace Artificial Intelligence Innovation and Creativity Competition" [火箭院 6 个项目在"BAACI 杯"航天人工智能创新创意大赛中获奖], *CALT*, 28 May 2018. http://calt.spacechina.com/n689/c11933/content.html
[1937] "Beijing Institute of Aerospace Automatic Control won the first place in the assessment and evaluation of key laboratories of group companies" [北京航天自动控制研究所在集团公司重点实验室考核评比中获第一名], *China Academy of Launch Vehicle Technology* [中国运载火箭技术研究院], 20 April 2020. http://calt.spacechina.com/n481/n497/n855/c17574/content.html
[1938] "Future rockets will have smarter "brains" to determine faults and solve them themselves" [未来火箭将拥有更聪明的"大脑"判断故障 自己解决], *CALT*, 16 October 2020. http://calt.spacechina.com/n689/c19302/content.html
[1939] From a search for this lab in the *Discipline Service of Kashi University* [喀什大学学科服务]. http://ksuxk.cqvip.com/asset/search?key=O%3D%E5%AE%87%E8%88%AA%E6%99%BA%E8%83%BD%E6%8E%A7%E5%88%B6%E6%8A%80%E6%9C%AF%E5%9B%BD%E5%AE%B6%E5%AE%9E%E9%AA%8C%E5%AE%A4&page=1
[1940] ""Key Laboratory of Aerospace Intelligent Control Technology" won the first place in the assessment of group companies, " ["宇航智能控制技术重点实验室"获集团公司考核第一名], *CALT*, 3 June 2019. http://www.calt.com/n689/c15234/content.html
[1941] Per a search of two scientific databases, as well as "Key Lab of Missile Guidance and Control established" [导弹制导与控制技术重点实验室成立], *Research and Development* [高校科技], 20 March 2006. https://www.edu.cn/ke_yan_yu_fa_zhan/gao_xiao_cheng_guo/ke_yan_ji_gou/200603/t20060320_168287.shtml
[1942] Mark Stokes, "China's Evolving Conventional Strategic Strike Capability," *Project 2049 Institute*, 14 September 2009. https://project2049.net/wp-content/uploads/2018/06/chinese_anti_ship_ballistic_missile_asbm.pdf
"Key Laboratory of National Defense Science and Technology for Missile Guidance and Control Technology was inaugurated" [导弹制导与控制技术国防科技重点实验室揭牌], *Sinoma Advanced Materials Co. Ltd*. [中材高新材料股份有限公司], Accessed 2021, http://www.cnbmgx.com/cnt.php?id=187&fid=8&navid=53
[1943] "Rocket recovery technology verification success! The Chinese version of the Falcon-9 is here!" [火箭回收技术验证成功！中国版的"猎鹰-9"号来了?!], *Sohu*, 30 October 2018. https://www.sohu.com/a/272099214_419351
[1944] "Future rockets will have smarter "brains" to determine faults and solve them themselves" [未来火箭将拥有更聪明的"大脑"判断故障 自己解决], *CALT*, 16 October 2020. http://calt.spacechina.com/n689/c19302/content.html
"Learn as you fly! China is developing a launch vehicle that learns" [边飞边学！我国正在研制会学习的运载火箭], *Sina*, 21 October 2020. https://finance.sina.com.cn/tech/2020-10-21/doc-iiznezxr7164774.shtml
[1945] 无人机装上它，沙尘暴、雾霾天也能一眼看清目标, *CALT*, 2 August 2019. http://calt.spacechina.com/n689/c15559/content.html
[1946] "Notice of the "Alumni Lecture"" [关于举办"校友大讲堂"的通知], *Hebei University of Science and Technology* [河北科技大学], 3 March 2018. https://www.hebust.edu.cn/tzgg/tz/92708.htm
[1947] ""Key Laboratory of Aerospace Intelligent Control Technology" won the first place in the assessment of group companies, " ["宇航智能控制技术重点实验室"获集团公司考核第一名], *CALT*, 3 June 2019. http://www.calt.com/n689/c15234/content.html
[1948] "Future rockets will have smarter "brains" to determine faults and solve them themselves" [未来火箭将拥有更聪明的"大脑"判断故障 自己解决], *CALT*, 16 October 2020. http://calt.spacechina.com/n689/c19302/content.html
"State Key Laboratory of Aerospace Intelligent Control Technology visited Pengcheng Laboratory" [宇航智能控制技术国家重点实验室来访鹏城实验室交流], *CALT*, 8 November 2018. https://www.pcl.ac.cn/m/897/2018-11-08/content-2783.html
"Professor Ren Zhang, Professor and Vice Dean of School of Automation, Beijing University of Aeronautics and Astronautics and Adjunct Professor of our university, visited the Department of Automatic Control, School of

Automation" [北京航空航天大学自动化学院教授、副院长、我校兼职教授任章教授访问自动化学院自动控制系], *NUAA*, 21 January 2015. http://cae.nuaa.edu.cn/2015/0121/c5399a142095/page.htm

[1949] "Notice of the "Alumni Lecture"" [关于举办"校友大讲堂"的通知], *Hebei University of Science and Technology* [河北科技大学], 3 March 2018. https://www.hebust.edu.cn/tzgg/tz/92708.htm

[1950] "Intelligent UAV Cluster Cooperative Control Technology Exchange Meeting was successfully held" [智能无人机集群协同控制技术交流会顺利召开], *Peng Cheng Laboratory* [鹏城实验室], 11 August 2020. http://210.22.22.135:8000/html/943/2020-08-11/content-3357.html

[1951] "State Key Laboratory of Aerospace Intelligent Control Technology visited Pengcheng Laboratory" [宇航智能控制技术国家重点实验室来访鹏城实验室交流], *CALT*, 8 November 2018. https://www.pcl.ac.cn/m/897/2018-11-08/content-2783.html

[1952] "State Key Laboratory of Aerospace Intelligent Control Technology visited Pengcheng Laboratory" [宇航智能控制技术国家重点实验室来访鹏城实验室交流], *CALT*, 8 November 2018. https://www.pcl.ac.cn/m/897/2018-11-08/content-2783.html

"Intelligent UAV Cluster Cooperative Control Technology Exchange Meeting was successfully held" [智能无人机集群协同控制技术交流会顺利召开], *Peng Cheng Laboratory* [鹏城实验室], 11 August 2020. http://210.22.22.135:8000/html/943/2020-08-11/content-3357.html

[1953] "Key Laboratory of National Defense Science and Technology for Missile Guidance and Control Technology was inaugurated" [导弹制导与控制技术国防科技重点实验室揭牌], *Sinoma Advanced Materials Co. Ltd*. [中材高新材料股份有限公司], Accessed 2021, http://www.cnbmgx.com/cnt.php?id=187&fid=8&navid=53

[1954] "Experts and scholars gathered at the ninth "Aerospace Control Forum" to discuss the intelligent development of space devices" [专家学者齐聚第九届"航控论坛" 共议航天装置智能化发展], *CALT*, 3 November 2017. http://calt.spacechina.com/n482/n756/c9939/content.html

[1955] "Conference Homepage" [会议首页], *CSOE*, September 2020. https://b2b.csoe.org.cn/meeting/JD2020.html

[1956] "Notice of the "Alumni Lecture"" [关于举办"校友大讲堂"的通知], *Hebei University of Science and Technology* [河北科技大学], 3 March 2018. https://www.hebust.edu.cn/tzgg/tz/92708.htm

[1957] "Astronaut Systems" [航天员系统], *China Manned Space*, Accessed July 2024, https://www.cmse.gov.cn/gygc/xtzc/htyxt/

[1958] "Development of Key Laboratory of Space Intelligent Control Technology, Institute 502, Fifth Academy of Space Science and Technology" [航天科技五院 502 所空间智能控制技术重点实验室发展侧记], *CASC*, 15 June 2020, https://www.spacechina.com/n25/n1991299/n1991333/c2942127/content.html

[1959] "Notice on the Release of the 2023 Open Fund Guidelines of National Key Laboratory of Space Intelligent Control Technology" [关于发布空间智能控制技术全国重点实验室 2023 年度开放基金指南的通知], *Weixin*, 18 July 2023, https://mp.weixin.qq.com/s?__biz=MzIxODYyMzE2OA==&mid=2247560235&idx=1&sn=803c3bab3aa253d6e85433089f322a24

[1960] "Running to Deep Space and Controlling the Future - The 12th Tonoyuan Academic Lecture Theater of School of Mechanical and Power Engineering" ["奔向深空 智控未来" 机械与动力工程学院砺远学术讲坛第十二期], *Shanghai Jiao Tong University*, 26 June 2019, https://me.sjtu.edu.cn/report/13196.html

[1961] "Notice on the Release of the 2023 Open Fund Guidelines of National Key Laboratory of Space Intelligent Control Technology" [关于发布空间智能控制技术全国重点实验室 2023 年度开放基金指南的通知], *Weixin*, 18 July 2023, https://mp.weixin.qq.com/s?__biz=MzIxODYyMzE2OA==&mid=2247560235&idx=1&sn=803c3bab3aa253d6e85433089f322a24

[1962] "Development of Key Laboratory of Space Intelligent Control Technology, Institute 502, Fifth Academy of Space Science and Technology" [航天科技五院 502 所空间智能控制技术重点实验室发展侧记], *CASC*, 15 June 2020, https://www.spacechina.com/n25/n1991299/n1991333/c2942127/content.html

[1963] "Joint Research Center on Dynamics and Control of Deep Space Probes Established in the Key Laboratory of National Defense Science and Technology for Space Intelligent Control Technology, School of Astronautics, Beijing Institute of Technology" [北京理工大学宇航学院——空间智能控制技术国防科技重点实验室深空探测

器动力学与控制联合研究中心成立], *Beijing Institute of Technology*, 18 September 2009, https://www.bit.edu.cn/xww/xwtt/a30473.htm

[1964] "Ni Maolin" [倪茂林], *x-Mol*, Accessed July 2024, https://www.x-mol.com/university/faculty/341354

[1965] "Duan Guangren" [段广仁], *SUSTech*, Accessed July 2024, https://sdim.sustech.edu.cn/index/teacher_detail?id=5

[1966] "The 13th National Academic Conference on Space Motion Body Control Technology Successfully Held/The Third Annual Meeting of Academic Committee of National Defense Science and Technology Key Laboratory of Space Intelligent Control Technology Grandly Held" [全国第十三届空间运动体控制技术学术会议成功举办/空间智能控制技术国防科技重点实验室学术委员会第三届年会隆重召开], *Wanfang*, 20 October 2008, https://wf.pub/perios/article:kjkzjsyyy200804013

[1967] "Meng Fanwei" [孟范伟], *Northeast University*, 4 March 2024, http://graduate.neuq.edu.cn/info/1136/2926.htm

[1968] "Recruitment brief of 502 Institute of the Fifth Academy (self-submission of resume)" [五院 502 所招聘简章（自投简历）], *Sohu*, 4 March 2020, https://www.sohu.com/a/377605952_735146

[1969] Wang Li [王立] et al., "Space non-cooperative target spin rate measurement method and experiment" [空间非合作目标自旋速率测量方法与实验], *Journal of Applied Optics* [应用光学], 2019, 40(6), http://www.yygx.net/cn/article/doi/10.5768/JAO201940.0603002?viewType=HTML

[1970] "Summary of Open Fund Guidelines for 30 State-level Key Laboratories" [给力！30 个国家级重点实验室开放基金指南汇总], *163.com*, 13 October 2021, https://www.163.com/dy/article/GM7MBF6V0532RM6P.html

[1971] "Development of Key Laboratory of Space Intelligent Control Technology, Institute 502, Fifth Academy of Space Science and Technology" [航天科技五院 502 所空间智能控制技术重点实验室发展侧记], *CASC*, 15 June 2020, https://www.spacechina.com/n25/n1991299/n1991333/c2942127/content.html

[1972] "Development of Key Laboratory of Space Intelligent Control Technology, Institute 502, Fifth Academy of Space Science and Technology" [航天科技五院 502 所空间智能控制技术重点实验室发展侧记], *CASC*, 15 June 2020, https://www.spacechina.com/n25/n1991299/n1991333/c2942127/content.html

[1973] "Notification of 2022 Stabilization Support Scientific Research Projects of State Key Laboratory of Space Intelligent Control Technology" [空间智能控制技术国家级重点实验室 2022 年度稳定支持科研项目申报通知], *Keyan Pro*, 2 June 2022, https://web.archive.org/web/20220812204730/https://www.keyanpro.com:5000/get_project?md5_new=4dc590879d7dce295f1f

[1974] Ma Peixin [马佩鑫] et al., "Cooperative Navigation Application Based on Multi-agent Deep Reinforcement Learning" [基于多智能体深度强化学习的协作导航应用], *Computer Systems & Applications* [计算继续同应用], 2023, 32(8), https://www.c-s-a.org.cn/1003-3254/9200.html

[1975] "Huang Jie" [黄捷], *Fuzhou University*, 11 September 2018, https://dqxy.fzu.edu.cn/info/1010/3367.htm

[1976] "Development of Key Laboratory of Space Intelligent Control Technology, Institute 502, Fifth Academy of Space Science and Technology" [航天科技五院 502 所空间智能控制技术重点实验室发展侧记], *CASC*, 15 June 2020, https://www.spacechina.com/n25/n1991299/n1991333/c2942127/content.html

[1977] Wang Li [王立] et al., "Space non-cooperative target spin rate measurement method and experiment" [空间非合作目标自旋速率测量方法与实验], *Journal of Applied Optics* [应用光学], 2019, 40(6), http://www.yygx.net/cn/article/doi/10.5768/JAO201940.0603002?viewType=HTML

[1978] "Notice on the Release of the 2023 Open Fund Guidelines of National Key Laboratory of Space Intelligent Control Technology" [关于发布空间智能控制技术全国重点实验室 2023 年度开放基金指南的通知], *Weixin*, 18 July 2023, https://mp.weixin.qq.com/s?__biz=MzIxODYyMzE2OA==&mid=2247560235&idx=1&sn=803c3bab3aa253d6e85433089f322a24

[1979] "Notification of 2022 Stabilization Support Scientific Research Projects of State Key Laboratory of Space Intelligent Control Technology" [空间智能控制技术国家级重点实验室 2022 年度稳定支持科研项目申报通知], *Keyan Pro*, 2 June 2022, https://web.archive.org/web/20220812204730/https://www.keyanpro.com:5000/get_project?md5_new=4dc590879d7dce295f1f

[1980] "Research Team" [研究队伍], *Chinese Academy of Sciences*, Accessed July 2024, http://sourcedb.aoe.cas.cn/zw/rck/201809/t20180920_5085633.html
[1981] "Running to Deep Space and Controlling the Future - The 12th Tonoyuan Academic Lecture Theater of School of Mechanical and Power Engineering" ["奔向深空 智控未来" 机械与动力工程学院砺远学术讲坛第十二期], *Shanghai Jiao Tong University*, 26 June 2019, https://me.sjtu.edu.cn/report/13196.html
[1982] "Robotics and intelligent control in the cognitive era" [认知时代的机器人及智能控制], *Deep Blue* [深蓝学院], 20 October 2018, https://www.shenlanxueyuan.com/society/detail/9
[1983] "Early bird registration closes in 1 week | CCF Sys 2021 Conference in Hangzhou in August!" [早鸟报名 1 周后截止 | CCF Sys 2021 学术大会八月与您相聚杭州!], *Chinese Computer Federation*, 15 July 2021, https://www.ccf.org.cn/Chapters/TC/TC_Listing/TCARCH/hyxw/2021-07-15/732452.shtml
[1984] "Joint Research Center on Dynamics and Control of Deep Space Probes Established in the Key Laboratory of National Defense Science and Technology for Space Intelligent Control Technology, School of Astronautics, Beijing Institute of Technology" [北京理工大学宇航学院——空间智能控制技术国防科技重点实验室深空探测器动力学与控制联合研究中心成立], *Beijing Institute of Technology*, 18 September 2009, https://www.bit.edu.cn/xww/xwtt/a30473.htm
[1985] "Development of Key Laboratory of Space Intelligent Control Technology, Institute 502, Fifth Academy of Space Science and Technology" [航天科技五院 502 所空间智能控制技术重点实验室发展侧记], *CASC*, 15 June 2020, https://www.spacechina.com/n25/n1991299/n1991333/c2942127/content.html
[1986] "[CAC2023] "Intelligent Travel, Intelligent Control, and Exploring Space" Forum Successfully Held " ["智行智控 探索空间"专题论坛顺利召开], *Sohu*, 18 November 2023, https://www.sohu.com/a/737429677_121118938
[1987] "Early bird registration closes in 1 week | CCF Sys 2021 Conference in Hangzhou in August!" [早鸟报名 1 周后截止 | CCF Sys 2021 学术大会八月与您相聚杭州!], *Chinese Computer Federation*, 15 July 2021, https://www.ccf.org.cn/Chapters/TC/TC_Listing/TCARCH/hyxw/2021-07-15/732452.shtml
[1988] Wu Jianfa [吴健发] et al., "Spacecraft Multi-Constraint Rapid Avoidance Motion Planning Based on Deep Reinforcement Learning" [基于深度强化学习的航天器多约束规避动作快速规划 OACSTPCD], *Space Control Technology & Applications* [空间控制技术与应用], 2023 (002), cache:https://coaa.istic.ac.cn/openJournal/periodicalArticle/0120230506981371
[1989] "China Develops Global Super Anti-Stealth Radar That Breaks F-22 and F-35's Stealth Performance" [中国研制的全球超级反隐形雷达，让 F-22 和 F-35 的隐形性能破功], *Tencent*, 19 October 2024, https://news.qq.com/rain/a/20241019A056D200
[1990] ""Space Electronics Technology" National Magazine Call for Papers" [《空间电子技术》国家级杂志征稿], *Qikan VIP* [期刊 VIP 网], 25 May 2015. http://www.qikanvip.com/dianziqikan/30852.html / https://www.ixueshu.com/h5/document/9e34d7aacc0ae6f193ce693bc73d527e318947a18e7f9386.html
[1991] ""Space Electronics Technology" National Magazine Call for Papers" [《空间电子技术》国家级杂志征稿], *Qikan VIP* [期刊 VIP 网], 25 May 2015. http://www.qikanvip.com/dianziqikan/30852.html / https://www.ixueshu.com/h5/document/9e34d7aacc0ae6f193ce693bc73d527e318947a18e7f9386.html
[1992] "Space Electronics Information Technology Research Institute" [空间电子信息技术研究院], *CAST* [中国空间技术研究院], 21 April 2016. https://www.cast.cn/news/4074
[1993] "Translation of "Principles of Terahertz Science and Technology" published" [《太赫兹科学与技术原理》译著出版], *China Space News* [中国航天报], 19 September 2009. http://feitingspace.com/n2014789/n2014809/c286238/content.html
[1994] ""Space Electronics Technology" National Magazine Call for Papers" [《空间电子技术》国家级杂志征稿], Qikan VIP [期刊 VIP 网], 25 May 2015. http://www.qikanvip.com/dianziqikan/30852.html / https://www.ixueshu.com/h5/document/9e34d7aacc0ae6f193ce693bc73d527e318947a18e7f9386.html
[1995] "Translation of "Principles of Terahertz Science and Technology" published" [《太赫兹科学与技术原理》译著出版], *China Space News* [中国航天报], 19 September 2009. http://feitingspace.com/n2014789/n2014809/c286238/content.html
"Development of International Space Electronics Countermeasure Technology" [国外空间电子对抗技术发展], *Space Electronic Technology* [空间电子技术] (1) 2015.; "Research progress of aerospace electronic

countermeasures technology" [航天电子对抗技术研究进展], [航天电子对抗], 2017 年第 4 期. https://www.ixueshu.com/document/0fe434d4483a3b3c05d245eaa5878b66.html
"Research of signal processing method based on supervision and space situation awareness for space debris" [空间碎片监测与态势感知信号处理方法研究], *Infrared and Laser Engineering* [红外与激光工程], 2016, 45(S2). http://hwyjggc.xml-journal.net/cn/article/doi/10.3788/IRLA201645.S229008
[1996] "China Develops Global Super Anti-Stealth Radar That Breaks F-22 and F-35's Stealth Performance" [中国研制的全球超级反隐形雷达，让 F-22 和 F-35 的隐形性能破功], *Tencent*, 19 October 2024, https://news.qq.com/rain/a/20241019A056D200
[1997] "The 4th "Space Information Technology and Application Prospect Academician Forum" of the Chinese Academy of Engineering and the 2017 Satellite Payload Technology Academic Annual Conference" [中国工程院第四届"空间信息技术与应用展望院士论坛"暨 2017 年卫星有效载荷技术学术年会], *Chinese Academy of Engineering* [中国工程院], 10 September 2017. https://www.bit.edu.cn/docs/2017-09/20170910212244128355.doc / https://www.ixueshu.com/document/576bb22bf2d688879484d76b936c7e8a318947a18e7f9386.html
[1998] "2014 Symposium on Expandable Space Structure" [2014 年可展开空间结构学术研讨会], *Chinese Society of Theoretical and Applied Mechanics* [中国力学学会], 9 December 2014. https://www.cstam.org.cn/article/173513.html
[1999] "Telecom•Zhihui High-end Forum (No. 9)-Specially invited researcher Cui Wanzhao to give an academic report" [电信•智荟高端论坛（第 9 期）-特邀崔万照研究员做学术报告], *Nanjing University of Information Science & Technology-School of Electronics and Information Engineering* [南京信息工程大学-电子与信息工程学院], 24 November 2020. https://dxy.nuist.edu.cn/info/1034/2873.htm
"Xi'an Branch of the Fifth Research Institute of China Aerospace Science and Technology Corporation delegation from the Key Laboratory of Space Microwave Technology visited the School of Communication Engineering" [中国航天科技集团第五研究院西安分院 空间微波技术重点实验室一行访问通信工程学院], *Faculty of Information Science, Chongqing University* [重庆大学信息学部], Accessed 2021, http://fis.cqu.edu.cn/info/1017/1406.htm
[2000] "China Develops Global Super Anti-Stealth Radar That Breaks F-22 and F-35's Stealth Performance" [中国研制的全球超级反隐形雷达，让 F-22 和 F-35 的隐形性能破功], *Tencent*, 19 October 2024, https://news.qq.com/rain/a/20241019A056D200
[2001] "The 4th "Space Information Technology and Application Prospect Academician Forum" of the Chinese Academy of Engineering and the 2017 Satellite Payload Technology Academic Annual Conference" [中国工程院第四届"空间信息技术与应用展望院士论坛"暨 2017 年卫星有效载荷技术学术年会], *Chinese Academy of Engineering* [中国工程院], 10 September 2017. https://www.bit.edu.cn/docs/2017-09/20170910212244128355.doc / https://www.ixueshu.com/document/576bb22bf2d688879484d76b936c7e8a318947a18e7f9386.html
[2002] "Commercial Aerospace Advanced Communication Technology Forum and Xidian Aerospace Alumni Council held" [商业航天先进通信技术论坛暨西电航天校友理事会举办], *Xidian University* [西安电子科技大学], 20 November 2020. http://dxs.moe.gov.cn/zx/a/xyh_xyh_xadzkjdx/201120/1599555.shtml
[2003] "Notice of 2020 Space Electronic Information Academic Exchange Conference" [2020 空间电子信息学术交流大会的通知], *Chinese Institute of Electronics* [中国电子学会], 3 March 2020. http://radars.ie.ac.cn/news/bianjibugonggao/5dc6e637-04a3-477a-9d8a-e96aa086f1c5.htm
[2004] "Conference Homepage" [会议首页], 8th Conference on Microwave Photonics Technology and Applications [第八届微波光子学技术及应用会议], Accessed January 2025, https://b2b.csoe.org.cn/meeting/MPTA2023.html
[2005] "Contact information" [联系方式], "Space Electronics Information Technology Research Institute" [空间电子信息技术研究院], Accessed 2021, https://web.archive.org/web/20200810105853/http://cast504.com/space-relation.html
[2006] Liu Qingbin [刘庆彬] et al., "Influence of polycrystalline diamond on silicon-based GaN material" [多晶金刚石对硅基氮化镓材料的影响], *Physics* [物理学报], 2023, 72(9), https://wulixb.iphy.ac.cn/cn/article/doi/10.7498/aps.72.20221942
[2007] Feng Zhihong [冯志红] et al., "New Hybrid IC for Terahertz Mixers" [用于太赫兹混频器的新型混合集成电路], *Google Patents*, 13 August 2014. https://patents.google.com/patent/CN104158495B/zh

“Researcher Feng Zhihong, 13th Research Institute of China Electronics Technology Group Corporation: Reliability Evaluation and High Frequency Characterization of InAlN/GaN HFETs” [中国电子科技集团公司第十三研究所研究员冯志红：InAlN/GaN HFETs 的可靠性评估和高频特性研究], *China-LED* [中国半导体照明网], 6 November 2017. http://www.china-led.net/news/201711/06/38964.html
“What can third-generation semiconductors do when a new generation of mobile communications technology is on the rise?” [当新一代移动通信技术崛起，第三代半导体可以做些什么?], *Internet Weekly* [互联网周刊], 8 November 2016. http://www.ciweek.com/article/2016/1108/A20161108574341.shtml
[2008] “Company Overview” [企业简介], *CETC 13th RI*, Accessed 2021, http://webcache.googleusercontent.com/search?q=cache%3Awww.cetc13.cn%2F13%2F338465%2F338453%2Findex.html&rlz=1C1CHBD_enUS895US895&oq=cache%3Awww.cetc13.cn%2F13%2F338465%2F338453%
[2009] Liu Qingbin [刘庆彬] et al., "Influence of polycrystalline diamond on silicon-based GaN material" [多晶金刚石对硅基氮化镓材料的影响], *Physics* [物理学报], 2023, 72(9), https://wulixb.iphy.ac.cn/cn/article/doi/10.7498/aps.72.20221942
[2010] "Spring in the Key Laboratory | Sprint to open the floodgates" [重点实验室里“春意”浓 | 全力冲刺开门红], *CETC*, 12 March 2024, https://www.cetc.com.cn/zgdk/1592960/1592965/1802042/index.html
[2011] "Diamond Substrate Heterogeneous Integrated GaNHEMT--New Generation of Solid-State Microwave Power Devices--An Interview with Chen Tangsheng, Chief Scientist of Manufacturing Processes at CEC Corporation" [金刚石衬底异质集成 GaNHEMT——新一代固态微波功率器件——专访中国电科集团有限公司制造工艺领域首席科学家陈堂胜], *EET China*, 25 March 2024, https://www.eet-china.com/mp/a300854.html
"Nanjing Institute of Electronic Devices (China Electronics Technology Group Corporation 55th Research Institute) Recruitment of RF Chip Circuit Designer" [南京电子器件研究所（中国电子科技集团公司第五十五研究所）招聘射频芯片电路设计师], *CN Xincai*, 18 September 2023, https://daohang.cnxincai.com/zhaokao/show-7347254.html
[2012] "Nanjing Institute of Electronic Devices (China Electronics Technology Group Corporation 55th Research Institute) Recruitment of RF Chip Circuit Designer" [南京电子器件研究所（中国电子科技集团公司第五十五研究所）招聘射频芯片电路设计师], *CN Xincai*, 18 September 2023, https://daohang.cnxincai.com/zhaokao/show-7347254.html
[2013] "Guo Cheng" [郭诚], *Xi'an Jiaotong University* [西安交通大学], Accessed 2021, http://gr.xjtu.edu.cn/web/guocheng
“Guest Lecture – Feng Zhihong” [演讲嘉宾-冯志红], *GRAP China 2018* [中国国际石墨烯创新大会], 19 September 2018. http://www.grapchina.cn/Baogao/view/id/783.html
“What can third-generation semiconductors do when a new generation of mobile communications technology is on the rise?” [当新一代移动通信技术崛起，第三代半导体可以做些什么?], *Internet Weekly* [互联网周刊], 8 November 2016. http://www.ciweek.com/article/2016/1108/A20161108574341.shtml
“The future world is encrusted with diamonds?” [未来世界都是镶钻的?], *QQ*, 5 December 2019. https://kuaibao.qq.com/s/20191205A02YW000?refer=spider
[2014] “When new materials meet new technology: Graphene detection makes terahertz imaging three-dimensional” [当新材料遇上新技术：石墨烯探测让太赫兹成像立体起来], *CCTV*, 14 July 2017. http://news.cctv.com/2017/07/14/ARTI5GbJxSpatcHuXPR6RjIV170714.shtml
[2015] “The 3rd "CASA 3rd Generation Young Innovators of Excellence" Award Announced!” [第三届“CASA 第三代半导体卓越创新青年”评选结果揭晓!], *China Advanced Semiconductor Industry Innovation Alliance* [第三代半导体产业技术创新战略联盟], 24 October 2018. http://www.casa-china.cn/a/news/trends/532.html
“What can third-generation semiconductors do when a new generation of mobile communications technology is on the rise?” [当新一代移动通信技术崛起，第三代半导体可以做些什么?], *Internet Weekly* [互联网周刊], 8 November 2016. http://www.ciweek.com/article/2016/1108/A20161108574341.shtml
[2016] “Guest Lecture – Feng Zhihong” [演讲嘉宾-冯志红], *GRAP China 2018* [中国国际石墨烯创新大会], 19 September 2018. http://www.grapchina.cn/Baogao/view/id/783.html
[2017] “CETC 13 makes major breakthrough in InAlN/GaN HEMT reliability” [中国电科十三所在 InAlN/GaN HEMT 可靠性方面取得重大突破], *simxhs.com*, 19 May 2017. http://webcache.googleusercontent.com/search?q=cache%3Asimxhs.com%2FHome%2FIntelligencePages%2F190

%3Fname%3D%E7%83%AD%E7%82%B9&rlz=1C1CHBD_enUS895US895&oq=cache%3Asimxhs.com%2FHome%2FIntelligencePages%2F190%3Fname%3D%E7%83%AD%E7%82%B9&aqs=chrome..69i57j69i58.1563j0j4&sourceid=chrome&ie=UTF-8

[2018] "The 2nd Annual National Academic Conference on Terahertz Science and Technology was successfully held" [第二届全国太赫兹科学技术学术年会成功举办], *MWRF* [微波射频网], 11 May 2016. http://www.mwrf.net/news/zhbd/2016/19226.html

[2019] "The 18th National Conference on Compound Semiconductor Materials, Microwave Devices and Optoelectronic Devices Call for Papers (Round 1)" [第十八届全国化合物半导体材料、微波器件和光电器件学术会议 征文通知(第一轮)], *CAS Institute of Semiconductors* [中国科学院半导体研究所]. 25 March 2016. http://www.semi.cas.cn/xxgk/zdgk/xxgkgjhz/gjhy/201710/t20171027_4879432.html

[2020] "Opportunities and challenges brought by the new generation of mobile communication technology" [新一代移动通信技术带来的机遇和挑战], *China Advanced Semiconductor Industry Innovation Alliance*, 22 November 2016. http://www.casa-china.cn/a/news/251.html

[2021] "Researcher Feng Zhihong, 13th Research Institute of China Electronics Technology Group Corporation: Reliability Evaluation and High Frequency Characterization of InAlN/GaN HFETs" [中国电子科技集团公司第十三研究所研究员冯志红：InAlN/GaN HFETs 的可靠性评估和高频特性研究], *China-LED* [中国半导体照明网], 6 November 2017. http://www.china-led.net/news/201711/06/38964.html

[2022] "The 21st China International Semiconductor Lighting Forum" [第二十一届中国国际半导体照明论坛], SSL China, Accessed February 2024, http://www.sslchina.org/guest
"Guests" [嘉宾] http://www.sslchina.org/guest
"Program Committee" [程序委员会] http://www.sslchina.org/about/program
"Conference Chairman" [大会主席] http://www.sslchina.org/about/chairs

[2023] "Company Overview" [企业简介], CETC 13th RI, Accessed 2021, http://webcache.googleusercontent.com/search?q=cache%3Awww.cetc13.cn%2F13%2F338465%2F338453%2Findex.html&rlz=1C1CHBD_enUS895US895&oq=cache%3Awww.cetc13.cn%2F13%2F338465%2F338453%2Findex.html&aqs=chrome..69i57j69i58.1634j0j4&sourceid=chrome&ie=UTF-8

[2024] "National 863 Program Key Laboratory of Strong Radiation" [国家 863 计划强辐射重点实验室], *UESTC*, 11 October 2010, https://web.archive.org/web/20130206154859/https://www.rd.uestc.edu.cn/content/89

[2025] "National 863 Program Key Laboratory of Strong Radiation" [国家 863 计划强辐射重点实验室], *UESTC*, 11 October 2010, https://web.archive.org/web/20130206154859/https://www.rd.uestc.edu.cn/content/89

[2026] "National 863 Program Key Laboratory of Strong Radiation" [国家 863 计划强辐射重点实验室], *UESTC*, 11 October 2010, https://web.archive.org/web/20130206154859/https://www.rd.uestc.edu.cn/content/89

[2027] "Du Xiangwan: A Lifelong Affair with "Nuclear" and "Light" [杜祥琬：一生结缘"核"与"光"], *Peking University*, 22 May 2007, https://news.pku.edu.cn/bdrw/137-114315.htm

[2028] "National 863 Program Key Laboratory of Strong Radiation" [国家 863 计划强辐射重点实验室], *UESTC*, 11 October 2010, https://web.archive.org/web/20130206154859/https://www.rd.uestc.edu.cn/content/89

[2029] "University of Electronic Science and Technology (UEST) has made leapfrog development in the scale and level of science and technology" [电子科技大学科技规模和水平取得跨越式发展], *Ministry of Education*, 11 December 2008, http://www.moe.gov.cn/jyb_xwfb/s6192/s133/s211/201004/t20100419_85185.html

[2030] "Introduction of Postdoctoral Research Station of China Academy of Engineering Physics (CAEP)" [中国工程物理研究院博士后科研流动站简介], *CAEP*, 12 March 2012, https://www.caep.cn/doc/2020/01/07/1933.shtml

[2031] "Announcement of the Academic Lecture by Researcher HD Song at Laser Center, Institute of Applied Electronics, Chinese Academy of Engineering Physics (CAEP)" [关于中国工程物理研究院应用电子学研究所激光中心高清松研究员学术报告的通知], *Zhejiang University*, 20 October 2011, http://www.epi.zju.edu.cn/index/article/show.html?id=126
Huang Hua [黄华] et al., "Study on A L Band Relativistic Klystron Amplifier" [L 波段相对论速调管放大器研究[, High Power Laser and Particle Beams [强激光与粒子束], 1998, 10(01), https://www.hplpb.com.cn/article/id/3299

[2032] Zhao Jianheng [赵剑衡] et al., "Fractographic Analysis of Aluminum Cylindrical Shells Damaged By Inner Pressure And Surface Laser Irradiation" [激光辐照下充压铝柱壳爆裂断口分析[, *High Power Laser and Particle Beams* [强激光与粒子束], 1998, 10(01), https://www.hplpb.com.cn/cn/article/id/3292

[2033] "National 863 Program Key Laboratory of Strong Radiation" [国家 863 计划强辐射重点实验室], *UESTC*, 11 October 2010, https://web.archive.org/web/20130206154859/https://www.rd.uestc.edu.cn/content/89
[2034] "National 863 Program Key Laboratory of Strong Radiation" [国家 863 计划强辐射重点实验室], *UESTC*, 11 October 2010, https://web.archive.org/web/20130206154859/https://www.rd.uestc.edu.cn/content/89
[2035] "Chinese Academy of Engineering Physics Dedicated to National Prosperity," *Engineering Science* [中国工程科学], 2001, 3(8), https://www.engineering.org.cn/en/article/24871/detail
[2036] "Du Xiangwan: A Lifelong Affair with "Nuclear" and "Light" [杜祥琬：一生结缘“核”与“光”], *Peking University*, 22 May 2007, https://news.pku.edu.cn/bdrw/137-114315.htm
“Enrollment for the 3rd Advanced Training Course on "Innovative Management in China's New Energy Industry” [第 3 期《中国新能源产业创新经营》高级研修班招生], National Revitalization Think-tank, 1 September 2023, http://www.xbzk.org/news/edp.asp?id=1090
[2037] "Colleges and professors in antennas or computational electromagnetics that you know are at a higher level in the country" [你所了解的国内较高水平的天线或计算电磁学方面的高校和教授们], *Microwave EDA*, Accessed August 2024, http://www.mweda.com/html/tianxian-9076-1.html
[2038] "Xu Zhou" [许州], *Xihua University*, 29 March 2023, https://lxy.xhu.edu.cn/40/ce/c581a147662/page.htm
[2039] Cui Xuesu [崔学芳], "Key Laboratory of Intense Radiation 2007 Annual Academic Exchange Meeting was held successfully" [强辐射重点实验室 2007 年度学术交流会顺利召开], *Intense Laser and Particle Beam* [强激光与粒子束], 2007, 11, http://www.soolun.net/periodical/cedebce3dece00038da62d13ab6c7fac.html
[2040] "National 863 Program Key Laboratory of Strong Radiation" [国家 863 计划强辐射重点实验室], *UESTC*, 11 October 2010, https://web.archive.org/web/20130206154859/https://www.rd.uestc.edu.cn/content/89
[2041] Huang Hua [黄华] et al., "STUDY ON A L BAND RELATIVISTIC KLYSTRON AMPLIFIER" [L 波段相对论速调管放大器研究[, *High Power Laser and Particle Beams* [强激光与粒子束], 1998, 10(01), https://www.hplpb.com.cn/article/id/3299
Zhao Jianheng [赵剑衡] et al., "FRACTOGRAPHIC ANALYSIS OF ALUMINUM CYLINDRICAL SHELLS DAMAGED BY INNER PRESSURE AND SURFACE LASER IRRADIATION" [激光辐照下充压铝柱壳爆裂断口分析], *High Power Laser and Particle Beams* [强激光与粒子束], 1998, 10(01), https://www.hplpb.com.cn/cn/article/id/3292
[2042] “State Key Labs,” *NWPU*, Accessed 2021, https://en.nwpu.edu.cn/Research1/CentersandInstitutions.htm
[2043] “Key Laboratory of Ultra-high Temperature Structural Composites” [超高温结构复合材料重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=301
“No.023 Key Laboratory pf Ultra-High Temperature Material Composites,” [No.023 超高温结构复合材料重点实验室] *Changzhou Military-Civil Fusion Public Service Platform*, 14 June 2016. http://www.czjmrh.com/content/?1043.html
[2044] “Key Laboratory of Ultra-high Temperature Structural Composites” [超高温结构复合材料重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=301
“Key Laboratory of Ultra-high Temperature Structural Composites” [超高温结构复合材料重点实验室], *Shaanxi Province Industry-University-Research Cooperation Promotion Association* [陕西省产学研合作促进会], 18 December 2018. http://webcache.googleusercontent.com/search?q=cache%3Awww.iura.org.cn%
[2045] “Key Laboratory of Ultra-high Temperature Structural Composites” [超高温结构复合材料重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=301
[2046] “Key Laboratory of Ultra-high Temperature Structural Composites” [超高温结构复合材料重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=301
[2047] “Key Laboratory of Ultra-high Temperature Structural Composites” [超高温结构复合材料重点实验室], *Shaanxi Province Industry-University-Research Cooperation Promotion Association* [陕西省产学研合作促进会], 18 December 2018. http://webcache.googleusercontent.com/search?q=cache%3Awww.iura.org.cn%2FShowArticle.asp%3FID%3D18406&rlz=1C1CHBD_enUS895US895&oq=cache%3Awww.iura.org.cn%2FShowArticle.asp%3FID%3D18406&aqs=chrome..69i57j69i58.1676j0j4&sourceid=chrome&ie=UTF-8

[2048] "Key Laboratory of Ultra-high Temperature Structural Composites" [超高温结构复合材料重点实验室], *Chinese Society for Composite Materials* [中国复合材料学会], 30 September 2019. http://cccm.csfcm.org.cn/show/news_show/27
[2049] "Key Laboratory of Ultra-high Temperature Structural Composites" [超高温结构复合材料重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=301
"A leap of ten years in "carbon" and a triumph of "stop" at the point" [精"碳"一跃十年过 点到即"止"奏凯歌], *kkNews*, 16 January 2017. https://kknews.cc/news/p4a5ao2.html
"Braking Liu Haiping: Building a world-class Chinese brand of aviation brake materials" [制动刘海平：打造世界级的航空刹车材料中国品牌], *kkNews*, 11 June 2018. https://kknews.cc/finance/j4z9jol.html
[2050] "Key Laboratory of Ultra-high Temperature Structural Composites" [超高温结构复合材料重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=301
[2051] "Key Laboratory of Ultra-high Temperature Structural Composites" [超高温结构复合材料重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=301
[2052] "Key Laboratory of Ultra-high Temperature Structural Composites" [超高温结构复合材料重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=301
[2053] "Key Laboratory of Ultra-high Temperature Structural Composites" [超高温结构复合材料重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=301
[2054] "Prof. Laifei Cheng's team "explores" new laminar ceramic materials" [成来飞教授团队"探秘"新型层状陶瓷材料], *ECORR* [国家材料环境腐蚀平台], 12 September 2016. http://www.ecorr.org/dhTJDAOHANG/cjzl/yejiedongtai/2016-09-12/121135.html
[2055] "Professor Cheng Laifei of NWPU: The application extension of ceramic matrix composites is an inevitable trend" [西工大成来飞教授：陶瓷基复合材料的应用延伸是必然趋势], *Xi'an Software Park*, 17 September 2020. www.xasoftpark.com/info/1008/8445.htm
[2056] "No.023 Key Laboratory pf Ultra-High Temperature Material Composites," [No.023 超高温结构复合材料重点实验室] Changzhou Military-Civil Fusion Public Service Platform, 14 June 2016. http://www.czjmrh.com/content/?1043.html
[2057] "Li Hejun: A new academician who has done great work on carbon/carbon composites" [李贺军：研究碳/碳复合材料功夫到家的新科院士], *Science Net* [科学网], 24 November 2019. http://news.sciencenet.cn/htmlnews/2019/11/433042.shtm
[2058] "Five academicians in the field of ceramic matrix composites research" [陶瓷基复合材料研究领域的 5 位院士], *Sohu*, 20 December 2020. https://www.sohu.com/a/439370250_99919252
"Remembering Academician Zhang Litong, the First Prize Winner of National Technical Invention" [记国家技术发明一等奖获得者张立同院士], *Sohu*, 2 April 2005. http://news.sohu.com/20050402/n224984057.shtml
[2059] Prof. Laifei Cheng's team "explores" new laminar ceramic materials" [成来飞教授团队"探秘"新型层状陶瓷材料], *ECORR* [国家材料环境腐蚀平台], 12 September 2016.
[2060] "Hidden investment big brother Yan Jianya, and then "order" to be listed companies" [隐藏投资大佬严建亚，再"下单"拟上市公司], *nbd.com.cn*, Accessed April 2025, http://www.nbd.com.cn/rss/toutiao/articles/2668618.html
[2061] "No.023 Key Laboratory pf Ultra-High Temperature Material Composites," [No.023 超高温结构复合材料重点实验室] Changzhou Military-Civil Fusion Public Service Platform, 14 June 2016. http://www.czjmrh.com/content/?1043.html
[2062] "Key Laboratory of Ultra-high Temperature Structural Composites" [超高温结构复合材料重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=301
[2063] "Key Laboratory of Ultra-high Temperature Structural Composites" [超高温结构复合材料重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=301
[2064] "Introduction" [简介], Science and Technology on Surface Physics and Chemistry Laboratory [表面物理与化学国家重点实验室], 24 October 2022, http://www.spc-lab.cn/doc/2022/10/24/3450.shtml
[2065] "Wusheng: Harnessing nuclear power for martial arts, stopping the war for victory" [武胜：驭核为武 止戈为胜], *ScienceNet*, 4 January 2019, https://news.sciencenet.cn/sbhtmlnews/2019/1/342395.shtm

[2066] "Introduction" [简介], *Science and Technology on Surface Physics and Chemistry Laboratory* [表面物理与化学国家重点实验室], 24 October 2022, http://www.spc-lab.cn/doc/2022/10/24/3450.shtml
[2067] "Wusheng: Harnessing nuclear power for martial arts, stopping the war for victory" [武胜：驭核为武 止戈为胜], *ScienceNet*, 4 January 2019, https://news.sciencenet.cn/sbhtmlnews/2019/1/342395.shtm
[2068] "Our academy hosts the energy engineering academic exchange meeting of China Corrosion and Protection Society" [我院承办中国腐蚀与防护学会能源工程学术交流会], *Chinese Academy of Engineering Physics*, 23 September 2014, https://www.caep.cn/doc/2020/01/06/285.shtm
"Introduction" [简介], Science and Technology on Surface Physics and Chemistry Laboratory [表面物理与化学国家重点实验室], 24 October 2022, http://www.spc-lab.cn/doc/2022/10/24/3450.shtml
[2069] "Introduction" [简介], *Science and Technology on Surface Physics and Chemistry Laboratory* [表面物理与化学国家重点实验室], 24 October 2022, http://www.spc-lab.cn/doc/2022/10/24/3450.shtml
[2070] "Wusheng: Harnessing nuclear power for martial arts, stopping the war for victory" [武胜：驭核为武 止戈为胜], *ScienceNet*, 4 January 2019, https://news.sciencenet.cn/sbhtmlnews/2019/1/342395.shtm
[2071] "School of Materials "Excellence in Employment, Famous Enterprises" Social Practice Team in Sichuan visited the Institute of Materials Research of China Academy of Engineering Physics" [材料学院"卓越就业 名企之行"四川行社会实践队赴中国工程物理研究院材料研究所参观调研], *Northwestern Polytechnical University*, 14 August 2018, https://news.nwpu.edu.cn/info/1003/57935.htm
[2072] "Lab Organizational Structure" [重点实验室组织结构], *Science and Technology on Surface Physics and Chemistry Laboratory* [表面物理与化学国家重点实验室], 24 October 2022, http://www.spc-lab.cn/doc/2022/10/24/3464.shtml
[2073] "Introduction" [简介], *Science and Technology on Surface Physics and Chemistry Laboratory* [表面物理与化学国家重点实验室], 24 October 2022, http://www.spc-lab.cn/doc/2022/10/24/3450.shtml
[2074] "Introduction" [简介], *Science and Technology on Surface Physics and Chemistry Laboratory* [表面物理与化学国家重点实验室], 24 October 2022, http://www.spc-lab.cn/doc/2022/10/24/3450.shtml
[2075] "Research on the properties and environmental compatibility of actinide materials" [锕系材料特性与环境相容性研究], *Science and Technology on Surface Physics and Chemistry Laboratory* [表面物理与化学国家重点实验室], 24 October 2022, http://www.spc-lab.cn/doc/2022/10/27/3483.shtml
[2076] "Research Team on Hydrogen Isotopes and Compatibility of Helium with Materials" [氢同位素及氦与材料的相容性研究团队], *Science and Technology on Surface Physics and Chemistry Laboratory* [表面物理与化学国家重点实验室], 24 October 2022, http://www.spc-lab.cn/doc/2022/10/27/3484.shtml
[2077] "Compatibility between actinides and other materials Research Team" [锕系材料与其他材料相容性研究团队], *Science and Technology on Surface Physics and Chemistry Laboratory* [表面物理与化学国家重点实验室], 24 October 2022, http://www.spc-lab.cn/doc/2022/10/27/3485.shtml
[2078] "Actinide and related material surface modification research team" [锕系材料及相关材料表面改性研究团队], *Science and Technology on Surface Physics and Chemistry Laboratory* [表面物理与化学国家重点实验室], 24 October 2022, http://www.spc-lab.cn/doc/2022/10/27/3486.shtml
[2079] "Application of Numerical Simulation in Actinide Compatibility Studies Research Team" [数值模拟在锕系材料相容性研究中的应用研究团队], *Science and Technology on Surface Physics and Chemistry Laboratory* [表面物理与化学国家重点实验室], 24 October 2022, http://www.spc-lab.cn/doc/2022/10/27/3487.shtml
[2080] "Introduction" [简介], *Science and Technology on Surface Physics and Chemistry Laboratory* [表面物理与化学国家重点实验室], 24 October 2022, http://www.spc-lab.cn/doc/2022/10/24/3450.shtml
[2081] Zhang Pengcheng [张鹏程] et al., "Frictional wear characterization of plasma sprayed metal coatings on 1Cr17Ni4 stainless steel" [1Cr17Ni4 不锈钢等离子体喷涂金属涂层的摩擦磨损特性研究], *Nuclear Power Engineering* [核动力工程], 2005,26(1), https://d.wanfangdata.com.cn/periodical/ChlQZXJpb2RpY2FsQ0hJTmV3UzIwMjMxMjI2Eg5oZGxnYzIwMDUwMTAxNhoIMjhmbHg2ZXk%3D

[2082] Yin Yihui [尹益辉] et al., "Analysis of tritium permeation in spherical pressure vessels for tritium storage" [储氚球形压力容器中氚的渗透分析], *Scientia Sinica Technologica* [中国科学：技术科学], 2016,46(10), https://cytsk.zwu.edu.cn:8080/asset/detail.aspx?id=203208695252
[2083] "Zhang Jian" [张建], *x-mol*, Accessed June 2024, https://www.x-mol.com/university/faculty/23059
[2084] "Lab Leaders" [实验室领导], *Science and Technology on Surface Physics and Chemistry Laboratory* [表面物理与化学国家重点实验室], 24 October 2022, http://www.spc-lab.cn/jgsz/sysld/index.shtml
[2085] "National actinide physics and chemistry academic experts and scholars gathered in Baotou to discuss the progress of actinide scientific research and future development direction Opportunity" [全国锕系物理与化学学术专家学者齐聚包头研讨锕系科学研究进展与未来发展方向 机会], *Department of Science and Technology of Inner Mongolia Autonomous Region*, 24 July 2018, http://kjt.nmg.gov.cn/slb/kjdt/kjtgz/201807/t20180724_1408264.html
[2086] "Lab Leaders" [实验室领导], *Science and Technology on Surface Physics and Chemistry Laboratory* [表面物理与化学国家重点实验室], 24 October 2022, http://www.spc-lab.cn/jgsz/sysld/index.shtml
[2087] "The First Doctoral Party Branch of Light Alloy in School of Materials went to the Institute of Materials Research of China Academy of Engineering Physics to carry out the "Walking Together Program" summer social practice activities" [材料学院轻合金第一博士生党支部赴中国工程物理研究院材料研究所开展"共行计划"暑期社会实践活动], *Shanghai Jiao Tong University*, 20 June 2023, https://smse.sjtu.edu.cn/post/detail/4301
[2088] "Lab Leaders" [实验室领导], *Science and Technology on Surface Physics and Chemistry Laboratory* [表面物理与化学国家重点实验室], 24 October 2022, http://www.spc-lab.cn/jgsz/sysld/index.shtml
[2089] "Key Lab Academic Committee" [重点实验室学术委员会], *Science and Technology on Surface Physics and Chemistry Laboratory* [表面物理与化学国家重点实验室], 24 October 2022, http://www.spc-lab.cn/doc/2022/10/24/3473.shtml
[2090] "Key Lab Academic Committee" [重点实验室学术委员会], *Science and Technology on Surface Physics and Chemistry Laboratory* [表面物理与化学国家重点实验室], 24 October 2022, http://www.spc-lab.cn/doc/2022/10/24/3473.shtml
[2091] "Hao Daqiao" [蒙大桥], *Science and Technology on Surface Physics and Chemistry Laboratory* [表面物理与化学国家重点实验室], 24 October 2022, http://www.spc-lab.cn/doc/2022/10/24/3475.shtml
[2092] "Key Lab Academic Committee" [重点实验室学术委员会], *Science and Technology on Surface Physics and Chemistry Laboratory* [表面物理与化学国家重点实验室], 24 October 2022, http://www.spc-lab.cn/doc/2022/10/24/3473.shtml
[2093] "Key Lab Academic Committee" [重点实验室学术委员会*], Science and Technology on Surface Physics and Chemistry Laboratory* [表面物理与化学国家重点实验室], 24 October 2022, http://www.spc-lab.cn/doc/2022/10/24/3473.shtml
[2094] "The First Doctoral Party Branch of Light Alloy in School of Materials went to the Institute of Materials Research of China Academy of Engineering Physics to carry out the "Walking Together Program" summer social practice activities" [材料学院轻合金第一博士生党支部赴中国工程物理研究院材料研究所开展"共行计划"暑期社会实践活动], *Shanghai Jiao Tong University*, 20 June 2023, https://smse.sjtu.edu.cn/post/detail/4301
[2095] "Our sales engineer Hu Wei visited China Academy of Engineering Physics, Key Laboratory of Surface Physics and Chemistry" [我司销售工程师胡伟走访中国工程物理研究院、表面物理与化学重点实验室], *ScrollTec*, 16 December 2019, http://www.scrolltec.com/news/news_406.html
[2096] "National actinide physics and chemistry academic experts and scholars gathered in Baotou to discuss the progress of actinide scientific research and future development direction Opportunity" [全国锕系物理与化学学术专家学者齐聚包头研讨锕系科学研究进展与未来发展方向 机会], *Department of Science and Technology of Inner Mongolia Autonomous Region*, 24 July 2018, http://kjt.nmg.gov.cn/slb/kjdt/kjtgz/201807/t20180724_1408264.html
[2097] "The Third Bilateral Exchange Meeting of the Key Laboratory of Surface Physics and Chemistry and the Key Laboratory of Material Modification of Three Beams was held in our university" [表面物理与化学重点实验室-三束材料改性重点实验室第三届双边交流会在我校召开], *Dalian University of Technology*, 24 October 2018, http://physics.dlut.edu.cn/info/1014/4485.htm

[2098] "Mr. Lai Xinchun, Director of Institute of Materials Research, China Academy of Engineering Physics, and his delegation visited the Department of Physics" [中国工程物理研究院材料研究所赖新春所长一行访问物理系], *Tsinghua University*, 13 November 2014, https://www.phys.tsinghua.edu.cn/info/1071/1509.htm
[2099] "Learning and Researching Masters, Touring Sichuan to Know the New--Northwestern Polytechnical University Queen Mary University of London School of Engineering Carries Out Winter Vacation Social Practice" [学研总师，川游知新——西北工业大学伦敦玛丽女王大学工程学院开展寒假社会实践], *Northwestern Polytechnical University*, 7 February 2024, https://youth.nwpu.edu.cn/info/1132/15051.htm
[2100] "Li Xiaona" [李晓娜 ], *Dalian University of Technology*, Accessed June 2024, http://faculty.dlut.edu.cn/1997011007/zh_CN/yjgk/754693/list/index.htm
[2101] "The 7th International Conference on Surface Engineering, the 11th National Conference on Surface Engineering and the 8th National Youth Academic Conference on Surface Engineering Opened in Chengdu" [第七届表面工程国际会议、第十一届全国表面工程大会暨第八届全国青年表面工程学术会议在成都开幕], *Chinese Mechanical Engineering Society*, 26 October 2016, https://www.cmes.org/dynamic/95991f23e9c54ad8a84c209b240a17de.html
[2102] "2017 Chinese Society of Mass Spectrometry Inorganic and Isotope Mass Spectrometry Conference Opens in Chengdu" [2017 年中国质谱学会无机及同位素质谱学术会议成都开幕], *Sohu*, 19 August 2017, https://www.sohu.com/a/165880673_243686
[2103] "Introduction" [简介], *Science and Technology on Surface Physics and Chemistry Laboratory* [表面物理与化学国家重点实验室], 24 October 2022, http://www.spc-lab.cn/doc/2022/10/24/3450.shtml
[2104] "School of Materials "New Journey to the Faraway Place"-Sichuan Tour Social Practice Team visited and researched at the Institute of Materials Research of China Academy of Engineering Physics" [材料学院"新征程 向远方"——四川行社会实践队赴中国工程物理研究院材料研究所参观调研], *Northwestern Polytechnical University*, 17 July 2019, https://news.nwpu.edu.cn/info/1003/64387.htm
[2105] Yin Yihui [尹益辉] et al., "Analysis of tritium permeation in spherical pressure vessels for tritium storage" [储氚球形压力容器中氚的渗透分析], *Scientia Sinica Technologica* [中国科学：技术科学], 2016,46(10), https://cytsk.zwu.edu.cn:8080/asset/detail.aspx?id=203208695252
[2106] Xiao Zhihe [肖志河], Zhang Xiangyang [张向阳], and Zhou Ping [周平], "Key Laboratory of National Defense Science and Technology for Target and Environment Electromagnetic Scattering and Radiation--To refine the eyes of modern weapons and equipments" [目标与环境电磁散射辐射国防科技重点实验室——为现代武器装备锤炼火眼金睛], *Defence Science & Technology Industry*, 2007, https://www.aminer.org/pub/53e9ca31b7602d9704ede024
[2107] "The Second Research Institute of China Aerospace Science and Industry Corporation" [中国航天科工集团第二研究院简介], *Kaoyan.com*, 22 April 2014, https://yz.kaoyan.com/casicedu/jianjie/
[2108] "China Changfeng Mechanics and Electronics Technology Academy", *NTI*, Accessed August 2021. https://www.nti.org/learn/facilities/65/
[2109] "Introduction to the 207th RI" [ 二○七所简介], *Peking University*, 13 March 2019, https://scc.pku.edu.cn/employment_ff808081694d0a5e01697521523d1c5c_1.html
[2110] It uses both names when describing the five DSTKLs of the 2nd Academy. See:
"Introduction to CASIC 2nd Academy" [中国航天科工二院简介], *CE.cn*, 14 October 2014
"Introduction to CASIC 2nd Academy" [中国航天科工集团第二研究院简介], *Kaoyan*, 22 April 2014, https://yz.kaoyan.com/casicedu/jianjie/
[2111] Jiang Wenting [蒋文亭] et al., "Summary of Key Technologies of Scale Model Measurement of RCS" [目标雷达散射截面缩比测量关键技术概述], *Journal of Information Engineering University* [信息工程大学学报], 2013, 14, http://www.edatop.com/down/paper/rcs/%E9%9B%B7%E8%BE%BE%E6%95%A3%E5%B0%84%E6%88%AA%E9%9D%A2-RCS-zjukkjmyo0i.pdf
[2112] "Introduction to BIT PhD" [北京理工大学博士生导师简介], *Youqing Documents* [友情文档王], Accessed August 2021. http://webcache.googleusercontent.com/search?q=cache%3Awww.oiuq.com%2Fdoc%2F4eb0dbc00c22590102029d

b1.html&rlz=1C1CHBD_enUS949US949&oq=cache%3Awww.oiuq.com%2Fdoc%2F4eb0dbc00c22590102029db1.html&aqs=chrome..69i57j69i58.1197j0j4&sourceid=chrome&ie=UTF-8

[2113] "CHINA CHANGFENG MECHANICS AND ELECTRONICS TECHNOLOGY ACADEMY," *NTI*, Accessed August 2021, https://www.nti.org/learn/facilities/65/

[2114] "Introduction to 207th RI" [二○七所简介], *Peking University*, 13 March 2019, https://scc.pku.edu.cn/employment_ff808081694d0a5e01697521523d1c5c_1.html

[2115] Yang Lei [杨磊] et al., "REAL-TIME METHOD FOR DETECTING MULTI-SMALL TARGETS IN INFRARED LARGE SIGHT FIELD," [一种红外大视场环境下的多小目标实时检测方法], *Journal of Infrared and Millimeter Waves* [红外与毫米波学报], 2006, 25, http://journal.sitp.ac.cn/hwyhmb/hwyhmbcn/ch/reader/view_abstract.aspx?journal_id=hwyhmbcn&file_no=20060597&html_url=hwyhmbcn/article/html/20060597

[2116] Zhu Zhenfu [朱振福] et al., "A Kind of Method for Ir Small Target Recognition Based nn Multi-Sensors Spatio-Temporal Information Fusion," [一种基于多传感器时间-空间信息融合的红外小目标识别方法], *Journal of Infrared and Millimeter Waves*, 2002, 21, http://ksuxk.cqvip.com/asset/detail/0/20395617482

[2117] Jiang Wenting [蒋文亭] et al., "Summary of Key Technologies of Scale Model Measurement of RCS" [目标雷达散射截面缩比测量关键技术概述], *Journal of Information Engineering University* [信息工程大学学报], 2013, 14, http://www.edatop.com/down/paper/rcs/%E9%9B%B7%E8%BE%BE%E6%95%A3%E5%B0%84%E6%88%AA%E9%9D%A2-RCS-zjukkjmyo0i.pdf

[2118] Zhu Zhenfu et al., "Development status and prospect of optical precision guidance technology," *Infrared and Laser Engineering*, 2007, 36, https://m.ishare.iask.sina.com.cn/f/GOiBaVCTz.html

[2119] Zhu Zhenfu [朱振福] et al., "A KIND OF METHOD FOR IR SMALL TARGET RECOGNITION BASED ON MULTI-SENSORS SPATIO-TEMPORAL INFORMATION FUSION," [一种基于多传感器时间-空间信息融合的红外小目标识别方法], *Journal of Infrared and Millimeter Waves*, 2002, 21, http://ksuxk.cqvip.com/asset/detail/0/20395617482

"Introduction to BIT PhD" [北京理工大学博士生导师简介], *Youqing Documents* [友情文档王], Accessed August 2021. http://webcache.googleusercontent.com/search?q=cache%3Awww.oiuq.com%2Fdoc%2F4eb0dbc00c22590102029db1.html&rlz=1C1CHBD_enUS949US949&oq=cache%3Awww.oiuq.com%2Fdoc%2F4eb0dbc00c22590102029db1.html&aqs=chrome..69i57j69i58.1197j0j4&sourceid=chrome&ie=UTF-8

[2120] Zhu Zhenfu [朱振福] et al., "A KIND OF METHOD FOR IR SMALL TARGET RECOGNITION BASED ON MULTI-SENSORS SPATIO-TEMPORAL INFORMATION FUSION," [一种基于多传感器时间-空间信息融合的红外小目标识别方法], *Journal of Infrared and Millimeter Waves*, 2002, 21, http://ksuxk.cqvip.com/asset/detail/0/20395617482

[2121] Wang Ningming [王宁明], Zhu Zhenfu [朱振福], "A stable and reliable electronic image stabilization method" [一种稳定可靠的电子稳像方法], *wf.pub*, 1 August 2008. https://wf.pub/conference/article:6473443

[2122] Yang Lei [杨磊] et al., "REAL-TIME METHOD FOR DETECTING MULTI-SMALL TARGETS IN INFRARED LARGE SIGHT FIELD," [一种红外大视场环境下的多小目标实时检测方法], *Journal of Infrared and Millimeter Waves* [红外与毫米波学报], 2006, 25, http://journal.sitp.ac.cn/hwyhmb/hwyhmbcn/ch/reader/view_abstract.aspx?journal_id=hwyhmbcn&file_no=20060597&html_url=hwyhmbcn/article/html/20060597

[2123] "Shandong No.1 Medical University transformed a project result into 204 million RMB" [高才内参丨山东第一医科大学一项目成果转化 2.04 亿元], *Netease*, 9 July 2024, https://www.163.com/dy/article/J6M1O7R405562P4Q.html

[2124] "The reform and development of the "old military industry" gained momentum" ["老军工"改革发展势头猛], *CN Stock* [中国证券网], 9 August 2016, https://news.cnstock.com/news,zxk-201608-3866800.htm

[2125] "The University and the Key Laboratory of National Defense Science and Technology for Transient Shock Technology Signed a Strategic Cooperation Agreement" [我校与瞬态冲击技术国防科技重点实验室签署战略合作协议], *Hunan University of Science and Technology*, 5 July 2018, https://science.hnust.edu.cn/kyyw/zkyw/74d3e74435fa49529489b2d7b45e7b9f.htm

[2126] "Shandong No.1 Medical University transformed a project result into 204 million RMB" [高才内参丨山东第一医科大学一项目成果转化 2.04 亿元], *Netease*, 9 July 2024, https://www.163.com/dy/article/J6M1O7R405562P4Q.html
[2127] "The 2023 Campus Recruitment of China National Institute of Hydrocarbons (CNIH 208) Officially Launched" [中国兵器 208 所 2023 届校园招聘正式启动], *SASAC*, 23 September 2022, http://www.sasac.gov.cn/n2588035/n2588325/n2588350/c26071317/content.html
"The Key Laboratory of Transient Impact Technology of 208 Research Institute came to our institute to give a lecture on the enrollment of graduate students for joint cultivation" [二零八研究所瞬态冲击技术重点实验室来我院进行联合培养研究生招生宣讲会], *North University of China*, 17 May 2023, https://www.jdgc.nuc.edu.cn/info/1012/13676.htm
[2128] Wang Junjie [王俊杰], *X-Mol*, Accessed January 2024, https://www.x-mol.com/university/faculty/137361
[2129] Bao Kuo [包阔] et al., "Ballistic test and numerical simulation on penetration of a boron-carbide-ceramic composite target by a bullet" [子弹撞击碳化硼陶瓷复合靶试验与数值模拟研究], *Explosion and Shockwaves* [爆炸与冲击], 2019, 12, http://cnki.hcnu.edu.cn/KCMS/detail/detail.aspx?filename=BZCJ201912006&dbcode=CJFQ&dbname=CJFD2019
[2130] Zheng Hao [ 郑浩] et al., "Blunt Injury Assessment Based on Dynamic Back Face Deformation of Body Armor," [基于防弹衣背面动态变形的钝击伤评估], *Journal of Ordnance Equipment Engineering*, 2021, 6, http://110.185.172.89:8777/KCMS/detail/detail.aspx?filename=CUXI202106023&dbcode=CJFD&dbname=CJFD2021
[2131] "Wang Shu, Director of National Defense Science and Technology Key Laboratory of Transient Impact Technology, and his delegation came to the university for research and exchange" [瞬态冲击技术国防科技重点实验室主任王舒一行来校调研交流], *Nanjing University of Science and Technology*, 24 January 2019, https://sme.njust.edu.cn/e1/95/c1579a188821/page.psp
[2132] Zheng Hao [ 郑浩] et al., "Blunt Injury Assessment Based on Dynamic Back Face Deformation of Body Armor," [基于防弹衣背面动态变形的钝击伤评估], *Journal of Ordnance Equipment Engineering*, 2021, 6, http://110.185.172.89:8777/KCMS/detail/detail.aspx?filename=CUXI202106023&dbcode=CJFD&dbname=CJFD2021
[2133] Li Zichao [李梓超;] et al., "Static and Dynamic Combustion Performance of 4-Perforated Gun Propellants" [四孔发射药的静态和动态燃烧性能研究], *China Open Access Archive, Chinese Journal of Explosives and Propellants*, 2022, 45(5), https://coaa.istic.ac.cn/openJournal/periodicalArticle/0120221101791874
[2134] "List of Accepted Manuscripts for the Proceedings of the 2015 National Symposium on Trauma Assessment Techniques" ["2015 全国毁伤评估技术学术研讨会"论文集录用稿件列表], *Acta Armamentarii*, Accessed January 2024, http://www.co-journal.com/CN/news/news7.shtml
[2135] "Notice of FY2023 Open Fund Project Submission for the Key Laboratory of Transient Shock Technology" [瞬态冲击技术重点实验室 2023 年度开放基金课题申报通知], *Weixin*, 7 November 2023, https://mp.weixin.qq.com/s/5UauCs42mK9AfjEFMVYHEQ
[2136] "Wang Shu, Director of National Defense Science and Technology Key Laboratory of Transient Impact Technology, and his delegation came to the university for research and exchange" [瞬态冲击技术国防科技重点实验室主任王舒一行来校调研交流], *Nanjing University of Science and Technology*, 24 January 2019, https://sme.njust.edu.cn/e1/95/c1579a188821/page.psp
[2137] "BIT and Key Laboratory of National Defense Science and Technology for Transient Impact Technology Sign Strategic Cooperation Agreement" [北理工与瞬态冲击技术国防科技重点实验室签署战略合作协议*], Beijing Institute of Technology*, 19 July 2017, cache:https://www.bit.edu.cn/xww/zhxw/a143101.htm
[2138] "BIT and Key Laboratory of National Defense Science and Technology for Transient Impact Technology Sign Strategic Cooperation Agreement" [北理工与瞬态冲击技术国防科技重点实验室签署战略合作协议], *Beijing Institute of Technology*, 19 July 2017, cache:https://www.bit.edu.cn/xww/zhxw/a143101.htm
[2139] "The Key Laboratory of Transient Impact Technology of 208 Research Institute came to our institute to give a lecture on the enrollment of graduate students for joint cultivation" [二零八研究所瞬态冲击技术重点实验室来我院进行联合培养研究生招生宣讲会], *North University of China*, 17 May 2023, cache:https://jdgc.nuc.edu.cn/info/1012/13676.htm

[2140] "The Key Laboratory of Transient Impact Technology of 208 Research Institute came to our institute to give a lecture on the enrollment of graduate students for joint cultivation" [二零八研究所瞬态冲击技术重点实验室来我院进行联合培养研究生招生宣讲会], *North University of China*, 17 May 2023, cache:https://jdgc.nuc.edu.cn/info/1012/13676.htm

[2141] "Wang Shu, Director of National Defense Science and Technology Key Laboratory of Transient Impact Technology, and his delegation came to the university for research and exchange" [瞬态冲击技术国防科技重点实验室主任王舒一行来校调研交流], *Nanjing University of Science and Technology*, 24 January 2019, https://sme.njust.edu.cn/e1/95/c1579a188821/page.psp

[2142] "BIT and Key Laboratory of National Defense Science and Technology for Transient Impact Technology Sign Strategic Cooperation Agreement" [北理工与瞬态冲击技术国防科技重点实验室签署战略合作协议], *Beijing Institute of Technology*, 19 July 2017, https://www.bit.edu.cn/xww/zhxw/a143101.htm

[2143] "The University and the Key Laboratory of National Defense Science and Technology for Transient Shock Technology Signed a Strategic Cooperation Agreement" [我校与瞬态冲击技术国防科技重点实验室签署战略合作协议], *Hunan University of Science and Technology*, 5 July 2018, https://science.hnust.edu.cn/kyyw/zkyw/74d3e74435fa49529489b2d7b45e7b9f.htm

[2144] "School of Civil Engineering and Transportation Successfully Hosts "2019 National Forum on Frontiers of Impact Dynamics"" [土木与交通学院成功承办"2019 年全国冲击动力学前沿论坛"], *South China University of Technology*, 19 December 2019, https://www2.scut.edu.cn/sklsbs/2019/1219/c15567a358953/page.htm

[2145] "The 10th National Academic Conference on Strong Dynamic Load Effects and Protection and Symposium of Innovative Research Groups on Dynamic Mechanical Behavior of Complex Media/Structures Successfully Held in Beijing" [第十届全国强动载效应及防护学术会议暨复杂介质/结构的动态力学行为创新研究群体学术研讨会在京顺利召开], *Free Kaoyan*, 18 April 2020, http://school.freekaoyan.com/bj/bit/dongtai/2020/04-18/15872035881096777.shtml

[2146] "2nd Acta Armamentarii Forum" [第二届兵工学报论坛], *Acta Amamentarii*, 23 February 2022, http://www.co-journal.com/attached/file/20220223/20220223142632_212.pdf

[2147] "Notice of FY2023 Open Fund Project Submission for the Key Laboratory of Transient Shock Technology" [瞬态冲击技术重点实验室 2023 年度开放基金课题申报通知], *Weixin*, 7 November 2023, https://mp.weixin.qq.com/s/5UauCs42mK9AfjEFMVYHEQ

[2148] "Defense S&T Key Lab of Tunable (Gas) Laser" [可调谐(气体)激光国防科技重点实验室], *Optics Journal*, Accessed 2021, http://www.opticsjournal.net/Lab/STTL.htm?action=index

[2149] "Defense S&T Key Lab of Tunable (Gas) Laser" [可调谐(气体)激光国防科技重点实验室], *Optics Journal*, Accessed 2021, http://www.opticsjournal.net/Lab/STTL.htm?action=index
"Harbin Institute of Technology" [哈尔滨工业大学], *Zhongshan Productivity Promotion Center* [中山市生产力促进中心], Accessed 2021, http://www.zsxtcx.com/zone_7891505/lab/14.html
"Harbin Institute of Technology, School of Astronautics, Department of Optoelectronics and Information Science and Technology Recruitment" [哈尔滨工业大学航天学院光电子信息科学与技术系招聘], *ScienceNet* [科学网], 23 September 2013. http://talent.sciencenet.cn/index.php?s=/Info/index/id/4439

[2150] "Defense S&T Key Lab of Tunable (Gas) Laser" [可调谐(气体)激光国防科技重点实验室], *Optics Journal*, Accessed 2021, http://www.opticsjournal.net/Lab/STTL.htm?action=indexl

[2151] "National Lab of Tunable (Gas) Laser" [可调谐（气体）激光技术 国家级重点实验室], *Dr. Technology Cloud* [博士云], Accessed 2021, https://www.ifuhua.com.cn/team/zone/980
"National Lab of Tunable (Gas) Laser: Deep Optical Service to the Country" [可调谐（气体）激光技术国家级重点实验室：深耕光学 服务国家], *Sohu*, 8 November 2017. https://www.sohu.com/a/203289914_739961

[2152] "National Lab of Tunable (Gas) Laser: Deep Optical Service to the Country" [可调谐（气体）激光技术国家级重点实验室：深耕光学 服务国家], *Sohu*, 8 November 2017. https://www.sohu.com/a/203289914_739961

[2153] "China's "MIT" adds a new engine of science and technology, HIT's key laboratory cluster lays foundation" [中国"MIT"再添科技新引擎 哈工大重点实验室集群奠基], *Xianji China* [贤集网], 4 June 2020. https://www.xianjichina.com/special/detail_448248.html

[2154] National Lab of Tunable (Gas) Laser: Deep Optical Service to the Country" [可调谐（气体）激光技术国家级重点实验室：深耕光学 服务国家], *Sohu*, 8 November 2017. https://www.sohu.com/a/203289914_739961

[2155] "Defense S&T Key Lab of Tunable (Gas) Laser" [可调谐(气体)激光国防科技重点实验室], *Optics Journal*, Accessed 2021, http://www.opticsjournal.net/Lab/STTL.htm?action=index
[2156] "Harbin Institute of Technology" [哈尔滨工业大学], *Zhongshan Productivity Promotion Center* [中山市生产力促进中心], Accessed 2021, http://www.zsxtcx.com/zone_7891505/lab/14.html
"National Lab of Tunable (Gas) Laser" [可调谐（气体）激光技术 国家级重点实验室], *Dr. Technology Cloud* [博士云], Accessed 2021, https://www.ifuhua.com.cn/team/zone/980
"National Lab of Tunable (Gas) Laser: Deep Optical Service to the Country" [可调谐（气体）激光技术国家级重点实验室：深耕光学 服务国家], *Sohu*, 8 November 2017. https://www.sohu.com/a/203289914_739961
[2157] "National Lab of Tunable (Gas) Laser: Deep Optical Service to the Country" [可调谐（气体）激光技术国家级重点实验室：深耕光学 服务国家], *Sohu*, 8 November 2017. https://www.sohu.com/a/203289914_739961
[2158] "Defense S&T Key Lab of Tunable (Gas) Laser" [可调谐(气体)激光国防科技重点实验室], *Optics Journal*, Accessed 2021, http://www.opticsjournal.net/Lab/STTL.htm?action=index
[2159] "National Lab of Tunable (Gas) Laser: Deep Optical Service to the Country" [可调谐（气体）激光技术国家级重点实验室：深耕光学 服务国家], *Sohu*, 8 November 2017. https://www.sohu.com/a/203289914_739961
[2160] "National Lab of Tunable (Gas) Laser: Deep Optical Service to the Country" [可调谐（气体）激光技术国家级重点实验室：深耕光学 服务国家], *Sohu*, 8 November 2017. https://www.sohu.com/a/203289914_739961
[2161] "Defense S&T Key Lab of Tunable (Gas) Laser" [可调谐(气体)激光国防科技重点实验室], *Optics Journal*, Accessed 2021, http://www.opticsjournal.net/Lab/STTL.htm?action=index
[2162] "HIT Grad Student Advisor Bio – Chen Deying" [哈尔滨工业大学研究生导师简介-陈德应], *Free Kaoyan*, 31 March 2016. http://school.freekaoyan.com/heilongjiang/hit/daoshi/2016/04-01/1459456782547792.shtml
[2163] "Defense S&T Key Lab of Tunable (Gas) Laser" [可调谐(气体)激光国防科技重点实验室], *Optics Journal*, Accessed 2021, http://www.opticsjournal.net/Lab/STTL.htm?action=index
[2164] "National Lab of Tunable (Gas) Laser: Deep Optical Service to the Country" [可调谐（气体）激光技术国家级重点实验室：深耕光学 服务国家], *Sohu*, 8 November 2017. https://www.sohu.com/a/203289914_739961
[2165] "Joint Technology Innovation Center of Aero-Technology Group-Harbin University was established" [航天集团-哈工大联合技术创新中心成立], *HIT*, 1 December 2008. https://web.archive.org/web/20190517054529/http://news.hit.edu.cn/2008/1201/c1990a49048/page.htm
[2166] "Avantes China visits HIT" [Avantes China 哈工大之行], *Avantes China*, 1 December 2020. http://www.avanteschina.com/News-1303495.html
[2167] "National Lab of Tunable (Gas) Laser: Deep Optical Service to the Country" [可调谐（气体）激光技术国家级重点实验室：深耕光学 服务国家], Sohu, 8 November 2017. https://www.sohu.com/a/203289914_739961
[2168] "State Key Labs," *NWPU*, Accessed 2021, https://en.nwpu.edu.cn/Research1/CentersandInstitutions.htm
[2169] "The First Inaugural Meeting and First Plenary Session of the First Academic Committee of National Key Laboratory of Unmanned Aerial Vehicle Technology was Held" [无人飞行器技术全国重点实验室第一届学术委员会成立大会暨第一次全体会议召开], *Northwestern Polytechnical University*, 9 April 2024, https://www.nwpu.edu.cn/info/1208/82708.htm
[2170] "Defense S&T Key Lab of UAV Special Technology" [无人机特种技术国防科技重点实验室], *Collaborative Innovation Center of Future Aerospace Vehicle* [未来飞行器协同创新中心], Accessed 2021, https://cicav.nwpu.edu.cn/info/1204/2623.htm
"Key Lab of UAV Special Technology" [西北工业大学无人机特种技术重点实验室], *81UAV* [全球无人机网], 4 January 2015. https://www.81uav.cn/uav-news/201501/04/9430.html
"Key Lab of UAV Special Technology" [无人机特种技术重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=360
[2171] "Defense S&T Key Lab of UAV Special Technology" [无人机特种技术国防科技重点实验室], *Collaborative Innovation Center of Future Aerospace Vehicle* [未来飞行器协同创新中心], Accessed 2021, https://cicav.nwpu.edu.cn/info/1204/2623.htm
[2172] "Xi'an ASN Co." [西安爱生技术集团公司], *Shaanxi University of Science and Technology* [陕西科技大学], 6 July 2020. http://jiuye.www.sust.edu.cn/info/1008/20178.htm

"Xi'an ASN Co." [西安爱生技术集团], *YouUAV* [无人机网], Accessed 2021, https://www.youuav.com/shop/2312/index/

[2173] "The First Inaugural Meeting and First Plenary Session of the First Academic Committee of National Key Laboratory of Unmanned Aerial Vehicle Technology was Held" [无人飞行器技术全国重点实验室第一届学术委员会成立大会暨第一次全体会议召开], *Northwestern Polytechnical University*, 9 April 2024, https://www.nwpu.edu.cn/info/1208/82708.htm

[2174] "The First Inaugural Meeting and First Plenary Session of the First Academic Committee of National Key Laboratory of Unmanned Aerial Vehicle Technology was Held" [无人飞行器技术全国重点实验室第一届学术委员会成立大会暨第一次全体会议召开], *Northwestern Polytechnical University*, 9 April 2024, https://www.nwpu.edu.cn/info/1208/82708.htm

[2175] "Key Lab of UAV Special Technology" [西北工业大学无人机特种技术重点实验室], *81UAV* [全球无人机网], 4 January 2015. https://www.81uav.cn/uav-news/201501/04/9430.html

[2176] "NWPU joins hands with Xixian New Area to build the largest drone base in China" [西工大联手西咸新区打造国内最大无人机基地], *ScienceNet* [科学网], 2 April 2016. http://news.sciencenet.cn/htmlnews/2016/4/342100.shtm

[2177] "Key Lab of UAV Special Technology" [西北工业大学无人机特种技术重点实验室], *81UAV* [全球无人机网], 4 January 2015. https://www.81uav.cn/uav-news/201501/04/9430.html

[2178] Key Lab of UAV Special Technology" [无人机特种技术重点实验室], NWPU, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=360

[2179] The "magic couple" of the world of drones" [无人机世界的"神雕侠侣"], *NWPU*, 17 October 2017. https://xyh.nwpu.edu.cn/info/1004/3193.htm

"NWPU drone parade receives inspection" [西工大无人机阅兵式接受检阅], *Edu.cn*, 31 July 2017. https://www.edu.cn/ke_yan_yu_fa_zhan/gao_xiao_cheng_guo/gao_xiao_zi_xun/201707/t20170731_1544446.shtml

[2180] The "magic couple" of the world of drones" [无人机世界的"神雕侠侣"], *NWPU*, 17 October 2017. https://xyh.nwpu.edu.cn/info/1004/3193.htm

"NWPU debuts "5G drone" application scenario to teach remote music lessons to elementary schools" [西工大首秀"5G 无人机"应用场景 给支教小学上远程音乐课], *BLCYW*, 15 July 2019. http://www.blcyw.com/news/h5/VEYzST1TNFQtbURVclB4T21SaWFCQ2FSNmdWMkw=?code=sign

[2181] "Domestic Leader! XNPU develops robot to make kiwifruit pollination and picking worry-free" [国内领先！西工大研发机器人让猕猴桃授粉、采摘不用愁], *iFeng*, 30 May 2024, https://sn.ifeng.com/c/8ZzE8aLJnDD

[2182] "NWPU debuts "5G drone" application scenario to teach remote music lessons to elementary schools" [西工大首秀"5G 无人机"应用场景 给支教小学上远程音乐课], *BLCYW*, 15 July 2019. http://www.blcyw.com/news/h5/VEYzST1TNFQtbURVclB4T21SaWFCQ2FSNmdWMkw=?code=sign

[2183] "Key Lab of UAV Special Technology" [西北工业大学无人机特种技术重点实验室], *81UAV* [全球无人机网], 4 January 2015. https://www.81uav.cn/uav-news/201501/04/9430.html

[2184] "Key Lab of UAV Special Technology" [西北工业大学无人机特种技术重点实验室], *81UAV* [全球无人机网], 4 January 2015. https://www.81uav.cn/uav-news/201501/04/9430.html

"Northwestern Polytechnical University Ningbo Research Institute's Five Innovation Centers Collectively Unveiled, take a look!" [西北工业大学宁波研究院五大创新中心集体亮相，看看他们的"名片"], *Sohu*, 27 August 2020. https://new.qq.com/omn/20200827/20200827A0S3SO00.html

[2185] "Defense S&T Key Lab of UAV Special Technology" [无人机特种技术国防科技重点实验室], *Collaborative Innovation Center of Future Aerospace Vehicle* [未来飞行器协同创新中心], Accessed 2021, https://cicav.nwpu.edu.cn/info/1204/2623.htm

[2186] "Introduction to the Key Lab of UAV Special Technology" [特种无人机技术研究所介绍], *NWPU*, 1 April 2019. https://hangkong.nwpu.edu.cn/info/1278/10079.htm

[2187] "Xi'an Lyncon Control signed a tripartite strategic cooperation agreement with Xi'an University of Technology UAV Special Technology Laboratory and Hubei Sanjiang Aerospace Hongfeng Control Co." [西安羚控与西工大无人机特种技术实验室、湖北三江航天红峰控制有限公司签署三方战略合作协议], *National Military-Civil*

*Fusion Public Service Platform* [国家军民融合公共服务平台], 12 April 2019. http://jmjh.miit.gov.cn/newsInfoWebMessage.action?newsId=12880523&moduleId=1062

[2188] "Call for Papers for the 5th China Air Armament Conference, Air Armament" [第五届中国航空兵器大会征文通知], *Aero Weaponry* [航空兵器], 8 May 2017. http://aeroweaponry.yywkt.com/Articles/Show.aspx?Mid=10081003331562126 3&Id=540

[2189] Homepage, *Dexin Technology*, Accessed April 2025, https://www.sxdxzn.com/

[2190] "2024 4th International Conference on Autonomous Unmanned Systems" [2024 第四届国际自主无人系统大会], *Drone World Congress*, 9 June 2024, http://droneworldcongress.com/zh-CN/NewDetails/83/2

[2191] "2022 International Conference on Autonomous Unmanned Systems (ICAUS 2022)," *Aconf*, Accessed January 2025, https://www.aconf.org/conf_183115.2022_International_Conference_

[2192] Key Lab of UAV Special Technology" [无人机特种技术重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=360

[2193] "Notice on the 2016 (6th) China International Unmanned Aerial Vehicle Systems Conference and Exhibition" [关于举办 2016（第六届）中国国际无人驾驶航空器系统大会暨展览的通知], *Chinese Society of Aeronautics and Astronautics* [中国航空学会], 26 February 2016. http://www.csaa.org.cn/art/2016/2/26/art_410_15123.html

[2194] Key Lab of UAV Special Technology" [无人机特种技术重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=360

[2195] "Key Lab of UAV Special Technology" [西北工业大学无人机特种技术重点实验室], *81UAV* [全球无人机网], 4 January 2015. https://www.81uav.cn/uav-news/201501/04/9430.html

[2196] "State Key Labs," *NWPU*, Accessed 2021, https://en.nwpu.edu.cn/Research1/CentersandInstitutions.htm

[2197] "The 6th Underwater Unmanned Systems Technology Summit and the 2023 Arms Science and Technology Summit successfully held" [第六届水下无人系统技术高峰论坛 暨 2023 年兵器科学与技术高峰论坛成功举办], *Journal of Unmanned Undersea Systems* [水下无人系统学报], 6 December 2023, https://sxwrxtxb.xml-journal.net/news/hangyezixun/7673502f-d7b8-43b6-918b-8fbb9d25cba1.htm

[2198] "Key Lab of Underwater Information Control" [水下信息与控制重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=261

"This university is also involved in the sea! Northwestern Polytechnic University: China's only university with aviation, aerospace and navigation (the three navigations)" [原来这所高校也涉海！西北工业大学:中国唯一拥有航空、航天、航海（三航）的大学], *Sohu*, 5 October2017. https://www.sohu.com/a/196462533_726570

[2199] "Key Laboratory of Torpedo Guidance Technology for National Defense Science and Technology successfully passed the operation assessment and performance evaluation" [鱼雷制导技术国防科技重点实验室顺利通过运行评估和绩效评价], *NWPU*, 3 September 2009. https://news.nwpu.edu.cn/info/1003/41166.htm

"Collection for children! These universities guarantee a golden rice bowl if you test in!" [为孩子收藏！这几所大学，只要考上绝对是金饭碗!], *QQ*, 25 March 2019. https://kuaibao.qq.com/s/20190325A03B0K00?refer=spider

[2200] Addition of Entities to the Entity List, Revision of Entry on the Entity List, and Removal of Entities From the Entity List, *Federal Register*, 22 December 2020. https://www.federalregister.gov/documents/2020/12/22/2020-28031/addition-of-entities-to-the-entity-list-revision-of-entry-on-the-entity-list-and-removal-of-entities

[2201] "705th RI Kunming Branch introduction" [七 0 五研究所昆明分部简介], *China University of Mining and Technology* [中国矿业大学], 21 October 2014. http://safe.cumt.edu.cn/d1/c9/c2839a184777/page.htm

"China's mysterious killing machine debuts, it can sink all incoming enemies!" [我国这款神秘杀器首次亮相，可击沉一切来犯之敌!], *QQ*, Accessed 2021, https://xw.qq.com/cmsid/20181021A1E3OC00

"CSIC 705 key models of underwater weapons successfully developed (pics)" [中船重工 705 所重点型号水下武器研制成功(图)], *Huanqiu*, 15 April 2008. https://mil.huanqiu.com/article/9CaKrnJknqe

[2202] Addition of Entities to the Entity List, Revision of Entry on the Entity List, and Removal of Entities From the Entity List, *Federal Register*, 22 December 2020. https://www.federalregister.gov/documents/2020/12/22/2020-28031/addition-of-entities-to-the-entity-list-revision-of-entry-on-the-entity-list-and-removal-of-entities

[2203] "This university is also involved in the sea! Northwestern Polytechnic University: China's only university with aviation, aerospace and navigation (the three navigations)" [原来这所高校也涉海！西北工业大学:中国唯一拥有航空、航天、航海（三航）的大学], *Sohu*, 5 October 2017. https://www.sohu.com/a/196462533_726570

[2204] "Key Lab of Underwater Information Control" [水下信息与控制重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=261
[2205] "Recruitment Announcement for Unmanned Navigation Technology Research Center, Ningbo Research Institute" [西工大宁波研究院无人航行技术研究中心招聘公告], *China Innovation Alliance of New Materials Industry* [中国新材料产业技术创新平台], 12 February 2023, http://www.chinanmia.com/view-3695.html4
[2206] "Key Laboratory of Torpedo Guidance Technology for National Defense Science and Technology successfully passed the operation assessment and performance evaluation" [鱼雷制导技术国防科技重点实验室顺利通过运行评估和绩效评价], *NWPU*, 3 September 2009. https://news.nwpu.edu.cn/info/1003/41166.htm
"Collection for children! These universities guarantee a golden rice bowl if you test in!" [为孩子收藏！这几所大学，只要考上绝对是金饭碗!], *QQ*, 25 March 2019. https://kuaibao.qq.com/s/20190325A03B0K00?refer=spider
"Underwater guidance technology key laboratory operation assessment and scientific research performance assessment joint meeting was held" [水下制导技术重点实验室运行评估和科研绩效评估联席会召开], *NWPU*, 26 March 2009. https://news.nwpu.edu.cn/info/1003/41922.htm
[2207] "Key Lab of Underwater Information Control" [水下信息与控制重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=261
[2208] "Key Lab of Underwater Information Control" [水下信息与控制重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=261
"No.020 Defense S&T Key Lab of Underwater Information Control" [No.020 水下信息与控制国防科技重点实验室], *Changzhou Military-Civil Fusion Public Service Platform*, 14 June 2016. http://www.czjmrh.com/content/?1008.html
"This university is also involved in the sea! Northwestern Polytechnic University: China's only university with aviation, aerospace and navigation (the three navigations)" [原来这所高校也涉海！西北工业大学:中国唯一拥有航空、航天、航海（三航）的大学], *Sohu*, 5 October 2017. https://www.sohu.com/a/196462533_726570
[2209] "Key Lab of Underwater Information Control" [水下信息与控制重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=261
[2210] "Key Lab of Underwater Information Control" [水下信息与控制重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=261
[2211] "Key Lab of Underwater Information Control" [水下信息与控制重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=261
[2212] "No.020 Defense S&T Key Lab of Underwater Information Control" [No.020 水下信息与控制国防科技重点实验室], *Changzhou Military-Civil Fusion Public Service Platform*, 14 June 2016. http://www.czjmrh.com/content/?1008.html
[2213] "No.020 Defense S&T Key Lab of Underwater Information Control" [No.020 水下信息与控制国防科技重点实验室], *Changzhou Military-Civil Fusion Public Service Platform*, 14 June 2016. http://www.czjmrh.com/content/?1008.html
[2214] "Northwestern Polytechnical University Ningbo Research Institute's Five Innovation Centers Collectively Unveiled, take a look!" [西北工业大学宁波研究院五大创新中心集体亮相，看看他们的"名片"], *Sohu*, 27 August 2020. https://new.qq.com/omn/20200827/20200827A0S3SO00.html
[2215] "The sea is wide, the fish leap, the water strikes three thousand miles" [海阔凭鱼跃 水击三千里], *Ministry of Education* [教育部], 8 February 2018. http://www.moe.gov.cn/jyb_xwfb/xw_zt/moe_357/jyzt_2018n/2018_zt02/zt1802_tdzs/201802/t20180208_327107.html
[2216] "Key Lab of Underwater Information Control" [水下信息与控制重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=261
[2217] "Key Lab of Underwater Information Control" [水下信息与控制重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=261
[2218] NSWC PCD commander honored for underwater vehicle work, *Panama City News Herald*, 28 May 2017. https://www.newsherald.com/news/20170328/nswc-pcd-commander-honored-for-underwater-vehicle-work
[2219] "Key Lab of Underwater Information Control" [水下信息与控制重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=261

"No.020 Defense S&T Key Lab of Underwater Information Control" [No.020 水下信息与控制国防科技重点实验室], *Changzhou Military-Civil Fusion Public Service Platform*, 14 June 2016. http://www.czjmrh.com/content/?1008.html

[2220] "Key Lab of Underwater Information Control" [水下信息与控制重点实验室], *NWPU*, Accessed 2021, http://kypt.nwpu.edu.cn/index.php?c=content&a=show&id=261

[2221] "Book of Programs and Abstracts," *IEEE/OES China Ocean Acoustics Conference*, 14 July 2021, http://www.iccsnt.org/COA2021/UploadFiles_8297/202107/2021071509340213.pdf

[2222] Si Weijiang [司伟建] et al., "Real-Time Estimation of Ultra-Wideband Borda Direction for Conformal Array Antennas" [共形阵列天线超宽频带波达方向实时估计], *Journal of Harbin Engineering University* [哈尔滨工程大学学报], 2014, 7, https://d.wanfangdata.com.cn/periodical/ChlQZXJpb2RpY2FsQ0hJTmV3UzIwMjQwNzA0EhJoZWJnY2R4eGIyMDE0MDcwMjEaCGk4aWc0NjFy

[2223] "[Dalian] China Shipbuilding Industry Corporation 760th Research Institute" [[大连]中国船舶重工集团公司第七六〇研究所], *Yingjiesheng* [应届生], 27 September 2020, http://archiver.yingjiesheng.com/job-004-815-247.html

[2224] Li Yunbo [李云波] et al., "Refraction Effects on Electro-Optical Target Characteristic in Near Sea Surface" [近海面异常折射对光电探测目标特征的影响分析], *Journal of Optics* [光学学报], 2011, 31(4), https://w.opticsjournal.net/Articles/OJ9c0fd90c01a46e7e/Abstract

[2225] Li Lanrui [李兰瑞] etal., "Research Status of Underwater Acoustic Signal Detection and Recognition Technology" [水声信号检测与识别技术研究现状], *Communications Technology* [通信技术], 2020, 12, https://knowledge.coalgeocloud.com/Detail?dbID=22&dbName=MTZJTOTAL&sysID=TXJS202012004

[2226] Lu Junjun [吕俊军] et al., "The Developing Trend and Coping Strategies about High Sensitive Electromagnetic Sensor of the Sea Battlefield" [海战场高灵敏度电磁场传感器研究动向与发展], *Computer Test and Control* [计算机测量与控制], 2015, 23(11), http://www.jsjclykz.com/jsjclykz/article/abstract/201504291235?st=search

[2227] Chen Yunfei [陈云飞] et al., "Statistical feature of underwater target echo highlight" [水中目标回波亮点统计特征研究], *Acta Physica Sinica*, 2013, 62(8), https://wulixb.iphy.ac.cn/article/doi/10.7498/aps.62.084302

[2228] Si Weijiang [司伟建] et al., "Real-Time Estimation of Ultra-Wideband Borda Direction for Conformal Array Antennas" [共形阵列天线超宽频带波达方向实时估计], *Journal of Harbin Engineering University* [哈尔滨工程大学学报], 2014, 7, https://d.wanfangdata.com.cn/periodical/ChlQZXJpb2RpY2FsQ0hJTmV3UzIwMjQwNzA0EhJoZWJnY2R4eGIyMDE0MDcwMjEaCGk4aWc0NjFy

[2229] "Fairy CCTV show style -- remember "fairy" scientist Zhang Qiong" [仙女央视展风采 ——记"仙女"科学家张琼], *Putian Times*, 17 April 2014, http://www.0594xyw.com/news-10502.html

[2230] "Warmly congratulate the underwater unmanned system frontier science and technology forum and the underwater unmanned system journal 30 years of celebration conference successfully held" [热烈祝贺水下无人系统前沿科技论坛 暨《水下无人系统学报》三十年刊庆大会顺利召开], *Journal of Unmanned Undersea Systems* [水下无人系统学报], 7 August 2023, https://sxwrxtxb.xml-journal.net/news/benkandongtai/32cd1159-1826-47e5-9940-f117803b5cc1.htm

[2231] "International Conference on Information Processing in Ocean Science and Technology (ICIPOST) 2022 Conference Announcement" [2022 年海洋科技信息处理国际会议(ICIPOST)会议通知], *Sohu*, 20 June 2022, https://www.sohu.com/a/558933402_726570

[2232] "2023 International Conference on the Frontiers of Ocean Science and Technology (ICFOST)" [2023 年海洋科技前沿国际会议 (ICFOST)], *ICFOST2023*, 13 October 2023, https://icfost.net/ICFOST2023/
Conference organizing committee: https://icfost.net/ICFOST2023/committee.html
Technical Program Committee: https://icfost.net/ICFOST2023/technical.html

[2233] "Book of Programs and Abstracts," *IEEE/OES China Ocean Acoustics Conference*, 14 July 2021, http://www.iccsnt.org/COA2021/UploadFiles_8297/202107/2021071509340213.pdf

[2234] "2021 China International Conference on Ocean Acoustics and Hydroacoustic and Ocean Technology Science and Technology Competition on campus" [2021 年中国海洋声学国际会议暨水声与海洋技术科技竞赛在校举办], *Bingjie101*, 18 July 2021, bingjie101.com/info/1082/3951.htm

[2235] Chen Yunfei [陈云飞] et al., "Statistical feature of underwater target echo highlight" [水中目标回波亮点统计特征研究], *Acta Physica Sinica*, 2013, 62(8), https://wulixb.iphy.ac.cn/article/doi/10.7498/aps.62.084302
[2236] "The Second Meeting of the First Academic Committee of Key Laboratory of Vacuum Technology and Physics for National Defense Science and Technology was held in Beijing" [真空技术与物理国防科技重点实验室第一届学术委员会第二次会议在北京召开], *Lanzhou Institute of Physics*, 15 October 2015, http://www.lipcast.cn/articles/2016/08/30/article_10161_13760_1.html
"Key Laboratory Condition Construction Project of 510 Institute of the Fifth Academy of CASC" [航天科技五院510所重点实验室条件建设项目通过验收], *CASC*, 19 June 2023, https://www.spacechina.com/n25/n1991299/n1991333/c3835279/content.html
[2237] "Advanced Materials of the Party Branch of Key Laboratory of Vacuum and Cryogenic Technology and Physics, 51O Research Institute, Fifth Academy of China Aerospace Science and Technology Corporation (CASC)" [中国航天科技集团公司五院五一O研究所真空低温技术与物理重点实验室党支部先进事迹材料], *CCP Members Online* [共产党员网], Accessed June 2024, https://dianxing.12371.cn/2014/03/18/TPPO1395113552871333.shtml
[2238] "The Second Meeting of the First Academic Committee of Key Laboratory of Vacuum Technology and Physics for National Defense Science and Technology was held in Beijing" [真空技术与物理国防科技重点实验室第一届学术委员会第二次会议在北京召开], *Lanzhou Institute of Physics*, 15 October 2015, http://www.lipcast.cn/articles/2016/08/30/article_10161_13760_1.html
[2239] "Five hundred and ten vacuum cryogenic key laboratory fund topics successfully passed the acceptance" [五一〇所真空低温重点实验室基金课题顺利通过验收], *Lanzhou Institute of Physics*, 16 August 2007, http://www.lipcast.cn/articles/2007/08/16/article_10066_12941_1.html
[2240] "Vacuum cryogenic technology and physics key laboratory to expand and improve the project signed technical cooperation" [真空低温技术与物理重点实验室拓展提高项目签署技术合], *Lanzhou Institute of Physics*, 18 May 2011, http://www.lipcast.cn/articles/2014/08/04/article_10066_13612_1.html
[2241] "Key Laboratory Condition Construction Project of 510 Institute of the Fifth Academy of CASC" [航天科技五院510所重点实验室条件建设项目通过验收], *CASC*, 19 June 2023, https://www.spacechina.com/n25/n1991299/n1991333/c3835279/content.html
[2242] "Introduction" [本所简介], *Lanzhou Institute of Physics*, Accessed June 2024, http://www.lipcast.cn/channels/channel_10074_1.html
"Lanzhou Institute of Physics" [兰州空间技术物理研究所], *Beidou.org*, Accessed June 2024, https://www.beidou.org/exhibitordetail_256.html
[2243] "The 510th Research Institute of the Fifth Research Institute of China Aerospace Science and Technology Corporation (CASC)" [中国航天科技集团公司第五研究院第五一〇研究所], *Gansu Industry Polytechnic College*, 28 June 2018, https://gfzj.gipc.edu.cn/info/1127/1158.htm
[2244] "China Aerospace Science and Technology Group Corporation Fifth Research Institute of the 510th Research Institute (Lanzhou Institute of Space Technology and Physics) 2022 for the global recruitment of high-level talents at home and abroad" [中国航天科技集团有限公司第五研究院第五一〇研究所（兰州空间技术物理研究所）2022年面向全球诚聘海内外高层次人才], *Gaoxiao Job*, 22 December 2022, https://www.gaoxiaojob.com/announcement/detail/37876.htmlx
[2245] "Institute 510: Up to the Heavenly Palace, down to the ground" [510所：上接天宫 下接地气], *Gansu Online* [中国甘肃网], 18 December 2010, http://gansu.gscn.com.cn/system/2018/12/10/012081961.shtml
[2246] "The Third Batch of National Military-Civilian Integration Industry Bases-Lanzhou Economic and Technological Development Zone" [第三批国家级军民结合产业基地·兰州经济技术开发区], *Gansu Provincial Development and Reform Commission*, 22 February 2017, https://fzgg.gansu.gov.cn/fzgg/c113599/201702/1744212.shtml
[2247] "Advanced Materials of the Party Branch of Key Laboratory of Vacuum and Cryogenic Technology and Physics, 51O Research Institute, Fifth Academy of China Aerospace Science and Technology Corporation (CASC)" [中国航天科技集团公司五院五一O研究所真空低温技术与物理重点实验室党支部先进事迹材料], *CCP Members Online* [共产党员网], Accessed June 2024, https://dianxing.12371.cn/2014/03/18/TPPO1395113552871333.shtml

[2248] "Advanced Materials of the Party Branch of Key Laboratory of Vacuum and Cryogenic Technology and Physics, 51O Research Institute, Fifth Academy of China Aerospace Science and Technology Corporation (CASC)" [中国航天科技集团公司五院五一O研究所真空低温技术与物理重点实验室党支部先进事迹材料], *CCP Members Online* [共产党员网], Accessed June 2024, https://dianxing.12371.cn/2014/03/18/TPPO1395113552871333.shtml
[2249] "The Second Meeting of the First Academic Committee of Key Laboratory of Vacuum Technology and Physics for National Defense Science and Technology was held in Beijing" [真空技术与物理国防科技重点实验室第一届学术委员会第二次会议在北京召开], *Lanzhou Institute of Physics*, 15 October 2015, http://www.lipcast.cn/articles/2016/08/30/article_10161_13760_1.html
[2250] "Laboratory Research Direction of State Key Laboratory of Vacuum Cryogenic Technology and Physics" [真空低温技术与物理国家级重点实验室实验室研究方向], *Baidu Zhidao*, 1 June 2024, https://zhidao.baidu.com/question/1766354659068366388.html
[2251] "Prof. Dong Changkun was appointed as a doctoral supervisor by Lanzhou Institute of Space Technology and Physics and National Defense Science and Technology Key Laboratory of Vacuum and Cryogenic Technology and Physics" [我院董长昆教授被兰州空间技术物理研究所暨"真空低温技术与物理国防科技重点实验室"聘为博士生导师], *Wenzhou University Computer Laboratory Center*, 2 April 2012, https://cslab.wzu.edu.cn/info/1130/1752.htm
[2252] You Hong [右红] et al., "Analysis of data from the solar wind ion detector of the Chang'e-1 satellite" [嫦娥一号卫星太阳风离子探测器数据分析], *Acta Physica Sinica* [物理学报], 2014, 63(6), https://wulixb.iphy.ac.cn/pdf-content/10.7498/aps.63.069601.pdf\9
[2253] Tian Licheng [田立成] et al., "Simulation of spacecraft surface charging and active control of spacecraft surface potential" [航天器表面充电仿真计算和电位主动控制技术], *Spacecraft Environment Engineering* [航天器环境工程], 2012, 29(2), https://114.242.111.41/article/id/6c71d261-f122-4ee3-8d71-ffe3888c685b
[2254] Yang Fuquan [杨福全] et al., " Technical project of ion propulsion for satellites in super low Earth orbit" [超低轨道卫星应用离子电推进技术方案], *Chinese Space Science and Technology* [中国空间科学技术], 2021, 41(3), http://journal26.magtechjournal.com/kjkxjs/CN/abstract/abstract11278.shtml
[2255] "Research on the adaptability of solid self-lubricating materials to extreme temperature environments" [固体自润滑材料极端温度环境适应能力研究], Sang Ruipeng [桑瑞鹏], *Space Material Process* [宇航材料工艺], 2009, 39(6), http://www.jmonline.org/apparticle/doi/10.3969/j.issn.1007-2330.2009.06.013
[2256] Wang Duoshu [王多书] et al., "Space Optical Thin Film Technology" [空间光学薄膜技术], *Chinese Journal of Vacuum Science Technology* [真空科学与技术学报], 2012, 08, https://www.cqvip.com/qk/95036a/2012008/43108185.html
[2257] "Institute 510: Up to the Heavenly Palace, down to the ground" [510所：上接天宫 下接地气], *Gansu Online* [中国甘肃网], 18 December 2010, http://gansu.gscn.com.cn/system/2018/12/10/012081961.shtml
[2258] "Notice on the publicity of the proposed projects of the 20th batch of provincial science and technology plans for the year 2023" [关于对2023年度第二十批省级科技计划拟立项项目公示的通知], *Science and Technology Department of Gansu Province*, 26 December 2023, http://kjt.gansu.gov.cn/kjt/c111529/202312/173824190.shtml
[2259] "The Second Meeting of the First Academic Committee of Key Laboratory of Vacuum Technology and Physics for National Defense Science and Technology was held in Beijing" [真空技术与物理国防科技重点实验室第一届学术委员会第二次会议在北京召开], *Lanzhou Institute of Physics*, 15 October 2015, http://www.lipcast.cn/articles/2016/08/30/article_10161_13760_1.html
[2260] Zheng Xing [郑兴], Wang Guan [王冠], "The first transparent oxide high-barrier film production line was completed in China" [波涛汹涌国内首条透明氧化物高阻隔薄膜生产线落成], *China Space News*, 22 July 2020.
[2261] "Advanced Materials of the Party Branch of Key Laboratory of Vacuum and Cryogenic Technology and Physics, 51O Research Institute, Fifth Academy of China Aerospace Science and Technology Corporation (CASC)" [中国航天科技集团公司五院五一O研究所真空低温技术与物理重点实验室党支部先进事迹材料], *CCP Members Online* [共产党员网], Accessed June 2024, https://dianxing.12371.cn/2014/03/18/TPPO1395113552871333.shtml
[2262] "Advanced Materials of the Party Branch of Key Laboratory of Vacuum and Cryogenic Technology and Physics, 51O Research Institute, Fifth Academy of China Aerospace Science and Technology Corporation (CASC)"

[中国航天科技集团公司五院五一O研究所真空低温技术与物理重点实验室党支部先进事迹材料], *CCP Members Online* [共产党员网], Accessed June 2024, https://dianxing.12371.cn/2014/03/18/TPPO1395113552871333.shtml

[2263] "Aerospace technology talent from Lanzhou" [航天科技才俊出自兰州], *Dalian University of Technology*, 15 May 2007, https://news.dlut.edu.cn/info/1026/15592.htm

[2264] "Optical Thin Film Technology" [光学薄膜技术], *cnblogs*, Accessed August 2024, https://www.cnblogs.com/wujianming-110117/p/14881783.html

[2265] "The Second Meeting of the First Academic Committee of Key Laboratory of Vacuum Technology and Physics for National Defense Science and Technology was held in Beijing" [真空技术与物理国防科技重点实验室第一届学术委员会第二次会议在北京召开], *Lanzhou Institute of Physics*, 15 October 2015, http://www.lipcast.cn/articles/2016/08/30/article_10161_13760_1.html

[2266] "The Second Meeting of the First Academic Committee of Key Laboratory of Vacuum Technology and Physics for National Defense Science and Technology was held in Beijing" [真空技术与物理国防科技重点实验室第一届学术委员会第二次会议在北京召开], *Lanzhou Institute of Physics*, 15 October 2015, http://www.lipcast.cn/articles/2016/08/30/article_10161_13760_1.html

[2267] "The Second Meeting of the First Academic Committee of Key Laboratory of Vacuum Technology and Physics for National Defense Science and Technology was held in Beijing" [真空技术与物理国防科技重点实验室第一届学术委员会第二次会议在北京召开], *Lanzhou Institute of Physics*, 15 October 2015, http://www.lipcast.cn/articles/2016/08/30/article_10161_13760_1.html

[2268] "Alumni of the Class of '85, Fellow Li Detian" [85届校友李得天研究员], *College of Physics and Electronic Engineering*, 6 June 2013, https://wdxy.nwnu.edu.cn/2013/0606/c2496a72244/page.htm
"Ten Thousand Mountains Pound Toward the Main Peak and Strive for a New Journey Together - Sidelights of Gansu Delegation to the Closing Meeting of the 20th Party Congress" [万山磅礴向主峰 同心奋进新征程——甘肃省代表团参加党的二十大闭幕会侧记], *New Gansu*, 23 October 2022, http://www.jygxw.com/index/news/detail_news.html?id=174998

[2269] "Aerospace technology talent from Lanzhou" [航天科技才俊出自兰州], *Dalian University of Technology*, 15 May 2007, https://news.dlut.edu.cn/info/1026/15592.htm

[2270] "Aerospace technology talent from Lanzhou" [航天科技才俊出自兰州], *Dalian University of Technology*, 15 May 2007, https://news.dlut.edu.cn/info/1026/15592.htm

[2271] "19th Annual Meeting of the Vacuum Metrology Committee of the Chinese Society of Metrology and Testing, the 22nd Annual Meeting of the Vacuum Mass Spectrometry and Leak Detection Committee of the Chinese Vacuum Society, and the 2024 Academic Conference of Vacuum and Cryogenic Specialized Group of the Science and Technology Committee of the Chinese Academy of Space Technology" [中国计量测试学会真空计量专委会第十九届年会、中国真空学会真空质谱分析与检漏专委会第二十二届年会、中国空间技术研究院科技委真空与低温专业组2024年学术会议], *Chinese Society for Measurement* [中国计量测试学会], 22 April 2024, http://www.china-csm.org/xueshujiaoliu/fenzhijigouhuiyi/huiyitongzhi/2269.html

[2272] "Conference Introduction" [会议介绍], *EDLA 2024*, 2024, https://www.edla2024.com/

[2273] "Conference Homepage" [会议首页], *Future Space Technology Forum*, 2020, https://b2b.csoe.org.cn/meeting/SP2020.html

[2274] "SKLPS Communications" [实验室通讯], *State Key Laboratory of Precision Spectroscopy*, February 2018, http://www.lps.ecnu.edu.cn/_upload/article/files/6f/64/3bd360574094b4fbaaab14121675/9e106389-9b21-4f29-926f-171353e99e6c.pdf

[2275] "Optical Thin Film Technology" [光学薄膜技术], *cnblogs*, Accessed August 2024, https://www.cnblogs.com/wujianming-110117/p/14881783.html

[2276] "Vacuum cryogenic technology and physics key laboratory to expand and improve the project signed technical cooperation" [真空低温技术与物理重点实验室拓展提高项目签署技术合*], Lanzhou Institute of Physics*, 18 May 2011, http://www.lipcast.cn/articles/2014/08/04/article_10066_13612_1.html

[2277] "Vacuum cryogenic technology and physics key laboratory to expand and improve the project signed technical cooperation" [真空低温技术与物理重点实验室拓展提高项目签署技术合*], Lanzhou Institute of Physics*, 18 May 2011, http://www.lipcast.cn/articles/2014/08/04/article_10066_13612_1.html

[2278] "Vehicle Transmission Lab" [车辆传动实验室], *Beijing Institute of Technology*, Accessed 2021, https://web.archive.org/web/20121026082800/http:/www.bit.edu.cn/kyxs1/zdsys/27325.htm
"State Key Laboratory--National Key Laboratory of Vehicle Transmission--Beijing University of Technology" [国家重点实验室--车辆传动国家级重点实验室--北京理工大学], *Hunan University* [湖南大学], 4 July 2012. http://machinery.hnu.xk.hnlat.com/index.php?m=content&c=index&a=show&catid=4821&id=6485&siteid=188
"New Energy Intelligent Vehicle Technology Innovation Center" [新能源智能车辆技术创新中心], *Beijing Institute of Technology*, Accessed 2021, http://www.bit-at.cn/intro/47.html
[2279] "New Energy Intelligent Vehicle Technology Innovation Center" [新能源智能车辆技术创新中心], *Beijing Institute of Technology*, Accessed 2021, http://www.bit-at.cn/intro/47.html
[2280] "China North Vehicle Research Institute" [中国北方车辆研究所], *Auto Peitao,* Accessed 2021, http://www.autopeitao.com/Templets/Temp1/About.asp?ID=415
[2281] See, for example, "Scientific research and youthful dreams for the country" [科研报国青春梦], *Beijing Institute of Technology*, 3 May 2017. https://www.bit.edu.cn/xww/lgxb21/139612.htmx. Other instances on file.
"Xiang Changle: a model of dedication and professionalism" [项昌乐： 奉献敬业的楷模], *Beijing Institute of Technology,* Accessed 2021, https://www.bit.edu.cn/dqgz5/bcxjxjy/xjdx/27937.htm
[2282] "State Key Laboratory--National Key Laboratory of Vehicle Transmission--Beijing University of Technology" [国家重点实验室--车辆传动国家级重点实验室--北京理工大学], *Hunan University* [湖南大学], 4 July 2012. http://machinery.hnu.xk.hnlat.com/index.php?m=content&c=index&a=show&catid=4821&id=6485&siteid=188
[2283] "Multi-Power Flow Transmission" [特种车辆研究所-多流传动课题组], *Beijing Institute of Technology*, Accessed 2021, http://www.bitmpft.com/
[2284] "Vehicle Transmission Lab" [车辆传动实验室], *Beijing Institute of Technology,* Accessed 2021, https://web.archive.org/web/20121026082800/http:/www.bit.edu.cn/kyxs1/zdsys/27325.htm
"State Key Laboratory--National Key Laboratory of Vehicle Transmission--Beijing University of Technology" [国家重点实验室--车辆传动国家级重点实验室--北京理工大学], *Hunan University* [湖南大学], 4 July 2012. http://machinery.hnu.xk.hnlat.com/index.php?m=content&c=index&a=show&catid=4821&id=6485&siteid=188
[2285] "Vehicle Transmission Lab" [车辆传动实验室], *Beijing Institute of Technology*, Accessed 2021, https://web.archive.org/web/20121026082800/http:/www.bit.edu.cn/kyxs1/zdsys/27325.htm
[2286] "Chinese army's strongest main battle tank 99A in the end how powerful, ranked among the world's top three" [中国陆军最强主战坦克 99A 到底有多厉害，名列世界前三], *Sohu*, 10 October 2020. https://www.sohu.com/a/442462556_99983438
"State Key Laboratory--National Key Laboratory of Vehicle Transmission--Beijing University of Technology" [国家重点实验室--车辆传动国家级重点实验室--北京理工大学], *Hunan University* [湖南大学], 4 July 2012. http://machinery.hnu.xk.hnlat.com/index.php?m=content&c=index&a=show&catid=4821&id=6485&siteid=188
"Why our army did not send 99A tanks to Russia military exercises, limited by the number of transmissions" [我军为何不派 99A 坦克赴俄军演 受限于变速器数量不多], *Sina*, 11 September 2018. http://mil.news.sina.com.cn/jssd/2018-09-11/doc-ihiycyfx1344547.shtml
[2287] "State Key Laboratory--National Key Laboratory of Vehicle Transmission--Beijing University of Technology" [国家重点实验室--车辆传动国家级重点实验室--北京理工大学], *Hunan University* [湖南大学], 4 July 2012. http://machinery.hnu.xk.hnlat.com/index.php?m=content&c=index&a=show&catid=4821&id=6485&siteid=188
[2288] "The birth of a tank: frozen at -40°C for 48 hours" [坦克诞生:零下 40℃下冷冻 48 小时], *People.cn*, 7 April 2017. http://military.people.com.cn/n1/2017/0407/c1011-29195513.html
[2289] "Special Vehicle Research Institute" [特种车辆研究所], *Beijing Institute of Technology*, Accessed 2021, https://me.bit.edu.cn/jgsz/jlgcx1/tzjlyjs1/index.htm
[2290] "China North Vehicle Research Institute," *Military Leak*, 5 December 2019. https://www.facebook.com/militaryleak/videos/china-north-vehicle-research-institute/2437806919800911/
[2291] "For China's "heavyweight weapons and equipment development" the largest contribution of 985, not Tsinghua, Peking University" [为我国"重量级武器装备研制"贡献最大的 985，不是清华、北大], *QQ*, 4 October 2019. https://kuaibao.qq.com/s/20191004A04ZNU00?refer=spider
[2292] "New Energy Intelligent Vehicle Technology Innovation Center" [新能源智能车辆技术创新中心], *Beijing Institute of Technology*, Accessed 2021, http://www.bit-at.cn/intro/47.html

"Xiang Changle" [项昌乐], *Chinese Academy of Engineering* [中国工程院], Accessed 2021, http://www.cae.cn/cae/html/main/colys/89115587.html
[2293] "New Energy Intelligent Vehicle Technology Innovation Center" [新能源智能车辆技术创新中心], *Beijing Institute of Technology*, Accessed 2021, http://www.bit-at.cn/intro/47.html
[2294] "Special Vehicle Research Institute" [特种车辆研究所], *Beijing Institute of Technology*, Accessed 2021, https://me.bit.edu.cn/jgsz/jlgcx1/tzjlyjs1/index.htm
[2295] "2019 International Conference on Rotating Machinery Drives and Controls held" [2019 年旋转机械传动与控制国际会议举行], *Chinese Mechanical Engineering Society* [中国机械工程学会], 20 July 2019. https://www.cmes.org/News/Dynamics/201988/1565245839862_1.html
[2296] "State Key Laboratory--National Key Laboratory of Vehicle Transmission--Beijing University of Technology" [国家重点实验室--车辆传动国家级重点实验室--北京理工大学], *Hunan University* [湖南大学], 4 July 2012. http://machinery.hnu.xk.hnlat.com/index.php?m=content&c=index&a=show&catid=4821&id=6485&siteid=188
[2297] "State Key Laboratory--National Key Laboratory of Vehicle Transmission--Beijing University of Technology" [国家重点实验室--车辆传动国家级重点实验室--北京理工大学], *Hunan University* [湖南大学], 4 July 2012. http://machinery.hnu.xk.hnlat.com/index.php?m=content&c=index&a=show&catid=4821&id=6485&siteid=188
[2298] "Vehicle Transmission Lab" [车辆传动实验室], *Beijing Institute of Technology*, Accessed 2021, https://web.archive.org/web/20121026082800/http:/www.bit.edu.cn/kyxs1/zdsys/27325.htm
[2299] "Vehicle Transmission Lab" [车辆传动实验室], *Beijing Institute of Technology*, Accessed 2021, https://web.archive.org/web/20121026082800/http:/www.bit.edu.cn/kyxs1/zdsys/27325.htm
"Vehicle Transmission Lab" [车辆传动实验室], *Beijing Institute of Technology*, Accessed 2021, https://web.archive.org/web/20121026082800/http:/www.bit.edu.cn/kyxs1/zdsys/27325.htm
[2300] "Institute of Special Vehicles" [特种车辆研究所], *Beijing Institute of Technology*, Accessed April 2025, https://me.bit.edu.cn/jgsz/jlgcx1/tzjlyjs1/index.htm
[2301] "Vehicle Transmission Lab" [车辆传动实验室], *Beijing Institute of Technology*, Accessed 2021, https://web.archive.org/web/20121026082800/http:/www.bit.edu.cn/kyxs1/zdsys/27325.htm
"Vehicle Transmission Lab" [车辆传动实验室], *Beijing Institute of Technology*, Accessed 2021, https://web.archive.org/web/20121026082800/http:/www.bit.edu.cn/kyxs1/zdsys/27325.htm
[2302] Cai Pengcheng [蔡鹏程] et al., "In this military school, Ma Weiming is bringing out more "Ma Weiming"" [在这所军校，马伟明正带出更多"马伟明"], *Ministry of Defense*, 18 March 2018. http://www.mod.gov.cn/education/2018-03/18/content_4807102_2.htm
[2303] "Academician Ma Weiming of Naval Engineering University: Research Status and Challenges of Electromagnetic Emission Technology" [海军工程大学马伟明院士：电磁发射技术的研究现状与挑战], *Guancha*, 17 August 2023, https://user.guancha.cn/main/content?id=1066066x
"If you lead, you lead the U.S.", China's electromagnetic gun breaks through again with 120 high-speed, high-precision shots" ["领先就领先美国"，中国电磁炮再次突破，高速高精度射击 120 次 ], *Sohu*, 13 December 2023, https://www.sohu.com/a/743664529_120582872
[2304] "The key laboratory of naval integrated power technology settled in Wuhan" [舰船综合电力技术 重点实验室落户武汉], *Power.In-En*, 17 April 2007. https://power.in-en.com/html/power-82116.shtml
"Naval Engineering University Power Integration Innovation Team" [海军工程大学电力集成创新团队], *Xinhua*, 23 May 2017. http://www.xinhuanet.com//science/2017-05/23/c_136308094.htm
[2305] "Independent intellectual property rights to help strengthen the army and the dream of a strong country" [自主知识产权助力强军强国梦想], *NIPSO* [国家知识产权战略网], 22 August 2018. http://nipso.cn/onews.asp?id=43060
[2306] "Independent intellectual property rights to help strengthen the army and the dream of a strong country" [自主知识产权助力强军强国梦想], *NIPSO* [国家知识产权战略网], 22 August 2018. http://nipso.cn/onews.asp?id=43060
"The key laboratory of naval integrated power technology settled in Wuhan" [舰船综合电力技术 重点实验室落户武汉], *Power.In-En*, 17 April 2007. https://power.in-en.com/html/power-82116.shtml
[2307] "Research progress of China's naval medium voltage DC integrated power system" [我国舰船中压直流综合电力系统研究进展], *Read01*, 9 March 2016. https://web.archive.org/web/20191003054007/https://read01.com/L28jO5.html

[2308] "Naval Engineering University Power Integration Innovation Team" [海军工程大学电力集成创新团队], *Xinhua*, 23 May 2017. http://www.xinhuanet.com//science/2017-05/23/c_136308094.htm
[2309] "Xiao Fei, who solved the world's problems at the age of 25 and made China's naval power system lead the world, is really cool" [25 岁解决世界性难题，让中国舰艇动力系统领先世界的肖飞究竟多牛], *Tencent*, 15 February 2021. https://new.qq.com/omn/20210215/20210215A03IS100.html
[2310] "Independent intellectual property rights to help strengthen the army and the dream of a strong country" [自主知识产权助力强军强国梦想], *NIPSO* [国家知识产权战略网], 22 August 2018. http://nipso.cn/onews.asp?id=43060
"Ship integrated power technology national defense science and technology key laboratory recruitment announcement" [舰船综合电力技术国防科技重点实验室招聘公告], *Job910*, 19 November 2007. https://m.job910.com/jobs/zhaopin-150688.html
[2311] "Independent intellectual property rights to help strengthen the army and the dream of a strong country" [自主知识产权助力强军强国梦想], *NIPSO* [国家知识产权战略网], 22 August 2018. http://nipso.cn/onews.asp?id=43060
"Ship integrated power technology national defense science and technology key laboratory recruitment announcement" [舰船综合电力技术国防科技重点实验室招聘公告], *Job910*, 19 November 2007. https://m.job910.com/jobs/zhaopin-150688.html
[2312] "Ship integrated power technology national defense science and technology key laboratory recruitment announcement" [舰船综合电力技术国防科技重点实验室招聘公告], *Job910*, 19 November 2007. https://m.job910.com/jobs/zhaopin-150688.html
[2313] "If you lead, you lead the U.S.", China's electromagnetic gun breaks through again with 120 high-speed, high-precision shots" ["领先就领先美国"，中国电磁炮再次突破，高速高精度射击 120 次 ], *Sohu*, 13 December 2023, https://www.sohu.com/a/743664529_120582872
[2314] "Chinese Communist Party military reform: military school leaks that it is setting up a new major" [中国船舶重工集团公司第七一二研究所需求信息], *Xiamen University*, 20 November 2019. https://jyzd.xmu.edu.cn/2019/1120/c18713a387557/page.htm" [中共军改：军校首设新专业泄海军秘密], DW News, 10 June 2017. https://www.dwnews.com/%E4%B8%AD%E5%9B%BD/59819404/%E4%B8%AD%E5%85%B1%E5%86%9B%E6%94%B9%E5%86%9B%E6%A0%A1%E9%A6%96%E8%AE%BE%E6%96%B0%E4%B8%93%E4%B8%9A%E6%B3%84%E6%B5%B7%E5%86%9B%E7%A7%98%E5%AF%86
[2315] Cai Pengcheng [蔡鹏程] et al., "In this military school, Ma Weiming is bringing out more "Ma Weiming"" [在这所军校，马伟明正带出更多"马伟明"], *Ministry of Defense*, 18 March 2018. http://www.mod.gov.cn/education/2018-03/18/content_4807102_2.htm
"076 amphibious assault ship may use medium voltage DC electric propulsion system technology ahead of a generation" [076 两栖攻击舰或采用中压直流电推系统 技术领先一代], *Sina*, 7 September 2020. https://mil.sina.cn/zm/2020-09-07/detail-iivhvpwy5329406.d.html?oid=5_ydzz&vt=4&wm=4007&cid=263329&node_id=263329
"Ma Weiming academician: China's electromagnetic equipment research strength than the United States, electromagnetic catapult will soon be practical!" [马伟明院士：中国电磁装备研究实力超过美国，电磁弹射即将实用!], *Weibo*, 13 May 2017. https://card.weibo.com/article/m/show/id/2309404107010944679239
"Xiao Fei, who solved the world's problems at the age of 25 and made China's naval power system lead the world, is really cool" [25 岁解决世界性难题，让中国舰艇动力系统领先世界的肖飞究竟多牛], *Tencent*, 15 February 2021. https://new.qq.com/omn/20210215/20210215A03IS100.html
[2316] "Xiao Fei, who solved the world's problems at the age of 25 and made China's naval power system lead the world, is really cool" [25 岁解决世界性难题，让中国舰艇动力系统领先世界的肖飞究竟多牛], *Tencent*, 15 February 2021. https://new.qq.com/omn/20210215/20210215A03IS100.html
[2317] "Ma Weiming: Giving ships a strong "heart"" [马伟明：赋予舰船一颗坚强的"心脏"], *Tsinghua University*, 23 November 2010. https://www.tsinghua.org.cn/info/1014/10146.htm
"Putting a "Chinese heart" into a Chinese warship, China's new network" [为中国军舰装上"中国心", 中国搞新网], *ZGGXJS*, 31 May 2011. http://www.zggxjs.com/13513.html
[2318] "Excellent Paper Selection Results of the 15th Annual Academic Conference of Chinese Electrotechnical Society (Excellent)" [第十五届中国电工技术学会学术年会优秀论文评选结果(优秀)], *China Electrotechnical*

*Society* [中国电工技术学会], Accessed 2021, http://www.ces.org.cn/res/ces/report/1706/2e963560c3609d664238edfceaa9caf1.pdf

[2319] "Xiao Fei, who solved the world's problems at the age of 25 and made China's naval power system lead the world, is really cool" [25 岁解决世界性难题，让中国舰艇动力系统领先世界的肖飞究竟多牛], *Tencent*, 15 February 2021. https://new.qq.com/omn/20210215/20210215A03IS100.html

[2320] "Xiao Fei, who solved the world's problems at the age of 25 and made China's naval power system lead the world, is really cool" [25 岁解决世界性难题，让中国舰艇动力系统领先世界的肖飞究竟多牛], Tencent, 15 February 2021. https://new.qq.com/omn/20210215/20210215A03IS100.html

[2321] "Weiming Ma" [马伟明], *National Natural Science Foundation of China*, 国家自然科学基金委员会], 2007. http://www.nsfc.gov.cn/nsfc/cen/ndbg/2007ndbg/03/07.htm

[2322] "China's submarine big technological breakthrough: the first independent property rights boat with permanent magnet propulsion electric motor success" [中国潜艇大技术突破：首台自主产权艇用永磁推进电机动车成功], *Sohu*, 24 October 2017. http://webcache.googleusercontent.com/search?q=cache%3Ahttps%3A%2F%2Fwww.sohu.com%2Fa%2F200081164_764234&rlz=1C1CHBD_enUS949US949&oq=cache%3Ahttps%3A%2F%2Fwww.sohu.com%2Fa%2F200081164_764234&aqs=chrome..69i57j69i58.1170j0j4&sourceid=chrome&ie=UTF-8

[2323] "Newly promoted central committee member Ma Weiming: "national treasure" expert" [新晋中央委员马伟明："国宝级"专家], *BJ News* [新京报], 31 October 2019. http://www.bjnews.com.cn/feature/2019/10/31/644149.html

"China's submarine big technological breakthrough: the first independent property rights boat with permanent magnet propulsion electric motor success" [中国潜艇大技术突破：首台自主产权艇用永磁推进电机动车成功], *Sohu*, 24 October 2017. http://webcache.googleusercontent.com/search?q=cache%3Ahttps%3A%2F%2Fwww.sohu.com%2Fa%2F200081120_764234&rlz=1C1CHBD_enUS949US949&oq=cache%3Ahttps%3A%2F%2Fwww.sohu.com%2Fa%2F200081120_764234&aqs=chrome..69i57j69i58.1170j0j4&sourceid=chrome&ie=UTF-8

"Putting a "Chinese heart" into a Chinese warship, China's new network" [为中国军舰装上"中国心", 中国搞新网], *ZGGXJS*, 31 May 2011. http://www.zggxjs.com/13513.html

[2324] "Independent intellectual property rights to help strengthen the army and the dream of a strong country" [自主知识产权助力强军强国梦想], *NIPSO* [国家知识产权战略网], 22 August 2018. http://nipso.cn/onews.asp?id=43060

[2325] "Newly promoted central committee member Ma Weiming: "national treasure" expert" [新晋中央委员马伟明："国宝级"专家], *BJ News* [新京报], 31 October 2019. http://www.bjnews.com.cn/feature/2019/10/31/644149.html

"Ma Weiming: Giving ships a strong "heart"" [马伟明：赋予舰船一颗坚强的"心脏"], *Tsinghua University*, 23 November 2010. https://www.tsinghua.org.cn/info/1014/10146.htm

[2326] "Research progress of China's naval medium voltage DC integrated power system" [我国舰船中压直流综合电力系统研究进展], *Read01*, 9 March 2016. https://web.archive.org/web/20191003054007/https://read01.com/L28jO5.html

[2327] "Xiao Fei, who solved the world's problems at the age of 25 and made China's naval power system lead the world, is really cool" [25 岁解决世界性难题，让中国舰艇动力系统领先世界的肖飞究竟多牛], *Tencent*, 15 February 2021. https://new.qq.com/omn/20210215/20210215A03IS100.html

"President Xi signed a general order to give him a first-class merit, the boy in the end how good?" [习主席签署通令给他记一等功，这位小伙儿到底有多牛?], *China Daily*, 20 July 2018. http://china.chinadaily.com.cn/2018-07/20/content_36615016.htm

[2328] "Independent intellectual property rights to help strengthen the army and the dream of a strong country" [自主知识产权助力强军强国梦想], *NIPSO* [国家知识产权战略网], 22 August 2018. http://nipso.cn/onews.asp?id=43060

[2329] "China's submarine big technological breakthrough: the first independent property rights boat with permanent magnet propulsion electric motor success" [中国潜艇大技术突破：首台自主产权艇用永磁推进电机动车成功], *Sohu*, 24 October 2017. http://webcache.googleusercontent.com/search?q=cache%3Ahttps%3A%2F%2Fwww.sohu.com%2Fa%2F200081164_764234&rlz=1C1CHBD_enUS949US949&oq=cache%3Ahttps%3A%2F%2Fwww.sohu.com%2Fa%2F200081164_764234&aqs=chrome..69i57j69i58.1170j0j4&sourceid=chrome&ie=UTF-8

[2330] "Prince new material performance forecast released, the acquisition of 51% stake in Zhongdian Huarui layout of military technology field" [王子新材业绩预告发布，收购中电华瑞 51%股权布局军工科技领域], *Economic Information Daily* [经济参考报社], 1 February 2021. http://www.jjckb.cn/2021-02/01/c_139713186.htm
[2331] "Visit from CSIC's Wuhan Institute of Marine Electric Propulsion," *UC Merced*, 2 November 2015. https://teel.ucmerced.edu/news/2015/visit-csics-wuhan-institute-marine-electric-propulsion
[2332] "China's first ship integrated power technology national defense key laboratory was established in Wuhan" [我国第一个舰船综合电力技术国防重点实验室在武汉成立], *Guangming Daily* [光明日报], 10 April 2007. https://www.gmw.cn/01gmrb/2007-04/10/content_587564.htm"Naval Engineering University Power Integration Innovation Team" [海军工程大学电力集成创新团队], *Xinhua*, 23 May 2017. http://www.xinhuanet.com//science/2017-05/23/c_136308094.htm
[2333] "Explore the mystery of military systems engineering scientific research - systems engineering research institute introduction" [探寻军事系统工程科研的奥秘—系统工程研究院简介], *China graduate student enrollment information network* [中国研究生招生信息网], Accessed January 2024, https://yz.chsi.com.cn/news/file.do?method=downFile&id=2106965907&attach=true&hist=false (automatically downloads Word doc)
[2334] Ma Yiwei [麻毅威], "Research on the application of high and low trajectory penetration model for ballistic missile simulation" [高、低弹道突防模型在弹道导弹仿真中的应用研究], *Flight Dynamics* [飞行力学], 2013,31(2), http://webcache.googleusercontent.com/search?client=firefox-b-1-d&q=cache%3Awww.jasp.com.cn%2Fjasp_cn%2Farticle%2Fview_reference%3Fpcid%3D26FCEE7E0C06EA5863D91553F1CAF79C693AA6D910AD699D%26cid%3DCC2B5CBBB526AA32%26jid%3DE7A9704434E0FB11113858B1B4B6E687%26aid%3D0B5F6399D7D5A2AF5DA8ADE0AFEFE8AD%26yid%3DFF7AA908D58E97FA%26vid%3D4AD960B5AD2D111A%26iid%3D0B39A22176CE99FB
[2335] First study: Ye Feng [ 叶丰] et al., "Research on Key Technologies for Development of Armaments System Confrontation Models" [武器装备体系对抗仿真模型开发关键技术研究], *Military Operations Research and Systems Engineering* [军事运筹与系统工程], 2008, 22(4), http://military.alljournals.cn/view_abstract.aspx?pcid=E88DC30DBE2F08B751E4DF143EC9284B&jid=8BAC25D94FE2DD2FBE12D191FD3518DD&aid=C611C76E3699053D3ED72009A751A466&yid=67289AFF6305E306&vid=BC12EA701C895178&iid=E158A972A605785F&sid=95D537AC89B28832&eid=5D71B28100102720&referenced_num=
Second Study: Bo Haohua [傅好华], "Joint Experimental Research on Weapon and Equipment Systems" [武器装备体系联合试验研究], *Military Operations and Systems Engineering* [军事运筹与系统工程], 2015, 1, https://d.wanfangdata.com.cn/periodical/jsycyxtgc201501012
[2336] Bu Guangzhi [卜广志] et al., "Modeling of Cutting Runways with Ballistic Missile and Aircraft" [弹道导弹和航空兵联合突击机场跑道的仿真建模方法], *System Simulation Technology* [系统仿真技术], 2014, 2, http://www.alljournals.cn/view_abstract.aspx?pcid=3C5CA5E51F7D0F8A&cid=3C5CA5E51F7D0F8A&jid=A2CBAF71CAF04279DB5584D5D51C44F0&aid=0DC2EA7ECEF91394DB9FD0D25A1DDB72&yid=9EAD63ADE6B277ED&vid=&iid=&sid=&eid=&from_absract=1
[2337] Peng Jinghui [彭京徽] et al., "Research on Multi-modal Knowledge Graph Technology in Equipment Field" [装备领域多模态知识图谱技术研究], *Journal of Ordnance Equipment Engineering*, 2022, 43(11), https://bzxb.cqut.edu.cn/html/202211/2096-2304(2022)11-0136-05.html
[2338] Cai Jiwei [蔡纪伟], "Research on the application of ant colony algorithm in the assignment of war-damaged equipment repair tasks" [蚁群算法在战损装备抢修任务指派中的应用研究], *Mathematics in Practice and Theory*, 2012, 19, cache:ccj.pku.edu.cn/article/info?id=278125002
[2339] First study: Zhang Yangming [张洋铭] et al., "Identification of Hammerstein systems using decomposition based finite-data-window recursive least squares method with a forgetting factor" [Hammerstein 系统遗忘因子有限窗口分解辨识], *Journal of Chongqing University* [重庆大学学报], 2023, 46(7), http://qks.cqu.edu.cn/cqdxzrcn/article/abstract/202307004
Second study: Zhang Yangming [张洋铭] et al., "Identification of Hammerstein systems using decomposition based finite-data-window recursive least squares method with a forgetting factor" [Hammerstein 系统遗忘因子有限窗口

分解辨识], *Journal of Chongqing University* [重庆大学学报], 2023, 46(7), http://qks.cqu.edu.cn/cqdxzrcn/article/abstract/zk-202011046
Third study: Ye Feng [叶丰] et al., "Research on Key Technologies for Development of Armaments System Confrontation Models" [武器装备体系对抗仿真模型开发关键技术研究], *Military Operations Research and Systems Engineering* [军事运筹与系统工程], 2008, 22(4), http://military.alljournals.cn/view_abstract.aspx?pcid=E88DC30DBE2F08B751E4DF143EC9284B&jid=8BAC25D94FE2DD2FBE12D191FD3518DD&aid=C611C76E3699053D3ED72009A751A466&yid=67289AFF6305E306&vid=BC12EA701C895178&iid=E158A972A605785F&sid=95D537AC89B28832&eid=5D71B28100102720&referenced_num=
FOurth Study: Bo Haohua [傅妤华], "Joint Experimental Research on Weapon and Equipment Systems" [武器装备体系联合试验研究], *Military Operations and Systems Engineering* [军事运筹与系统工程], 2015, 1, https://d.wanfangdata.com.cn/periodical/jsycyxtgc201501012
[2340] "Chen Yingwu" [陈英武], *iCourse* [课题程], Accessed January 2024, https://www.icourses.cn/web/sword/portal/teacherDetails?userId=ff8080813b79aefd013b7acd642c0413
[2341] "Chen Yingwu" [陈英武], *iCourse* [课题程], Accessed January 2024, https://www.icourses.cn/web/sword/portal/teacherDetails?userId=ff8080813b79aefd013b7acd642c0413
[2342] Bu Guangzhi [卜广志] et al., "Modeling of Cutting Runways with Ballistic Missile and Aircraft" [弹道导弹和航空兵联合突击机场跑道的仿真建模方法], *System Simulation Technology* [系统仿真技术], 2014, 2, http://www.alljournals.cn/view_abstract.aspx?pcid=3C5CA5E51F7D0F8A&cid=3C5CA5E51F7D0F8A&jid=A2CBAF71CAF04279DB5584D5D51C44F0&aid=0DC2EA7ECEF91394DB9FD0D25A1DDB72&yid=9EAD63ADE6B277ED&vid=&iid=&sid=&eid=&from_absract=1
[2343] Peng Jinghui [彭京徽] et al., "Research on Multi-modal Knowledge Graph Technology in Equipment Field" [装备领域多模态知识图谱技术研究], *Journal of Ordnance Equipment Engineering*, 2022, 43(11), https://bzxb.cqut.edu.cn/html/202211/2096-2304(2022)11-0136-05.html
[2344] Cai Jiwei [蔡纪伟], "Research on the application of ant colony algorithm in the assignment of war-damaged equipment repair tasks" [蚁群算法在战损装备抢修任务指派中的应用研究], *Mathematics in Practice and Theory*, 2012, 19, cache:ccj.pku.edu.cn/article/info?id=278125002
[2345] Ma Yiwei [麻毅威], "Research on the application of high and low trajectory penetration model for ballistic missile simulation" [高、低弹道突防模型在弹道导弹仿真中的应用研究], *Flight Dynamics* [飞行力学], 2013,31(2), http://webcache.googleusercontent.com/search?client=firefox-b-1-d&q=cache%3Awww.jasp.com.cn%2Fjasp_cn%2Farticle%2Fview_reference%3Fpcid%3D26FCEE7E0C06EA5863D91553F1CAF79C693AA6D910AD699D%26cid%3DCC2B5CBBB526AA32%26jid%3DE7A9704434E0FB11113858B1B4B6E687%26aid%3D0B5F6399D7D5A2AF5DA8ADE0AFEFE8AD%26yid%3DFF7AA908D58E97FA%26vid%3D4AD960B5AD2D111A%26iid%3D0B39A22176CE99FB
[2346] "2019 China Aerospace Congress Specialized Forum on Vehicle Mission Planning Technology under New Circumstances Successfully Held" [2019 年中国航天大会新形势下飞行器任务规划技术专业论坛成功举办], *Sohu*, 29 April 2019, https://www.sohu.com/a/311150482_317203
[2347] "Chen Yingwu" [陈英武], *iCourse* [课题程], Accessed January 2024, https://www.icourses.cn/web/sword/portal/teacherDetails?userId=ff8080813b79aefd013b7acd642c0413
[2348] "2019 China Aerospace Congress Specialized Forum on Vehicle Mission Planning Technology under New Circumstances Successfully Held" [2019 年中国航天大会新形势下飞行器任务规划技术专业论坛成功举办], *Sohu*, 29 April 2019, https://www.sohu.com/a/311150482_317203
[2349] "The First National Intelligent Joint Maritime Operations Algorithmic Competition Award Announcement" [首届全国智能联合海上作战算法赛获奖情况通报], *Sohu*, 30 December 2022, https://www.sohu.com/a/622712471_358040
[2350] "Selection of Outstanding Papers for the Intelligent Joint Maritime Operations Concept Call for Papers" [智能联合海上作战概念征集活动优秀论文评选情况通报], *Sohu*, 30 December 2022, https://www.sohu.com/a/622712466_358040

[2351] "Our Students Win National Intelligent Joint Maritime Operations Concept Solicitation and Algorithmic Competition" [我院学子在全国智能联合海上作战概念征集和算法赛获得优异成绩], *North University of China*, 23 April 2023, cache:https://jdgc.nuc.edu.cn/info/1070/13527.htm
"Automation College Students Win National Intelligent Joint Maritime Combat Algorithm Competition" [自动化学院学子在全国智能联合海上作战算法赛中斩获佳绩], *Southeast University School of Automation*, 22 April 2023, https://automation.seu.edu.cn/2023/0422/c24459a442589/page.htm
[2352] "The Grand Opening of the 10th China Command and Control Conference and the 8th China (Beijing) Military Intelligent Technology and Equipment Expo" [第十届中国指挥控制大会暨第八届中国（北京）军事智能技术装备博览会盛大开启], *Sina*, 21 April 2023, https://mil.sina.cn/2023-04-21/detail-imyrcpan8521955.d.html
[2353] "Explore the mystery of military systems engineering scientific research - systems engineering research institute introduction" [探寻军事系统工程科研的奥秘—系统工程研究院简介], *China graduate student enrollment information network* [中国研究生招生信息网], Accessed January 2024, https://yz.chsi.com.cn/news/file.do?method=downFile&id=2106965907&attach=true&hist=false (automatically downloads Word doc)
[2354] "Yuan Hongbing" [袁红兵], *Nanjing University of Science & Technology* [南京理工大学], Accessed 2021, http://teacher.njust.edu.cn/jxgc/yhb/list.htm
[2355] "Implement the exit mechanism and focus on improving the operational quality of the national defense technology independent innovation base" [落实退出机制 着力提升国防科技自主创新基地的运行质量], *www.tt91.com* (original source unclear – possibly 国防科技工业), 31 August 2006. http://www.tt91.net/detailed_tt91.asp?id=3743&sid=1755 / (abstract / beginning of same article, but dated 10 December 2005) http://www.xschn.com/article/200512/ZGBG200512013.html
"Reliability Analysis on Collaborative Manufacturing System" [协同制造系统的可靠性分析], *Journal of Armored Force Engineering Institute* [装甲兵工程学院学报], 2007 年第 1 期. http://60.171.75.82:82/article/detail.aspx?id=24355630
"Talent Recruitment" [人才招聘], Changchun Equipment & Technology Institute [长春设备工艺研究所], Accessed 2021, http://ccetri55.com/index.php/cn/Job/index.html
"An Technological Information Management System Based on Driving System Database" [基于传动系统数据库的工艺信息管理系统设计], *Journal of Jilin Teachers Institute of Engineering and Technology* [吉林工程技术师范学院学报], 2016, 32(12). https://d.wanfangdata.com.cn/periodical/jlgcjssfxyxb201612033
[2356] "Unit introduction" [单位简介], *Changchun Equipment & Technology Institute* [长春设备工艺研究所], Accessed 2021, https://web.archive.org/web/20210512224544/http://ccetri55.com/index.php/cn/About/index.html
[2357] "Yuan Hongbing" [袁红兵], *Nanjing University of Science & Technology* [南京理工大学], Accessed 2021, http://teacher.njust.edu.cn/jxgc/yhb/list.htm
[2358] "CH-85 FMS fault analysis and reliability improvement" [CH-85 FMS 故障分析及可靠性改进], *Journal of Jilin University (Engineering and Technology Edition)* [吉林大学学报(工学版)], 2003, (4). http://xuebao.jlu.edu.cn/gxb/CN/abstract/abstract11072.shtml; "Information Integration Based on Product Data Management in CIMS Environment" [CIMS 环境下基于产品数据管理的信息集成], *Journal of Changchun Institute of Optics and Fine Mechanics* [长春光学精密机械学院学报] (2) 1999.; "Research on FMS Heterogeneous Multi-Data Source Integration Technology" [FMS 异构多数据源集成技术研究], *Nanjing University of Science & Technology* [南京理工大学], 2001. https://d.wanfangdata.com.cn/thesis/ChJUaGVzaXNOZXdTMjAyMDEwMjgSB1kzOTgxMDIaCDcxMnF3MnFi
[2359] "Unit introduction" [单位简介], *Changchun Equipment & Technology Institute* [长春设备工艺研究所], Accessed 2021, https://web.archive.org/web/20210512224544/http://ccetri55.com/index.php/cn/About/index.html
[2360] "Key Laboratory of Pulsed Power Technology Ministry of Education" [脉冲功率技术教育部重点实验室], HUST School of Electrical and Electronic Engineering [华中科技大学电气与电子工程学院], 13 January 2017. http://ceee.hust.edu.cn/info/1068/1866.htm
[2361] "Key Laboratory of Pulsed Power Technology Ministry of Education" [脉冲功率技术教育部重点实验室], HUST School of Electrical and Electronic Engineering [华中科技大学电气与电子工程学院], 13 January 2017. http://ceee.hust.edu.cn/info/1068/1866.htm
"Scientific research institutions" [科研机构], HUST [华中科技大学], accessed June 2019. https://archive.fo/zIwzI

[2362] "Key Laboratory of Pulsed Power Technology Ministry of Education" [脉冲功率技术教育部重点实验室], HUST School of Electrical and Electronic Engineering [华中科技大学电气与电子工程学院], 13 January 2017. http://ceee.hust.edu.cn/info/1068/1866.htm
[2363] "The Key Laboratory of Pulse Power Technology of the Ministry of Education held an academic committee meeting" [脉冲功率技术教育部重点实验室举行学术委员会会议], HUST School of Electrical and Electronic Engineering [华中科技大学电气与电子工程学院], 21 October 2016. http://www.poolservice4u.com/info/1123/4329.htm
[2364] "A Review of Current Distribution in Electromagnetic Railguns" [电磁轨道炮电流分布特性研究综述], Transactions of China Electrotechnical Society [电工技术学报] (21) 2020.
"Research on the Coupling Mechanical High Voltage DC Circuit Breaker" [耦合型机械式高压直流断路器研究], Proceedings of the CSEE [中国电机工程学报] (24) 2018.
"Calculation and Analysis of Internal Overvoltage of 500 kV High Coupled Split Reactor" [500kV 高耦合分裂电抗器内部过电压计算与分析], High Voltage Engineering [高电压技术], 2021 年第 47 卷第 2 期, 495-503. http://lib.bdu.edu.cn/asset/detail/0/2031022441790
"Introduction to the laboratory" [实验室简介], State Key Laboratory of Advanced Electromagnetic Engineering and Technology (AEET) [强电磁工程与新技术国家重点实验室], accessed April 2021. http://aeet.hust.edu.cn/sysgk/sysjj.htm
[2365] "Auto-optimization design of ring-shaped switch electrode" [环形开关电极的自动优化设计方法], High Power Laser and Particle Beams [强激光与粒子束], 2006, 18. http://221.10.93.196/cn/article/id/2493
[2366] "School Introduction" [学院简介], HUST School of Electrical and Electronic Engineering [华中科技大学电气与电子工程学院], February 2020. http://ceee.hust.edu.cn/xygk/xyjj.htm
[2367] "China AVIC-1 established a key laboratory of precision manufacturing technology for aviation technology" [中国一航成立精密制造技术航空科技重点实验室], *China Aviation Industry - 1 Corporation* [中国航空工业第一集团公司], 28 March 2006. http://www.sasac.gov.cn/n2588025/n2588124/c3886161/content.html
[2368] "National-level ultra-precision machining technology laboratory established in China Aviation Precision Machinery Research Institute" [国家级超精密加工技术实验室在中国航空精密机械研究所建立], *Aviation Precision Manufacturing Technology* [航空精密制造技术] (29) 1993. https://www.ixueshu.com/document/a48f5b1995b2ca2b318947a18e7f9386.html (full text: http://xiazai.lunwenfw.com/article/ngxq70np2wjjjveo.html); "National Defense Key Laboratory of Ultra-precision Processing Technology" [超精密加工技术国防科技重点实验室], *Aviation Production Engineering* [航空制造工程], 1996 年第 9 期. https://www.ixueshu.com/document/88fc5e425d2777bc318947a18e7f9386.html
"Introduction to the laboratory" [实验室简介], Beijing Aviation Precision Machinery Research Institute [北京航空精密机械研究所], Accessed 2021, https://web.archive.org/web/20130821012445/http:/www.bj303.com/1s/1s_index.html
"Precision Manufacturing Technology for Aviation Industry" [以"精"为业 助力航空——走进精密制造技术航空科技重点实验室], *Aeronautical Manufacturing Technology* [航空制造技术], 2019 年第 62 卷第 6 期. https://www.ixueshu.com/document/03d3884ec484856c77bdc3d06037f661318947a18e7f9386.html / http://www.amte.net.cn/CN/abstract/abstract3669.shtml (PDF available)
[2369] "China AVIC-1 established a key laboratory of precision manufacturing technology for aviation technology" [中国一航成立精密制造技术航空科技重点实验室], China Aviation Industry - 1 Corporation [中国航空工业第一集团公司], 28 March 2006. http://www.sasac.gov.cn/n2588025/n2588124/c3886161/content.html
"Application of Micro-optic Electromechanical System in Advanced Weaponry" [微光机电系统在先进武器装备中的应用], *Proceedings of the 2007 Academic Conference of the Auxiliary Machinery Group of the Technology Branch of the Chinese Society of Aeronautics and Astronautics* [中国航空学会工艺专业分会辅机学组 2007 年度学术会议论文集], 1 January 2007. https://d.wanfangdata.com.cn/conference/6500630; "Application and Manufacture of Microstructure Function Surface" [微结构功能表面的应用及制造], *Aviation Precision Manufacturing Technology* [航空精密制造技术], 2015 年第 5 期. https://qikan.cqvip.com/Qikan/Article/Detail?id=666398379

"Implement the exit mechanism and focus on improving the operational quality of the national defense technology independent innovation base" [落实退出机制 着力提升国防科技自主创新基地的运行质量], *www.tt91.com* (original source unclear – possibly 国防科技工业), 31 August 2006. http://www.tt91.net/detailed_tt91.asp?id=3743&sid=1755 / (abstract / beginning of same article, but dated 10 December 2005) http://www.xschn.com/article/200512/ZGBG200512013.html

[2370] "National-level ultra-precision machining technology laboratory established in China Aviation Precision Machinery Research Institute" [国家级超精密加工技术实验室在中国航空精密机械研究所建立], *Aviation Precision Manufacturing Technology* [航空精密制造技术] (29) 1993. https://www.ixueshu.com/document/a48f5b1995b2ca2b318947a18e7f9386.html (full text: http://xiazai.lunwenfw.com/article/ngxq70np2wjjjveo.html); "National Defense Key Laboratory of Ultra-precision Processing Technology" [超精密加工技术国防科技重点实验室], *Aviation Production Engineering* [航空制造工程], 1996 年第 9 期. https://www.ixueshu.com/document/88fc5e425d2777bc318947a18e7f9386.html
"AVIC One Group builds a base for cutting-edge aviation technology (Photos)" [中航一集团打造尖端航空技术的基地(组图)], *China Aviation News* [中国航空报], 17 June 2004. https://mil.news.sina.com.cn/2004-06-17/1036204751.html
"Precision Manufacturing Technology for Aviation Industry" [以"精"为业 助力航空——走进精密制造技术航空科技重点实验室], *Aeronautical Manufacturing Technology* [航空制造技术], 2019 年第 62 卷第 6 期. https://www.ixueshu.com/document/03d3884ec484856c77bdc3d06037f661318947a18e7f9386.html http://www.amte.net.cn/CN/abstract/abstract3669.shtml (PDF available)

[2371] "Institute Introduction" [本所介绍], Beijing Aviation Precision Machinery Research Institute of Aviation Industry Corporation of China [中国航空工业集团公司北京航空精密机械研究所], Accessed 2021, http://www.bj303.com/cn/about.aspx (Chinese) / http://www.bj303.com/en/about.aspx (English)
"Institute Overview" [本所概况], Beijing Aviation Precision Machinery Research Institute [北京航空精密机械研究所], Accessed 2021, https://web.archive.org/web/20130821013839/http://bj303.com/bsgk.html
"Key labs" [重点实验室], AVIC Manufacturing Technology Institute [中国航空制造技术研究院], Accessed 2021, https://web.archive.org/web/20210121070642/https://www.avicmti.avic.com/gxwm/xfbs/cdsys/index.shtml
"Contact Details" [联系方式], *Beijing Aviation Precision Machinery Research Institute of Aviation Industry Corporation of China* [中国航空工业集团公司北京航空精密机械研究所], Accessed 2021, http://www.bj303.com/cn/zcontent.aspx?id=711

[2372] "Introduction to the laboratory" [实验室简介], *Beijing Aviation Precision Machinery Research Institute* [北京航空精密机械研究所], Accessed 2021, https://web.archive.org/web/20130821012445/http:/www.bj303.com/1s/1s_index.html
"Institute Introduction" [本所介绍], *Beijing Aviation Precision Machinery Research Institute of Aviation Industry Corporation of China* [中国航空工业集团公司北京航空精密机械研究所], Accessed 2021, http://www.bj303.com/cn/about.aspx (Chinese) / http://www.bj303.com/en/about.aspx (English)

[2373] "Yang Hui Chief Expert of Precision Ultra-precision and Micro-machining Technology" [杨辉 精密超精密及微细加工技术首席专家], *Aeronautical Manufacturing Technology* [航空制造技术], 2014 年第 15 期. https://www.ixueshu.com/document/466acba9d1aca3e9d5e384611a28cd49318947a18e7f9386.html / https://www.amte.net.cn/CN/article/downloadArticleFile.do?attachType=PDF&id=685 (PDF)

[2374] "Yang Hui Chief Expert of Precision Ultra-precision and Micro-machining Technology" [杨辉 精密超精密及微细加工技术首席专家], *Aeronautical Manufacturing Technology* [航空制造技术], 2014 年第 15 期. https://www.ixueshu.com/document/466acba9d1aca3e9d5e384611a28cd49318947a18e7f9386.html / https://www.amte.net.cn/CN/article/downloadArticleFile.do?attachType=PDF&id=685 (PDF)

[2375] "Yang Hui Chief Expert of Precision Ultra-precision and Micro-machining Technology" [杨辉 精密超精密及微细加工技术首席专家], *Aeronautical Manufacturing Technology* [航空制造技术], 2014 年第 15 期. https://www.ixueshu.com/document/466acba9d1aca3e9d5e384611a28cd49318947a18e7f9386.html / https://www.amte.net.cn/CN/article/downloadArticleFile.do?attachType=PDF&id=685 (PDF)

[2376] "Modeling and Simulation of Helicopter Cable Position System" [直升机缆位系统建模与仿真], *Aviation Precision Manufacturing Technology* [航空精密制造技术] (4) 2017.

[2377] "Experimental Research on the Focus Evaluation Function of Air Film Hole Image" [气膜孔图像对焦评价函数的实验研究], *Journal of Astronautic Metrology and Measurement* [宇航计测技术] (6) 2019.
[2378] "Experimental Research on the Focus Evaluation Function of Air Film Hole Image" [气膜孔图像对焦评价函数的实验研究], *Journal of Astronautic Metrology and Measurement* [宇航计测技术] (6) 2019.
"Precision Manufacturing Technology for Aviation Industry" [以"精"为业 助力航空——走进精密制造技术航空科技重点实验室], *Aeronautical Manufacturing Technology* [航空制造技术], 2019 年第 62 卷第 6 期. https://www.ixueshu.com/document/03d3884ec484856c77bdc3d06037f661318947a18e7f9386.html / http://www.amte.net.cn/CN/abstract/abstract3669.shtml (PDF available)
[2379] "AVIC One Group builds a base for cutting-edge aviation technology (Photos)" [中航一集团打造尖端航空技术的基地(组图)], *China Aviation News* [中国航空报], 17 June 2004. https://mil.news.sina.com.cn/2004-06-17/1036204751.html
"Introduction to the laboratory" [实验室简介], *Beijing Aviation Precision Machinery Research Institute* [北京航空精密机械研究所], Accessed 2021, https://web.archive.org/web/20130821012445/http:/www.bj303.com/1s/1s_index.html
[2380] "Introduction to the laboratory" [实验室简介], Beijing Aviation Precision Machinery Research Institute [北京航空精密机械研究所], Accessed 2021, https://web.archive.org/web/20130821012445/http:/www.bj303.com/1s/1s_index.html
"Institute Overview" [本所概况], Beijing Aviation Precision Machinery Research Institute [北京航空精密机械研究所], Accessed 2021, https://web.archive.org/web/20130821013839/http://bj303.com/bsgk.html
[2381] "Contact Us" [联系我们], *Beijing Aviation Precision Machinery Research Institute of Aviation Industry Corporation of China* [中国航空工业集团公司北京航空精密机械研究所], accessed April 2021. http://www.bj303.com/cn/contact.aspx