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China's Role in Making Outer Space More Congested, Contested, and Competitive

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Executive Summary

This paper addresses how China's rapidly expanding space program challenges U.S. access to space. In 2011, the U.S. National Security Space Strategy described outer space as "congested, contested, and competitive." As more countries operate in space, the United States has raised concerns over the sustainability of the space environment, the proliferation of space weapons, and its ability to remain commercially competitive in space. One of the most important countries contributing to the congested, contested, and competitive nature of space is China.

Key Findings

- **China is a major contributor to space congestion**. Although Chinese satellites make up nearly 7 percent of the total number of satellites in orbit, China accounts for nearly 25 percent of the total amount of space debris, mainly due to its 2007 antisatellite test. The increased risk of collisions between spacecraft and between debris and spacecraft could raise the costs of operating in orbit. These costs could include replacing spacecraft more often because of collisions and over-engineering spacecraft to make them more resilient.

- **China is developing a wide range of counterspace technologies, including direct-ascent kinetic kill vehicles (KKVs), co-orbital satellites, directed-energy weapons, jammers, and cyber capabilities**. Taken together, Chinese counterspace and counterspace-related activities likely represent the intention to undermine the U.S. military's conventional advantage by threatening satellites from the ground to geosynchronous orbit (GEO).

- **China is placing increasing importance on its commercial space sector**. China currently has more than 160 commercial space companies, offering products and services ranging from satellite manufacturing to orbital launch. Chinese mercantilist industrial policies could result in China offering cheaper alternatives to U.S. space products and services. Chinese satellite developers may become more prominent as the demand for smaller, less sophisticated, and less expensive satellites lowers customer requirements and expectations for functionality and reliability.

Introduction

This paper addresses how China's rapidly expanding space program potentially challenges U.S. access to space. In 2011, the U.S. National Security Space Strategy (NSSS) described outer space as "congested, contested, and competitive."[1] As more countries operate in space, the United States has raised concerns over the sustainability of the space environment, the proliferation of space weapons, and its ability to remain commercially competitive in space.

One of the most important countries contributing to the congested, contested, and competitive nature of space is China. China has announced its intention to become the leading space power, surpassing the United States by 2045.[2] The expansion of capabilities that will result in its efforts to achieve this goal will likely impact the U.S. ability to access space physically, militarily, and commercially. Its expanding launch capabilities and increasing on-orbit satellite inventory will exacerbate crowding in the Earth's orbital domain. The development of a robust suite of counterspace capabilities, including direct-ascent kinetic kill vehicles (KKVs), directed-energy, electronic warfare, cyber capabilities, and co-orbital satellite systems threatens U.S. space operations. Observers in the United States are also concerned that China's nascent commercial space industry may displace the U.S. commercial space industry through mercantilist trade policies.

"Congested, Contested, and Competitive" Explained

Why is outer space congested?

Earth's orbits are increasingly crowded. More than 900,000 objects greater than one centimeter, some natural, such as asteroids, and some man-made, such as satellites, rocket bodies, and other debris, orbit the Earth.[3] As more countries have become active in space, the increasing number of satellites, and the concomitant debris produced by their launch and operation, threaten the normal operation of satellites. Plans by commercial companies to create satellite communications networks composed of thousands of satellites, such as SpaceX's Starlink constellation, will also exacerbate crowding in low Earth orbit (LEO).

The increasingly congested nature of LEO heightens the chance of collisions, not only between satellites and debris but also between satellites. Between 1999 and September 2020, the International Space Station (ISS) conducted 26 debris-avoidance maneuvers. In 2009, an Iridium communications satellite and a derelict Russian Cosmos military satellite accidently collided.[4] Moreover, the hypersonic speeds of objects orbiting the earth—17,500 mph—mean that even small pieces of debris can have a large impact. In 2016, for example, a piece of debris identified as either a fleck of paint or small piece of metal measuring just a few thousandths of a millimeter across chipped a window on the ISS.[5]

According to computer simulations conducted by six different space agencies, "even with a 90 percent compliance of the commonly-adopted [space debris] mitigation measures" the amount of debris in LEO is "expected to increase by…approximately 30 percent in the next 200 years," even if commonly used measures are adopted and no explosions take place.6 The region in LEO between 700 and 1,000 kilometers will also see additional collisions similar to the Iridium- Cosmos collision every five to nine years.[7] The need to more frequently replace damaged satellites coupled with the need to over-engineer satellites to make them

more resilient to collisions will likely increase the costs of spaceflight.[8]

Why is outer space contested?

Countries increasingly treat outer space as a warfighting domain. During the Cold War, only the United States and the Soviet Union had space weapons. But as more militaries have increased their use of space, denying space capabilities to an adversary is seen as an asymmetric approach to countering conventional military superiority and as a sign of great power status. Today, China, Russia, France, India, Iran, and North Korea are fielding or testing counterspace technologies intended to degrade, disrupt, or destroy space capabilities.[9]

Space weapons come in a variety of forms. They include direct-ascent KKVs, co-orbital satellites designed to attack another satellite in orbit, directed-energy weapons such as lasers, electronic warfare weapons such as jammers, and computer network attack. Not every country is developing the full range of space weapons. Iran's counterspace capabilities, for example, have been assessed "to have very limited military utility" and focus on jamming civilian satellite communication signals.[10] Similarly, North Korea's "very limited military counterspace capabilities" include the ability to jam GPS's civilian signal.[11] China and Russia, on the other hand, have much more extensive counterspace programs.[12] The dual-use nature of most space technologies, however, means that technologies developed for peaceful civilian use can have military applications. Moreover, defining what is a space weapon is often in the eye of the beholder. The Soviet Union, for example, argued that the U.S. space shuttle was designed to bomb targets from orbit, and that the shuttle's robotic arm was intended to capture Soviet satellites.[13]

Why is outer space competitive?

Lower market-entry barriers and expanding expertise have increased the number of countries and entities involved in space commerce. Between 2005 and 2019, the space economy grew from $179.65 billion to $423.8 billion, and the number of spacecraft serving commercial missions increased from 170 in 2018 to 251 in 2019.[14] Commercial space encompasses many different activities, including those that were once restricted to government actors. Although companies like SpaceX have popularized commercial space, space launch is just one sector of the space economy. Companies are also involved in providing hardware or services in the fields of satellite manufacture, remote sensing, communications, positioning navigation and timing, and even space situational awareness.[15]

The proliferation of commercial space actors has eroded the U.S. competitive advantage and technological lead in space as barriers to market entry have lowered and international expertise has grown. Although U.S. space startups have traditionally dominated the commercial sector, in 2019 nearly 60 percent of space startups were outside the United States.[16]

China's role in making outer space more congested, contested, and competitive

How does China's space program increase congestion in outer space?

China is a major contributor to space congestion. Although Chinese satellites make up nearly 7 percent of the total number of satellites in-orbit, China accounts for nearly 25 percent

of the total amount of space debris. China's contribution to space debris is accentuated by its status as a relative newcomer to space. China launched its first satellite in 1970 but did not become a major launcher of satellites until after 2000. By comparison, although U.S. satellites constitute 41 percent of the total number of satellites in orbit, the United States is responsible for 32 percent of the total amount of space debris.

The primary reason for China's relatively large share of space debris was its 2007 KKV test against a retired meteorological satellite. That test, the single largest debris-producing event in history, created 3,400 pieces of space debris, more than half of which are expected to be in orbit in 2027.[17]

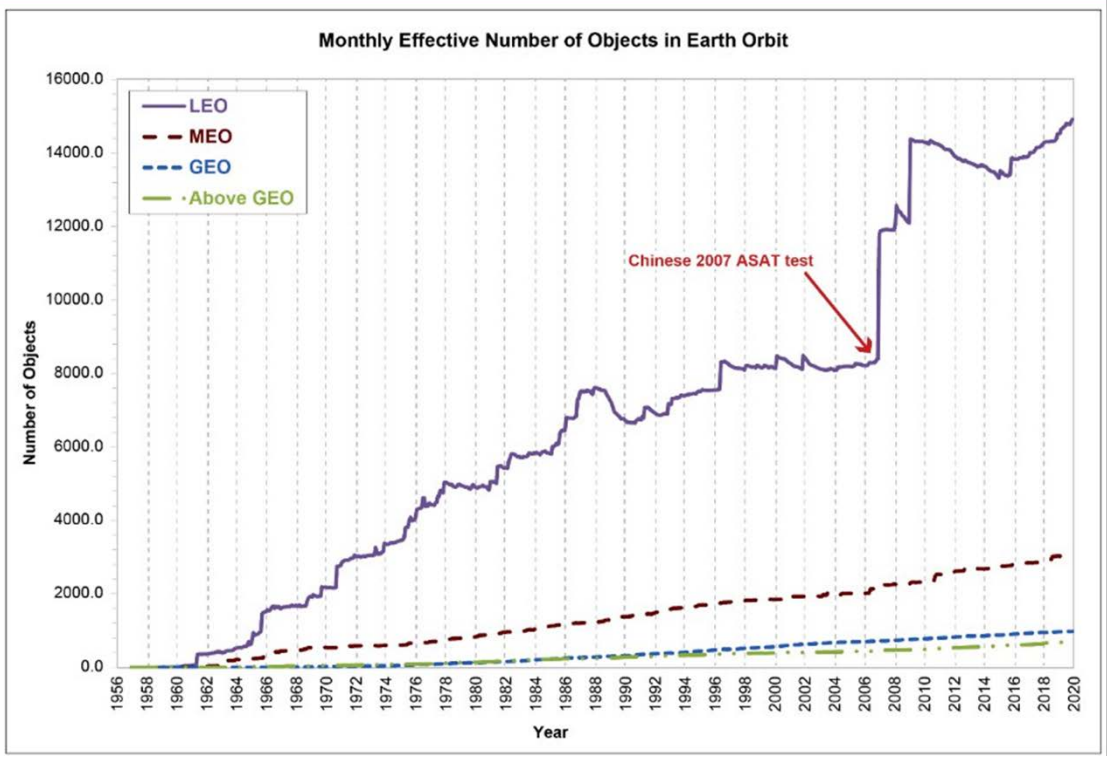
Since its 2007 test, China appears to have become more serious about mitigating the threat of space debris. In 2014, at the Inter-Agency Space Debris Coordination Committee's (IADC) 32nd annual meeting in Beijing, an official from the Chinese Foreign Ministry stated, "China requires its domestic institutions to conduct space activities in accordance with the work plan of the IADC and urges the Chinese space agency and enterprises to abide by its own guidelines on mitigation of space waste."[18] However, China has not publicly released its space debris mitigation policy, in contrast to the U.S. government, the National Aeronautics and Space Administration, the European Space Agency, and France.[19]

Table 1. Orbiting spacecraft, rocket bodies, and debris

Country/Organization	Spacecraft*	Rocket Bodies & Debris	Total
China	441	3.810	4.251
Commonwealth of Independent States	1,551	5,696	7,247
European Space	93	56	149
France	72	510	582
India	101	119	220
Japan	189	145	334
United States	2,866	4,998	7,864
Other	1,131	123	1,254
Total	6,444	15,457	21,901

*Active and defunct.
Source: NASA, Orbital Debris Quarterly News, February 2021, https://www.orbitaldebris.jsc.nasa.gov/quarterly- news/pdfs/odqnv25i1.pdf.

Figure 1. Monthly effective number of objects in Earth orbit



Source: NASA, Orbital Debris Quarterly News, April 2020,p. 11, https://www.orbitaldebris.jsc.nasa.gov/quarterly-news/pdfs/odqnv24i2.pdf.

China appears to have taken a number of practical and regulatory steps to carry out this plan:

- In contrast to its 2007 test, between 2010 and 2018, China conducted seven KKV tests that created little or no long-term debris.[20]

- China states that it has redesigned its launch vehicles to minimize the creation of debris and has retired satellites to higher orbits so that they do not interfere with operational satellites.[21]

- In 2005, China established guidelines for reducing space debris and, in 2015, revised these guidelines. The "Space Debris Mitigation Requirements" (Kongjian yapian jianhuan yaoqiu; 空间碎片减缓要求) are described as being in line with the United Nations Space Debris Mitigation Guidelines and the IADC Space Debris Mitigation Guidelines.[22]

- China has stated that it established a space debris coordination and expert group, a

> space debris high-speed-collision testing center, and the Chinese Academy of Sciences Space Target and Debris Monitoring Research Center (Zhongguo kexueyuan kongjian mubiao yu yapian guance yanjiu zhongxin; 中国科学院空间目标与碎片观测研究中心) to better research and coordinate its space debris mitigation efforts.[23]

In addition to increasing the amount of space debris, China's space program is also expected to contribute to space congestion through the launch of more satellites. As of June 1, 2021, China had 439 active satellites in orbit. In comparison, the United States had 2,717 active satellites in orbit.[24] The number of Chinese satellites is expected to increase as its space program develops. In particular, China's application with the International Telecommunications Union for two constellations with a total of 12,992 satellites will increase congestion in addition to the megaconstellations being launched or developed by SpaceX, Amazon, and OneWeb.[25]

How does China contest outer space?

Space plays a central role in China's plans to project power far from its shores and in its abilities to defeat high-tech adversaries, such as the U.S. military. China's military has designated outer space as a warfighting domain—described as a "new commanding height of war"—that China must fight for and seize if it is to win future wars. People's Liberation Army (PLA) officers and analysts assert that space is the ultimate high ground and that whoever controls space controls the Earth.[26] These analysts describe space-based command, control, communications, computers, intelligence, surveillance, and reconnaissance systems as a critical part of a modern military sensor-to-shooter network.[27] At the same time, Chinese military analysts regard space as a critical vulnerability that can debilitate an enemy, if access is denied.[28]

China is developing a wide range of counterspace technologies. These include direct-ascent KKVs, co-orbital satellites, directed-energy weapons, jammers, and cyber capabilities.[29] In 2007, China destroyed one of its weather satellites with a direct-ascent KKV. Since then, China's counterspace program has only become more robust through a series of counterspace and counterspace-related testing. Taken together, Chinese counterspace and counterspace-related activities likely represent the intention to undermine the U.S. military's conventional advantage by threatening satellites from the ground to GEO.

In recent years, China's counterspace program has begun the transition from development and testing to deployment. According to the U.S. intelligence community, "China has already fielded ground-based ASAT missiles intended to destroy satellites in LEO and ground-based ASAT lasers probably intended to blind or damage sensitive space-based optical sensors on LEO satellites."[30] In 2018, cybersecurity company Symantec revealed that attacks coming from Chinese IP addresses had targeted a satellite communications operator and a geospatial imaging and mapping organization.[31]

Table 2. Chinese counterspace and counterspace-related developments

Type	Year	Description	Comments
Direct Ascent	2007	KKV test	
	2010	Mid-course ballistic missile defense test	
	2013	Mid-course ballistic missile defense test	
	2013	KKV test	Test to GEO. China called it "high altitude science mission."
	2014	KKV test	China called it ballistic missile defense test. U.S. called it ASAT test.
	2015	Unknown test	
	2017	Unknown test	
	2018	Mid-course ballistic missile defense test	
	2019	DNI reports that China "has an operational ground-based ASAT missile intended to target low-Earth-orbit satellites."	
Co-orbital	2010	Two Shijian satellites involved in close proximity operation, causing slight change in one satellite's orbit	
	2013	Three satellites involved in close proximity operation to test space debris removal and robotic arm technologies	
	2016	Aolong-1 tested robotic arm to remove space debris	
	2016	Shijian-17 rendezvous with ChinaSat-5A	
	2018	TJS-3 satellite released probable subsatellite	
Cyber	2012	Attack against Jet Propulsion Laboratory	Allowed "full functional control" over JPL networks
	2014	Attack against NOAA	
	2017	Attack against Indian satellite communications	
	2018	Attack against satellite operators, defense contractors, and telecommunication companies	
Directed Energy	2006	Lased U.S.-remote sensing satellite	Intent unknown
	2021	DNI reports that China has already fielded "ground-based ASAT lasers probably intended to blind or damage sensitive space-based optical sensors on LEO satellites."	

Source: Brian Weeden and Victoria Samson, eds., *Global Counterspace Capabilities: An Open Source Assessment*, April 2021, https://swfound.org/counterspace/.

How do Chinese companies increase competition in the commercial space sector?

The Chinese government has been placing greater attention on developing China's commercial space industry since 2014. In November 2020, China was reported to have more than 160 commercial space companies, offering products and services ranging from satellite manufacturing to orbital launch.[32] Most of these companies were established since 2014 and their business operations are largely constrained to the domestic market.

Unlike in the United States, Chinese commercial space companies can include state-owned firms. A 2019 Chinese regulatory notice defines commercial launch activities as "companies using their own capital, private capital, and joint-capital/joint-venture models" to "satisfy national security and public interests" with "profit as the main objective."[33] As a result, some Chinese commercial space companies could potentially receive significant government support.

A strong Chinese commercial space sector has several implications for the United States that range across the congested, contested, and competitive outer space landscape: Chinese mercantilist industrial policies could result in China offering cheaper alternatives to U.S. space products and services. Such actions would undermine the profitability of the U.S. commercial space sector and render it less able to achieve U.S. policy goals.

Chinese satellite developers may become more prominent as the demand for smaller, less sophisticated, and less expensive satellites lowers customer requirements and expectations for functionality and reliability. The proliferation of these types of products using non-regulated, commercial off-the-shelf technologies will provide opportunities for non-Chinese satellite manufacturers to launch their satellites legally on Chinese launchers compliant with U.S. export control laws.

Chinese commercial space providers could offer technologies and services to countries that could use them to counter U.S. presence and operations globally. For example, Chinese remote-sensing data provided to U.S. adversaries could complicate U.S. military efforts to conceal its intentions and provide security to U.S. forces. Satellite communications could enable U.S. adversaries to conduct longer-range operations, and the Beidou satellite navigation system could provide an alternative to GPS and allow foreign militaries to be more independent of U.S. weapon systems.

The rapidly rising number of new commercial space companies in China suggests that many of them will be unfamiliar with, or unconcerned about, operating their spacecraft in ways that preserve space sustainability. Practices such as not deorbiting satellites as they reach the end of their service life or insufficient reliability may cause a proliferation of space debris.

Chinese commercial space companies could seek to acquire foreign companies to access better technologies. Such activities would require increased vigilance through the Committee on Foreign Investment in the United States to protect U.S. intellectual property and monitor efforts to acquire non-U.S. companies.

Conclusion

China's role in making space more congested, contested, and competitive is indicative of the long-term competition between the United States and China in which China has become a global power, in part, through the use of space. China's primary motivation for its space program is national security. However, as China's space program advances, its commercial and scientific activities will become more prominent and will extend the competition to encompass economics and diplomacy. Coordinated actions that emphasize U.S.-led diplomatic, scientific, military, and economic approaches to space and their role in helping other states achieve their space objectives will be the best guarantee of maintaining the U.S. lead in space affairs.

Endnotes

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