DoD Labs

Back to the Future?

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US Department of Defense labs are faced with significant challenges including an aging workforce and infrastructure, the inability to compete successfully for new scientists and engineers, and the loss of research prominence. This comes at a time when China is challenging the technological standing of the United States across the globe. This article proposes governance models that retain the best of the DoD lab workforce and infrastructure while leveraging the larger US research and development ecosystem to reset and retool the DoD labs for the twenty-first century. This article engages an historical account of the DoD Lab enterprise and offers recommendations for moving forward to regain our strengths through rethinking the way we do business.

In an acclaimed May 1915 *New York Times* interview, American icon Thomas Edison called on the US government to "maintain a great research laboratory. . . .[To develop] . . . all the technique of military and naval progression, without any vast expense."[1] Edison's advocacy was rooted in concerns about US military advantage in World War I, and funding was appropriated in the next year. But due to disagreements within the oversight board charged with establishing it, the Naval Research Laboratory was not launched until 1923. In the decades that followed, the Army and Air Force also established labs further contributing to America's military technological dominance. US Department of Defense labs have a rich innovation, invention, and problem-solving history. Since the Cold War, however, DoD labs have faced several challenges with shifting priorities, workforce constraints, and infrastructure challenges.

This article examines the "glory days" of the DoD labs, the shift of research and development dominance from the Department of Defense to the US commercial sector, and challenges with attracting and retaining a scientist and engineer workforce. These concerns, in the midst of technological threats from state and nonstate adversaries, call for a serious reconsideration of the role of DoD labs. Leaders in the Air Force and other Defense Department services that provide oversight over the lab structure should consider alternative governance models that retain the best of the DoD lab workforce and infrastructure while leveraging the larger research and development ecosystem in the United States. In short, the department must reset and retool its labs for the twenty-first century.

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1. Edward Marshall, "Edison's Plan for Preparedness," *New York Times*, May 30, 1915, https://timesmachine.nytimes.com/timesmachine/1915/05/30/issue.html.

The Glory Days

Suffice it to say, the fact the Department of Defense still has more than 60 laboratories, warfare centers, and combat development centers in the Defense laboratory enterprise speaks to their importance in the DoD research, development, test, and evaluation ecosystem.[2] Each DoD laboratory was created for specific purposes within the military technology base. At the time of establishment, each lab focused on specific needs expressed by its service or the military in general.

The Naval Surface Warfare Center Dahlgren was founded in 1918 as a proving ground for naval guns. In the 1920s and 1930s, scientists and engineers at Dahlgren invented the Norden bombsight that the Army Air Forces used in World War II, greatly increasing the success of aircraft bombing runs.[3]

The Army Research Lab (formerly the Ballistic Research Laboratory) was also founded in 1918 with the mission to work on land-based gun (cannon) ballistics. The Ballistic Research Laboratory is best known for developing the Electronic Numerical Integrator and Computer—the first programmable, electronic, general-purpose digital computer—in 1945 to calculate ballistics for the Army and the Defense Department.[4]

The Naval Research Lab, Thomas Edison's laboratory, was originally conceived to develop technology to counter the submarine threats posed by Germany in World War I. With a rich history of technology firsts, the Naval Research Lab invented, developed, and in 1938, installed the first operational US radar. The lab also built and deployed early versions of satellites and engaged in basic and applied research that provided the foundations for the global positioning system.[5]

Naval Air Weapons Station China Lake was established during World War II in cooperation with the California Institute of Technology to develop and test air-launched weapons. This organization developed weapons including the Sidewinder air-to-air missile in the 1950s and the Tomahawk, still in use today.[6]

Redstone Arsenal was originally established in 1941 in Huntsville, Alabama as a chemical weapons production facility. Since the latter part of World War II, Redstone and its tenant activities have become the premier center for Army aviation and airborne

2. "Research, Technology & Laboratories: Defense Laboratories and Centers," Department of Defense (DoD) Research and Engineering Enterprise (website), June 7, 2019, https://rt.cto.mil/.

3. Timothy Moy, *War Machines: Transforming Technologies in the U.S. Military, 1920–1940* (College Station: Texas A&M University Press, 2001).

4. William T. Moye, "ENIAC: The Army-Sponsored Revolution," Army Research Laboratory (website), January 1996, https://ftp.arl.army.mil/.

5. "NRL History: About Us," US Naval Research Laboratory (website), n.d., accessed October 25, 2022, https://www.nrl.navy.mil/.

6. Tom Hildreth, "The Sidewinder Missile," *Air-Britain Digest* 40, no. 2 (March–April 1988): 39–40; and "Weapons," China Lake Museum Foundation (website), n.d., accessed October 25, 2022, https://chinalakemuseum.org/.

ordnance, including the first laser-guided bombs. Redstone Arsenal now leads hypersonic weapons development for the Army.[7]

The Air Force Research Laboratory (AFRL) was founded as the Air Force Cambridge Research Laboratories/Center in 1945. After World War II, the center developed the first telephone modem communications for a digital radar relay in 1949.[8]

Throughout the Cold War and until 1986, DoD labs were responsible for technology development and owned the technical data packages for each weapon system. The technical data packages developed by the in-house workforce served as the foundation for most contracts issued to private industry. The DoD labs either created new technologies in-house or managed technical programs for new product development.

The labs developed technology products with strong linkages to acquisition programs that drove the deployment of war-fighting technologies for decades.[9] In-house laboratory technologies were translated into technical data packages and issued to industry as requirements demanded. Industry served the role of advancing technology development through prototyping and transitioning to a contract for manufacturing, often under the guidance and approval of laboratory scientists and engineers.

These roles and responsibilities began to change during the mid-to-late 1980s. In his history of the Sidewinder missile development, Ron Westrum noted industry had lobbied to lead technology development, prototyping, and manufacturing instead of the government.[10] The defense industrial base convinced Pentagon decisionmakers they could innovate faster and at less cost than the Defense Department's laboratory system. Congress agreed and responded in favor of industry.

Shift to the Private Sector

Further details and foundations for this sea change can be found in the Packard Commission Report of 1986.[11] The findings of the Packard Report generated many reforms that were codified in Title 10 via the Goldwater-Nichols Act: the DoD labs arguably lost their role as technology developers and became mostly acquisition support as program managers of industry.[12] This shift was codified in the Defense Acquisition Reform Act

7. "A History of Redstone Arsenal Airfield," US Army Aviation and Missile Life Cycle Management Command (website), n.d., accessed October 25, 2022, https://history.redstone.army.mil/.

8. Paul N. Edwards, *The Closed World: Computers and the Politics of Discourse in Cold War America* (Cambridge, MA: MIT Press, 1996), 19, chap. 3.

9. J. Ronald Fox, *Defense Acquisition Reform 1960–2009: An Elusive Goal* (Washington, DC: US Army Center of Military History, 2011), https://history.army.mil/.

10. Ron Westrum, *Sidewinder: Creative Missile Development at China Lake* (Annapolis, MD: Naval Institute Press, 1999).

11. David Packard, *A Quest for Excellence – A Final Report to the President by the Blue Ribbon Commission on Defense Management* (Washington, DC: The White House, June 1986), https://www.documentcloud.org/.

12. Goldwater-Nichols Department of Defense Reauthorization Act of 1986, 10 U.S.C. § 105 (1986).

(DAIWA) as part of the National Defense Authorization Act of 1991.[13] One of the most significant negative results of DAIWA was the loss of career laboratory systems engineers in the 1990s, as the government shifted the responsibilities for systems engineering to the largest defense contractors.[14] Supporting acquisition programs was not as attractive to the nation's best and brightest technical talent as actually working in a lab to develop cutting-edge technology products and creating fundamental scientific knowledge for next-generation systems.

Program failures such as Future Combat Systems and the Navy's A-12 program soon followed.[15] A close Defense Science Board examination of the many high-profile program failures in 2002 revealed a preponderance of systematic cost overruns, schedule slippages, and capability shortfalls in addition to "hollowing out of organic systems engineering capability within DoD."[16]

It is very difficult for a DoD lab-developed technology to be deployed as industry is the identified source for all new technologies delivered to acquisition programs of record. For example, Lockheed-Martin has a Total Systems Program Responsibility contract for the F-35 Joint Strike Fighter. The practical implication of this arrangement is that Lockheed-Martin has an overwhelming say about what technologies will be delivered for the F-35, provided the program's requirements are met by the deliverables provided. Because of their profit incentives, Lockheed-Martin is not motivated to integrate emerging technological advances resulting in the commonly heard statement that DoD weapons systems take too long to develop, and their technology is out of date by the time they are deployed.

While industry has assumed the dominant role in technology development, the government still assumes product liability for all weapon systems today. That is, as industry delivers its contractually obligated hardware and software to top-level performance specifications, if any problems occur, the Defense Department must find a remedy, including financial penalties. It cannot be overstated that shifting technology risk to the major prime defense contractors results in less capable weapons systems being deployed. If the risk of technology insertion was shifted back to the government through the labs, upgrades could be made more seamlessly.

Since the advent of the War on Terror in the early 2000s and subsequent operations in Iraq and Afghanistan, innovation and invention at DoD labs have been limited to and

13. National Defense Authorization Act for Fiscal Year 1991, Pub. L. No. 101-510, 104 Stat. 1485 (1990).

14. Michael Gibbs, "Returns to Skills and Personnel Management: U.S. DoD Scientists and Engineers," Discussion Paper 1539 (Bonn, Germany: Institute for the Study of Labor (IZA), March 2005), https://papers.ssrn.com/.

15. Sebastian Sprenger, "30 Years: Future Combat Systems—Acquisition Gone Wrong," Defense News, October 25, 2016, https://www.defensenews.com/; and David Montgomery, "How the A-12 Went Down," *Air & Space Forces Magazine*, April 1, 1991, https://www.airforcemag.com/.

16. Kathlyn Hopkins Loudin, *Lead Systems Integrators: A Post-Acquisition Reform Retrospective* (Fort Belvoir, VA: Defense Acquisition University Press, January 2010), https://www.dau.edu/.

focused on highly specific technologies to meet the new and unexpected threats experienced in the unconventional warfare practiced in a particular area of operation. Two examples of these technologies are "bunker-busting" bombs and improvised explosive device-detection devices.

While these technologies were successful in their application and impact on specific situations as niche tools and saving lives—improvised explosion device-detection detection technologies, for example—they were not on the same scale as the major weapons systems still under development by DoD prime contractors. A 2016 Air Force Studies Board report recommended the Air Force should embrace failure in the Edisonian sense (learning from small failures) and change the culture, including experimentation, to make way for disruptive innovation on a larger scale.[17]

The National Academies of Sciences, Defense Science Board, and other DoD-affiliated research institutions like the RAND Corporation have looked at national and international trends in science and technology and research and development shifts from government to the commercial or private sector. An often-cited 2007 National Academy of Sciences report, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, expresses significant concern "that the scientific and technical building blocks of our economic leadership are eroding at a time when many other nations are gathering strength."[18]

Almost 15 years later, the Congressional Research Service noted that "from 1960 to 2019, the U.S. share of global R&D fell (from 69%) to 30%, and the federal government's share of total U.S. R&D fell from 65% to 21%, while business' share more than doubled from 33% to 71%."[19] The CRS report recommended that because of this shift, the Department of Defense must explore new ways to acquire new technology and maintain US military technical superiority in three ways: (1) developing and modifying organizations and business models to access this technology; (2) adapting the DoD business culture to seek and embrace technologies developed outside of the department, the United States, and its traditional contractor base; and (3) finding ways to adapt and leverage commercial technologies for defense applications.[20]

One consideration is that these and similar recommendations over the years fail to account for the compounding statutory restrictions put in place because of the 1986 Packard Commission. But changing the governance structure of some of or all the labs

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17. National Academies of Sciences, Engineering, and Medicine, *The Role of Experimentation Campaigns in the Air Force Innovation Life Cycle* (Washington, DC: National Academies Press, 2016), https://doi.org/.

18. National Academy of Sciences, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (Washington, DC: National Academies Press, March 2007), https://nap.nationalacademies.org/.

19. John F. Sargent Jr. and Marcy E. Gallo, *The Global Research and Development Landscape and Implications for the Department of Defense*, R45403 (Washington, DC: Congressional Research Service, June 28, 2021), Summary, https://sgp.fas.org/.

20. Sargent and Gallo, *Development Landscape*.

would present an opportunity to leverage the shift in research and development investments to the commercial sector, adapt their business processes to take advantage of this commercial investment, and change the culture by focusing scientists and engineers on science and technology that is unique or must be done in DoD labs due to its sensitivity.

Loss of Scientific and Engineering Expertise

The "corporate labs" of the Department of Defense include the Naval Research Lab, Army Research Lab, and Air Force Research Lab. A majority of the workforce at the corporate labs are scientists and engineers. The rest of the DoD labs, especially the engineering centers, have a larger concentration of engineers and focus almost exclusively on acquisition support with emphasis on testing and evaluating contractor-developed products. While testing and evaluation is a critical product of the labs in direct support of acquisition programs of record, resources could be used for more prototyping and experimentation if the military services pursued those efforts more aggressively.

Because of the high visibility of military acquisition programs, many scientists and engineers in the three main service labs have also been redirected to acquisition. From the 1970s to the early 1990s, both civilian and military scientists and engineers used their technical skills in laboratory and engineering environments and were valued for the skills they brought to the development of technology.[21] After the Cold War, several trends in acquisition reform dominated the decision making in the Department of Defense and shifted the responsibility for developing technology to contractors, primarily a few major DoD contractors. Total System Performance Responsibility and the rise of lead systems integrators were used to justify the downsizing of the "in-house" laboratory and engineering center workforce.[22]

The DoD labs were also reduced in number and scope of influence through the Base Realignment and Closure processes of 1995 and 2005. As Brian Fry noted, from 1994 to 2020, "Air Force active-duty-officer end strength . . . decreased 21 percent, scientists decreased 26 percent, engineers decreased 22 percent, while acquisition managers increased 42 percent."[23] In the last two decades, the scientist and engineer workforce has continued to experience retention problems. As a result, a bathtub effect has been created as the aging senior workforce begins to retire in larger numbers and the mid-career workforce recruited in the late 1990s and early 2000s shrinks because of reduced opportunities and more robust non-DoD work opportunities.

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21. Brian J. Fry, "Taking the Brakes Off Uniformed Scientists and Engineers," *Air & Space Operations Review* 35, no. 1 (Spring 2022), https://www.airuniversity.af.edu/.

22. National Research Council, *Owning the Technical Baseline for Acquisition Programs in the U.S. Air Force: A Workshop Report* (Washington, DC: National Academies Press, 2015), 6, https://nap.nationalacademies.org/.

23. Fry, "Scientists and Engineers," 20.

Fry explained that uniformed scientists and engineers were relegated to program management and not given enough opportunity to engage in science and engineering that benefits Air Force war fighting. He recommended military scientists and engineers be given operational assignments via AFWERX Spark Cells and other programs to use their technical knowledge while enhancing their experience and usefulness to the Air Force. He used the example of how Air Force scientists and engineers were deployed to work with vehicle-mounted jamming equipment deployed by the Army in the Global War on Terrorism. They could understand the equipment and articulate applications and modifications that helped make its use more effective.[24]

Fry's observations about Air Force uniformed scientists and engineers are focused on better coupling their talents and warfighter training to innovate and adapt on a small scale. Still, the underlying theme of focusing on innovation to motivate the workforce can also be applied to the thousands of civilian scientists and engineers across the DoD laboratory enterprise who work on larger and more complex weapons systems.

A Call for Reform

In 2012, RAND reported on an expert panel that looked at the future of Army laboratories, discussing many of the same issues. The research questions for the expert panel and discussed in the report included: (1) What do broad trends in basic research and research and development, both federal and in the private sector, mean for the future of Army research? (2) What are the characteristics of top-quality research laboratories? And (3) How can the Army get the best long-term value from its investments in basic research?[25]

Five years later in 2017, a defense task force addressed four themes: (1) how well the defense laboratories anticipated and responded to the needs of the department; (2) the mechanisms that existed to refurbish and recapitalize DoD labs and how the state of the infrastructure (both physical and research) compared with other government, academic, international, and industrial counterparts; (3) how well the DoD laboratories and centers attracted, recruited, retained, and trained their workforce to remain technically current and flexible to respond to emerging national requirements; and (4) whether the appropriate balance existed between service control and laboratory-director discretion to maximize laboratory mission effectiveness.[26]

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24. Fry, "Scientists and Engineers," 28.

25. Gilbert Decker et al., *Improving Army Basic Research: Report of an Expert Panel on the Future of Army Laboratories* (Santa Monica, CA: RAND Corporation, 2012), https://www.rand.org/.

26. DoD Defense Science Board (DSB) Task Force, *Defense Research Enterprise Assessment* (Washington, DC: DoD DSB, January 2017), 21, https://dsb.cto.mil/.

Most recently, in January 2022, Heidi Shyu, Undersecretary of Defense for Research and Engineering, was tasked by Kathleen H. Hicks, Deputy Secretary of Defense, to assess the health of the Department's and individual services' laboratory and test infrastructure."[27]

This article could go on at length, summarizing all the studies and reports that explore the efficiency and effectiveness of the DoD labs. But the studies cited and summarized in table 1 highlight important issues that are driving an ongoing discussion about the ability of the current DoD lab enterprise to meet the new demands of the twenty-first century.

Table 1. Summary of recommendations from studies cited

	Structure/Process	Culture	Risk
2012 RAND Report	Resources are lacking to execute strategy and responsibilities	Workforce is not keeping up with emerging technologies	Army basic research program is risk-averse
2016 AF Studies Board	Fence-off organizations working on innovation	Create innovation catalysts	Embrace Edison failure
2017 DSB Report	Use innovative recapitalization mechanisms like minor MILCON (mainly Section 219 funds) and Enhanced Use Lease	Implement authorities that have already been granted – local control for local matters	Embrace open innovation – leverage Open Campus model to collaborate more easily with academia and industry
2021 CRS Study	Modify organization and business models	Adapt the DoD business culture to seek and embrace technologies developed outside of DoD	Leverage commercial technologies for defense applications

The answer for the future lies in an analysis of the historic strengths of the DoD lab system. The Department must regain those strengths by altering the governance structure to take advantage of the shift of research and development dominance of the Department of Defense after World War II to the current dominance of private sector R&D in twenty-first-century science and technology.

Consideration of New Governance Models

A few DoD lab realities must be considered. The first is aging infrastructure—the Department has failed to make sufficient investments to enable the labs to develop and test twenty-first-century technology. DoD labs will never be a military construction budget priority as operational infrastructure always takes priority. Lab directors have statutory authority for the creation and expenditure of discretionary budgets (e.g., 10 U.S. Code § 2805–unspecified minor construction) that could be used for laboratory enhancements

27. John A. Tirpak, "DOD's Research and Engineering Priorities Focus on Contested Areas," *Air and Space Forces Magazine*, January 20, 2022, https://www.airforcemag.com/.

including minor MILCON projects. But often they cannot exercise this authority as they must receive approval from service leadership which often refuses permission. This was not Congress's intent but still an operational reality.

The second reality is that competition for the scientist and engineer workforce is fierce, and the DoD lab workforce is aging fast.[28] Congress has given the DoD lab directors many legislative authorities for recruiting, hiring, and retention via Science and Technology Reinvention Lab statutes.[29] Implementing these flexible authorities has been challenging, though, because each service requires approval from senior nonlab leadership, which hesitates to support them for various reasons.

Given these realities, the Department of Defense should consider alternative governance models to revitalize the DoD labs. The 2016 task force mentioned above reviewed different operating models across the DoD labs and compared them with those of federally funded research and development centers (FFRDCs), university-affiliated research centers, government-owned, contractor-operated facilities, and overseas and private partner labs.[30]

The task force found the DoD labs operate under a more restrictive environment than the others that were reviewed. While the *Defense Research Enterprise Assessment* stopped short of suggesting a shift to alternative governance models, the challenges and restrictions outlined earlier in this article were the same.

One example of a lab that transitioned its governance model to adapt to resource challenges is HRL Laboratories. Formerly Hughes Research Laboratories, established in 1948, it transitioned to a limited liability company (LLC) in 1997 to perform research and development for the Boeing Company and General Motors (LLC members). This lab has millions of dollars of government and commercial contracts (as a prime and a subcontractor). It is a DoD-trusted foundry with 250,000 square feet of lab space and a 10,000-square-foot Class 10 clean room located on 72 acres in Malibu, California.

The HRL mission is to "enhance the mission of our government and commercial customers through the development and application of world-class science, technology and engineering."[31] It specializes in four core areas: (1) information and systems sciences, (2) materials and microsystems, (3) microfabrication technology, and (4) sensors and electronics.

HRL is considered a globally recognized premier lab that performs cutting-edge research and development for the government and commercial sectors and limits its specialization areas. The lab invests in talent development from the time students enter college

28. Courtney Buble, "The Aging Federal Workforce Needs 'New Blood,' Experts Say," Government Executive, August 30, 2019, https://www.govexec.com/.

29. "Science and Technology Reinvention Laboratory," Research, Technology, and Laboratories, DoD Research and Engineering Enterprise (website), n.d., accessed November 15, 2022, https://rt.cto.mil/.

30. DoD DSB Task Force, *Defense Research Enterprise Assessment*, 21.

31. "HRL Laboratories," accessed October 25, 2022, https://www.hrl.com.

through grants and engagement with faculty and continues its engagement by offering opportunities for scholarships, internships, and fellowships.

Similarly, the Department of Energy's (DOE) National Nuclear Defense Administration's primary weapons laboratories, including Sandia, Los Alamos, and Lawrence Livermore, are government-owned, contractor-operated, and FFRDCs. These laboratories and other DOE labs are considered among the world's most innovative and productive technical organizations. Indeed, these facilities not only support the nation's nuclear mission but also play significant roles in developing new conventional military technologies. Their facilities and, most importantly, the technical workforce exemplify how these business models can sustain the nation's security by creating new and innovative technology products.

Summary and Recommendations

One hundred years have passed since the founding of the first DoD lab. The present lab system developed in response to global threats during two world wars, one Cold War, two additional wars in the Far East, and multiple protracted engagements in the Middle East. Scientists and engineers at these labs played vital roles in building and maintaining US military dominance in the twentieth century, but the landscape has changed.

In the twenty-first century, the threats are more technology-centric, and technology itself is more ubiquitous. More broadly, the US government, and more specifically the Department of Defense, no longer dominate spending in the research and development sector. What has not changed is the creativity and ingenuity of our scientists and engineers. They need to continue to excel in their field by focusing on doing what only they can do and leveraging what the commercial sector has to offer. They must also be supported by policies and infrastructure that allow them to be the best.

In 2014, the DoD Laboratories Office sponsored a study by the RAND Corporation to examine innovation within the in-house laboratory system using patents as the gauge of performance.[32] Were patents emerging from the labs' new and innovative technologies, or were they variations on existing themes? This approach is widely used by industry to measure the potential market value of new products and the performance of an organization's technical base, including scientists, engineers, laboratories, and contract performers.

Utilizing this approach, the in-house labs could be measured against the DOE's national labs (science labs and the National Nuclear Security Administration weapons labs), FFRDCs (e.g., the MIT Lincoln Laboratory), university-affiliated research centers, (e.g., the Johns Hopkins University Applied Research Lab), industry laboratories (e.g., HRL), and nonprofit labs (e.g., the Southwest Research Institute). (Note: National Nuclear Security Administration labs are also FFRDCs and government-owned, contractor-operated facilities.)

32. Christopher A. Eusebi and Richard Silberglitt, *Identification and Analysis of Technology Emergence Using Patent Classification*, RR-629-OSD (Santa Monica, CA: RAND Corporation, 2014), https://www.rand.org/.

This comparison may yield valuable information on the best-performing business models that could be applied to the in-house DoD laboratory system.

Recommendations—DoD

1. As an internal assessment, in Base Realignment and Closure-like fashion, the Under Secretary of Defense (Research & Engineering) should engage the three service lab management organizations (Office of Naval Research, Army Research Laboratory, and AFRL) to prioritize lab assets and workforce strengths to determine priority foci and consider alternatives for the utilization of other lab assets.
2. Using the same metrics-based approach, the Department should commission a follow-on to the *Defense Research Enterprise Assessment* by the Defense Science Board to determine the current state of physical infrastructure, scientist and engineer workforce trends, and technology prominence of the DoD Labs. This assessment should solicit recommendations about which resources should be retained and improved, which resources should be shared or contracted out within the defense industrial base, and which resources should be divested.
3. The office of the undersecretary should engage major defense contractors in the defense industrial base in a discussion about options for repurposing existing DoD in-house laboratory resources under alternative governance models like government-owned, contractor-operated facilities, university-affiliated research centers, and FFRDCs.
4. As an external arbiter of laboratory prominence and the needs of the national security ecosystem, the Department of Defense should commission the National Academies to provide the results of the internal assessments and make recommendations for changes to strengthen the DoD lab system.

Recommendations—US Air Force

1. The Air Force should permit the Air Force Research Laboratory executive director to implement all authorities granted to the position by science and technology laboratory statutes and not require any additional permissions or restrictions from senior Air Force leadership. The service should hold the executive director responsible for laboratory performance based on those decisions.
2. The Air Force should clearly identify AFRL's role. In other words, is the lab a center for innovative technologies or is its primary role the support of acquisition programs of record? If the lab is responsible for innovative technologies, the Air Force should consider implementing a governance structure resembling the Army Futures Command, where the science and technology and acquisition communities share responsibilities for executing Budget Activities 1-7 and the transition of new products into acquisition. Within this structure, there must be a working relationship

between the lab and Air Force prime contractors. If the role of AFRL is acquisition support, the Air Force must hold the lab accountable for contract performance regarding cost, schedule, and deployment of new products. If the Air Force decides upon a hybrid approach, the service must clearly identify which laboratory elements are responsible for specific deliverables. It is improper to hold any laboratory responsible for products it is not authorized or staffed to accomplish.

3. The Air Force should establish performance metrics independent of which course of action is selected. If research, development, technology, and engineering is the path, publications in referred journals and scientific accomplishments are appropriate. If acquisition support is needed, prime contractor performance is necessary if the technical staff has decision authority.
4. The Air Force should measure AFRL performance compared to other service corporate labs (Naval Research Lab, Army Research Lab) and the DOE National Nuclear Security Administration National Labs. The service should consider a technology S-curve analysis on patents. This type of study was performed in 2013–14 by the office of the Undersecretary of Defense for Research & Development Laboratory, but results were not released. The service should implement Fry's recommendations to enhance career opportunities for uniformed scientists and engineers that will benefit their growth and the effectiveness of Air Force systems.
5. Based on the results of the analysis above, if performance is not sufficient when compared to other labs, the Air Force should consider alternative governance models such as the Working Capital Fund, reimbursable funding, FFRDCs, and university-affiliated research centers.

While this type of change is disruptive and disconcerting to many, all indications are that the DoD laboratory system will not be a competitive force in the twenty-first century without this change. One approach to forestall concerns about how to transition to a new model of operations is to maintain the existing system while moving to a new operational system over time. That is, offer the existing workforce the opportunity to move to a new organizational construct—primarily the early- and mid-career workforce—while allowing senior technical staff to remain government employees to eliminate risks and concerns with retirement planning. Although a potentially complex approach, this would eliminate political resistance because no one's financial well-being would be jeopardized.

These recommendations for the Department of Defense and for the Air Force will help retain the best of the DoD lab workforce and infrastructure while leveraging the larger research and development ecosystem in the United States. These actions will reinvigorate DoD labs, making them once again a critical DoD and service asset for the twenty-first century as they were in the years of lab research and development excellence following World War II.