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U.S. DETERRENCE OPTIONS IN A TWO-RIVAL THREAT ENVIRONMENT

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Executive Summary

From communications and navigation to intelligence and targeting, space is involved in nearly every aspect of U.S. military operations. U.S. rivals, however, are investing in capabilities that are increasingly putting U.S. space assets and, ultimately, access at risk.

Military competition in and for space is rising. Both the People's Republic of China (PRC) and the Russian Federation have put significant effort into developing, demonstrating, and fielding counterspace capabilities. The capabilities—including direct-ascent anti-satellite weapons, co-orbital weapons, directed energy, and electronic warfare and cyber capabilities—could allow the Chinese and Russian militaries to threaten U.S. space systems. These militaries' doctrines portray the U.S. armed forces' use of space, which Chinese and Russian analysts perceive as an asymmetric reliance on space, as a vulnerability that the PRC and Russia can exploit to shape U.S. behavior before conflict and to disrupt U.S. fighting power during conflict. Furthermore, these two countries are increasingly working together in space, and there are several scenarios under which the United States would need to compete with and deter both China and Russia simultaneously.

The two most recent National Defense Strategies employ a force-sizing construct based on fighting and winning a war in one theater while deterring opportunistic aggression elsewhere. This construct, however, does not fit the realities of the military competition in space. Is the United States prepared to compete with and deter two space rivals at the same time?

This report contends that the United States cannot treat the space threats from China and Russia in isolation and must instead be prepared to deter or counter both simultaneously. To compete and deter in a two-rival space environment, the U.S. Space Force (USSF) should adopt a more proactive approach and match resilience efforts with investments in counterspace capabilities that would enable the United States to apply a deterrence-by-punishment approach in space. Such an approach would suggest developing, exercising, and selectively revealing space weapons. Leveraging these weapons would enable deterrence-by-punishment options and support cost imposition during both peacetime and conflict. Ultimately, balancing resilience with a more proactive strategy that adopts a two-rival force concept would provide the United States with a framework to strengthen U.S. freedom of action in space and on Earth.

Key Findings

The space environment is becoming more contested and more dangerous for the United States, and current approaches to deterrence may not be sufficient.

- **China is investing heavily in its space and counterspace capabilities**. Its space architecture, which is growing and becoming more capable, supports terrestrial operations, particularly in the Indo-Pacific. At the same time, the People's Liberation Army (PLA) has put significant effort into counterspace capabilities. Chinese doctrinal emphasis on preemption suggests that, if a terrestrial conflict were on the horizon, U.S. space capabilities could be targeted early, putting U.S. mobilization and kill chains at risk. The PLA's increasing reliance on space for terrestrial use may limit its actions in space out of concern for harming its own capabilities. As a result, the PLA may emphasize soft kill capabilities. As long as the PLA judges, however, that threatening U.S. space assets will bring it more benefits than costs, China's counterspace capabilities will represent a significant threat to U.S. space capabilities. The trajectory of China's space program continues relatively unabated, suggesting the threat will expand into the near- and medium-term future, if not beyond.
- **The Russian space program, though more limited than those of China and the United States, could pose significant threats to U.S. capabilities.** Constrained by resource limitations and structural disadvantages, the Russian space program lacks the potential of the U.S. and Chinese programs. However, Russian space capabilities are still notable, and its mature and growing anti-satellite weapon (ASAT) capabilities are tailored toward the United States. This combination of strong ASAT capabilities and weaker space capabilities suggests that Russia may be more risk acceptant in space than China as it works to compete asymmetrically in space. Russia will likely continue to invest heavily in counterspace weapons and may continue to use its counterspace programs to disrupt and shape U.S. and allied activities.
- **China and Russia are increasingly working together in space, and the United States will have to compete with and deter them simultaneously.** The Sino-Russian space relationship appears to be an effort to balance against U.S. space dominance. Since 2014, cooperation between Russia and China has grown closer, marking a new phase in their space relationship characterized by more reciprocal contributions. In the past, the Chinese space program benefitted more from Russian help than vice versa, but the reverse is increasingly true today: The Russian space program is likely to rely to a growing extent on China.
- **Growing Sino-Russian cooperation could threaten the United States in several ways.** First, their support of each other's programs reinforces their own national capabilities, not only directly strengthening each other's capabilities through technical and industrial cooperation but also potentially by sharing lessons learned. Second, if they were to coordinate actions, one of them could distract or threaten U.S. space forces while the other took action in space or on Earth. Third, any growing

interlinkages between Chinese and Russian space assets could create scenarios in which the United States will have to be careful not to inadvertently pull one country into an ongoing crisis or conflict with the other.

- **Both China and Russia perceive that the United States is asymmetrically reliant on space for the conduct of military operations and believe that holding space capabilities at risk can coerce the United States.** Both also have forward-leaning approaches that emphasize not just signaling for deterrence but also demonstrating capabilities and taking early action to force the United States and other targets to react or back down.
- **There are likely limits to their relationship, and their cooperation does not mean that China and Russia pose the same challenge in space.** For example, Russia has fewer space assets and is limited in its ability to build out a robust space architecture. Whether a reflection of these realities or a different approach, Russia appears to be careful not to build too much reliance on space. China, on the other hand, is building a much more expansive space architecture. Russia may thus be more risk acceptant than China and may try to use space to bring others down instead of to build itself up. It may also be more likely than China to demonstrate and test counterspace weapons and to be more publicly brazen in its threats. Because Russia can be perceived as having less to lose in space than its adversaries, it could be more unpredictable and potentially dangerous.
- **Several scenarios would require the United States to contend with counter-space threats from both China and Russia simultaneously, and traditional strategies for mitigating the problem of simultaneity terrestrially do not work as well in the space domain, heightening the risk of having to deter and deny two actors at once.** First, the United States already faces ongoing challenges in space from both China and Russia. Second, there are scenarios in which the United States may face China and Russia simultaneously on Earth, which would likely require the United States not only to defend U.S. space capabilities from both adversaries but also potentially deny them access to their own space capabilities. Third, even if the United States were fighting a terrestrial war with just one of these countries, it would still likely need to account for counterspace threats from both as the noncombatant could continue previous counterspace activities, escalate its counterspace activities, or support the warring country in space.
- **The public discussion of U.S. approaches to deterrence in space focuses on deterrence by denial and, in particular, on resilience.** Resilience in space can take several forms, including disaggregation, distribution, diversification, reconstitution, and proliferation. Other measures to increase a deterrence-by-denial approach could include hardening satellites against ASATs. The United States has been pursuing multiple routes to increased resilience and denial, with proliferation as one frequently discussed approach.

- **Resilience-based approaches likely affect adversaries' threat calculations.** For example, proliferation in low Earth orbit (LEO) could make the costs of launching a direct-ascent ASAT to attack a satellite in orbit not worth the relatively minimal effect to resilient U.S. capabilities. Importantly, resilience also mitigates the effects of space attacks should deterrence fail.

- **Adversaries may seek to use counterspace weapons not only to damage U.S. capabilities, but also to deter the United States from intervening in conflicts in the first place. Resilience can contribute to efforts to convince adversaries that the United States will not be deterred by threats to its space capabilities.** One approach to this threat would be to increase resilience so attacks will not succeed—but Chinese and Russian deterrence attempts may still work if U.S. officials are not confident in the United States' resilience in space and thus hesitate to act. Resilience not only demonstrates to adversaries that some of its threats will not succeed; it also provides value by building up U.S. confidence in the country's own ability to operate in the face of counterspace attacks and, in the case of deterrence failure, by providing greater likelihood of minimized disruption.

- **However, a resilience-based approach is likely not sufficient to deter aggressive behavior in space.** Adopting that approach alone restricts U.S. options, has limited effects on some major threat types and potential targets, and is largely latent. A resilience-based approach may not be sufficient to defend against certain nonkinetic attacks or to protect existing constellations of high-performance, exquisite satellites upon which the United States will likely rely for many years. The Department of Defense will also be unable to ensure the resilience levels of commercial and allied space assets that it may be called to defend. At a broader level, signaling about resilience and denial could fail to accurately transmit messages to adversaries, impacting the degree to which adversaries' decision calculi are changed. In other words, resilience may be necessary, but it may not be sufficient.

- **The development, demonstration, and fielding of counterspace weapons would add flexibility to the U.S. space toolkit.** First, counterspace weapons provide a stronger deterrence-by-punishment mechanism. Threatening to disrupt adversaries' own space capabilities if they disrupt those of the United States is a more realistic and credible deterrence-by-punishment option than cross-domain options, allowing the United States to threaten proportionate punishment in the same domain as the behavior to be deterred. In addition to providing a stronger deterrence-by-punishment mechanism, counterspace options create opportunities for cost imposition during both competition and conflict.

Recommendations

- **The United States should think of its deterrence goals in space as twofold.** First, it should work to maintain full access to its space capabilities to enable terrestrial warfare, society, and economics. Second, it should work to ensure that adversaries do not use space to try to limit U.S. freedom of action on Earth and in space. This implies both seeking to convince China and Russia not to threaten or conduct counterspace attacks in the first place and building U.S. resilience to such threats so that U.S. freedom of action is not limited by Chinese or Russian threats.
- **The United States should emphasize building a balanced space architecture that is both resilient and capable of being proactive.** Investing in both resilience and counterspace options will provide the United States with more flexibility to pursue its objectives in space and to deter adversaries. A balanced approach would enable both deterrence by denial and by punishment and strengthen the United States' options during all stages of competition. Indeed, adding an option for deterrence by in-domain punishment to the U.S. toolbox would enhance its deterrence posture in a two-rival threat environment. A mixed deterrence approach relying on both deterrence by denial and deterrence by punishment (both cross- and in-domain) would enable the greatest protection of U.S. assets and afford the United States the most flexibility. The United States could also tailor deterrent options to each rival, capability, and situation.
- **To support deterrence efforts and provide cost imposition tools during peacetime and conflict, the United States should invest in more counterspace capabilities.** Efforts should focus on capabilities that avoid creating debris and minimize the risk of inadvertent or unintended escalation, suggesting that a deterrence-by-punishment approach adopted by the United States should prioritize highly discriminate counterspace capabilities that minimize or do not create debris.
- **To maximize the effectiveness of deterrence by punishment and cost imposition using counterspace weapons, the United States will need not only to increase investment in counterspace capabilities but also refine policies for when and how to reveal such capabilities.** Credibly threatening counterspace actions would require selective demonstration of the capability to follow through on the threats. Revealing capabilities, however, comes with the risk of allowing adversaries to observe the capability and develop countermeasures to or copy them. Thus, policymakers adopting counterspace weapons for deterrence and cost imposition will need to carefully calibrate when and which capabilities to reveal.
- **The Department of Defense should continue to invest in space domain awareness (SDA)**. SDA can enable attribution, which would be key for any deterrence-by-punishment efforts. The United States would have to demonstrate this ability to attribute.

- **The U.S. armed forces should hold more training programs and exercises to examine dynamics of deterrence and management in space**. These exercises could include developing and refining operational concepts for the threat and/or use of counterspace weapons for deterrence purposes. Exercises should also test resilience, in part to increase policymakers' confidence that resilience measures would allow the United States to continue to operate even in the face of adversary threats to U.S. space assets.
- **The Pentagon should continue to consider ways to bolster its own space efforts through external partnerships.** For example, the Pentagon should explore ways that allies can complement and support U.S. space activities and deterrence as well as strengthen their own deterrence efforts. The Pentagon should also continue to seek ways to boost its cooperation with the U.S. (and, possibly, allied) space industry, particularly to improve space resilience efforts. The U.S. government could also consider cross-cutting ways to capitalize on and continue to bolster the U.S. space sector. At the same time, there should be serious conversations about the role the USSF and others will play in protecting commercial space entities from attack and about expectations of the companies to harden themselves and their assets.
- **Investments in defense and resilience should continue, including those that would shore up the U.S. ability to operate in the face of disrupted space capabilities.** In addition to space-based resilience, shoring up redundancy in systems like advanced surveillance unmanned aerial vehicles and ground-based communications systems can allow the United States to focus on the mission, not just the domain.
- **Finally, Defense Department planners should adopt a two-rival force planning construct for space.** The United States faces two strong challengers in space and may have to compete with and deter them simultaneously. As the United States considers making investments in both resilience and counterspace weapons, it should balance qualitative and quantitative approaches to managing the problem of simultaneity.

The threats to U.S. space capabilities are real. China and Russia are already actively challenging U.S. space superiority and increasingly investing in, testing, and demonstrating ASAT capabilities targeted at the United States. They do so not only to deny a U.S. advantage but also to limit U.S. actions on Earth by trying to exploit a perceived U.S. reliance on space. Access to space is vital for U.S. military operations, and it would be very difficult for the United States to field alternatives to space-based and space-enabled capabilities that would be equally capable. The United States must work to protect U.S. space capabilities and ensure threats in space do not limit U.S. freedom of action.

Existing efforts at building U.S. resilience are key parts of any U.S. space strategy. Resilience contributes to a deterrence-by-denial approach. It also helps minimize disruption to space-based capabilities in case of deterrence failure. There is another important, potentially overlooked benefit that resilience provides: Resilience can play a role in ensuring that adversaries' efforts to deter the United States through space threats fail by increasing U.S. policymakers' confidence that the United States could still operate in the face of any such threats. At the same time, however, resilience-based approaches are limited in their ability to deter major threats, protect commercial and allied space assets, and proactively shape the space environment. Resilience also contributes minimally to cost imposition.

To support and supplement resilience efforts, the United States should also invest in counterspace weapons and concepts. Counterspace weapons contribute not only to deterrence-by-punishment approaches, but also to cost imposition in peacetime and conflict.

A toolkit including resilience and counterspace weapons would enable a proactive space strategy in which the United States could shape space rather than just respond to threats as they emerge. Doing so while adopting a two-rival force planning construct would optimize USSF flexibility to support U.S. freedom of decision-making and U.S. space superiority. The United States is in a strong position to continue to take advantage of the benefits space offers—but it must act wisely now to ensure that position endures.

CHAPTER 1

The Importance of Space

From communications and navigation to intelligence gathering and targeting, space is involved in nearly every aspect of U.S. military operations. As one U.S. space official put it, "Space is in our DNA for the military. It's absolutely essential to our way of war."[1] U.S. rivals, however, are investing in capabilities that are increasingly putting U.S. space assets—and, ultimately, space access—at risk.

The United States was long the beneficiary of a benign space environment, but now military competition in and for space is rising. Both the People's Republic of China (PRC) and the Russian Federation have put significant effort into developing, demonstrating, and fielding counterspace capabilities that could allow the Chinese and Russian militaries to threaten U.S. space systems. The Chinese and Russian militaries also have doctrines that portray the U.S. armed forces' use of space as a vulnerability they can exploit to shape U.S. behavior before conflict and to disrupt U.S. fighting power during conflict. Each country's doctrine and capabilities individually threaten U.S. space capabilities, but the PRC and Russia may also cooperate or coordinate actions in space, forcing the United States to compete with and manage threats in space from both countries simultaneously.

The two most recent National Defense Strategies have employed a force-sizing construct based on fighting and winning a war in one theater while deterring opportunistic aggression elsewhere. This construct, however, does not fit the realities of the military competition in space. Is the United States prepared to compete with and deter two space rivals at the same time?

Public discussion of military space strategy has focused on deterrence by denial and, in particular, resilience. This approach posits that a resilient architecture would make it too costly for rivals to succeed at denying U.S. space capabilities, so they will be deterred from attacking U.S. space assets. Resilience-based approaches—which can include aspects of

1 Jim Garamone, "Space Integral to the DOD Way of War, Policy Chief Says," DOD News, July 20, 2023, https://www.defense.gov/News/News-Stories/Article/Article/3465982/space-integral-to-the-dod-way-of-war-policy-chief-says/.

disaggregation, distribution, diversification, protection, proliferation, and deception—likely affect adversaries' threat calculations. A proliferated architecture in low Earth orbit (LEO), for example, could help deter physical attacks on individual satellites in that orbit. Resilience also, importantly, works to mitigate the effects of space attacks should deterrence fail. However, adopting this approach alone restricts U.S. options, has limited effects on some major threat types and potential targets, and is largely latent. In other words, an approach to space that is primarily based on resilience, although important, is insufficient for space competition with two major rivals and creates a risk that the United States may not have reliable access to space in case of conflict.

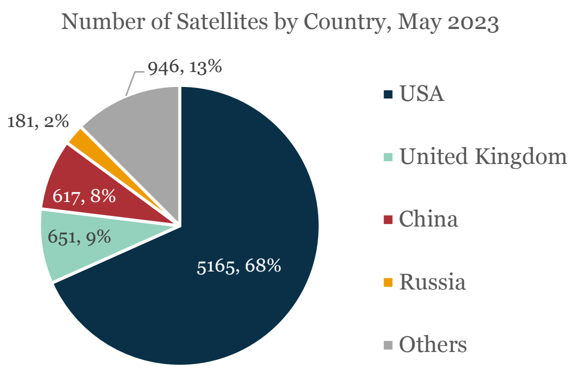
This report contends that the United States cannot treat the space threats from China and Russia in isolation and must be prepared to deter or counter both simultaneously. To compete and deter in a two-rival space environment, the U.S. Space Force (USSF) should adopt a more proactive approach and match resilience efforts with investments in counter-space capabilities that would enable the United States to apply a deterrence-by-punishment approach in space. Such an approach would suggest developing, exercising, and selectively revealing space weapons. Leveraging these weapons would enable deterrence-by-punishment options and support cost imposition during both peacetime and conflict. Balancing resilience with a more proactive strategy would provide the United States with a framework to strengthen its freedom of action in space and on Earth.

The Current State of Space

The space age brought significant economic and military benefits to the United States and other nations. From navigation to imaging and from weather mapping to satellite TV, space capabilities have changed the U.S. military, economy, and way of life.

The United States has enjoyed a benign space environment, and it maintains the world's largest satellite architecture (see Figure 1). Yet, the country now faces two major adversaries that have growing

FIGURE 1: GLOBAL LEADERS IN SATELLITES BY QUANTITY IN ORBIT



Data from Union of Concerned Scientists, "UCS Satellite Database," Union of Concerned Scientists, May 1, 2023, https://www.ucsusa.org/resources/satellite-database.

capabilities in the domain.[2] The space environment is no longer as permissive as it once was, and counterspace capabilities are increasing in both quantity and quality. China, which the 2022 *National Defense Strategy* (NDS) identified as the United States' "pacing challenge," has invested heavily in its own satellite architecture while also developing an array of anti-satellite weapon (ASAT) capabilities (see Callout Box 1).[3] Russia, described in the 2022 NDS as an "acute threat," has extensive space capabilities, but its current and future space program is constrained by economic and industrial limitations.[4] Russia has fewer satellites in orbit than either the United States or China, but it does possess individual satellites that are highly capable. It has also invested heavily in its ASAT program, including through reviving projects with origins in the Cold War.

2 The report focuses on Chinese and Russian space behavior and investments, given that these two nations currently have the most ASAT capabilities that could threaten U.S. space access. However, a growing number of space actors have invested in and could invest in ASAT and other technology. For example, India tested a DA-ASAT missile in 2019, becoming the fourth country to successfully demonstrate the capability. Terrorist organizations and other nonstate actors may also develop an interest in ASAT technology, particularly through relatively lower-cost methods such as targeting the ground-based support infrastructure and/or cyberattacks.

Allies are also investing in capabilities in spaces and ways to defend them. For example, in 2019, France announced a program to develop anti-satellite laser capabilities as part of a plan to defend its satellites. In 2019, NATO recognized space as an operational domain and released an "overarching space policy." In 2024, NATO established the NATO Space Operations Centre as part of Combined Force Space Component Command. The same year, 17 NATO allies signed a Memorandum of Understanding to establish the Alliance Persistent Surveillance from Space program to improve situational awareness and decision-making.

Brian Weeden, "Indian Direct Ascent Anti-Satellite Testing" (Washington, D.C: Secure World Foundation, May 2022), https://swfound.org/media/207370/swf-indian-da-asat-may-2022.pdf; Agence France-Press, "France to Develop Anti-Satellite Laser Weapons: Defence Minister," *France 24*, July 25, 2019, https://www.france24.com/en/20190725-france-develop-anti-satellite-laser-weapons-defence-minister; Joshua Posner and Saim Saeed, "France Lists Laser Weapons, Surveillance Satellites in Space Defense Plan," *POLITICO*, July 25, 2019, https://www.politico.eu/article/france-lists-lasers-weapons-surveillance-satellites-in-space-defense-plan/; Kaitlyn Johnson, "NATO in Space," in *NATO 2030: Towards a New Strategic Concept and Beyond*, edited by Jason Blessing, Katherine Kjellström Elgin, and Nele Marianne Ewers-Peters (Washington, DC: Foreign Policy Institute/Henry A. Kissinger Center for Global Affairs, Johns Hopkins University SAIS, 2021); NATO, "NATO's Overarching Space Policy," NATO, January 17, 2022, https://www.nato.int/cps/en/natohq/official_texts_190862.htm; NATO, "Alliance Persistent Surveillance from Space (APSS)" NATO, February 2023, https://www.nato.int/nato_static_fl2014/assets/pdf/2023/2/pdf/230215-factsheet-apss.pdf; and NATO, "NATO's Approach to Space," NATO, July 30, 2025, https://www.nato.int/cps/en/natohq/topics_175419.htm.

3 U.S. Department of Defense (DoD), *2022 National Defense Strategy of the United States of America* (Washington, DC: DoD, October 2022), iii.

4 DoD, *2022 National Defense Strategy*, 2.

CALLOUT BOX 1: COUNTERSPACE WEAPONS

There are essentially two ways to degrade space capabilities. First, an attacker can disrupt the information traveling to and from satellites by interrupting, blocking, or corrupting data flows. This can be done by targeting the information flow itself, the ground stations, or the mechanisms through which satellites receive data. An attacker can also disable a satellite through targeting its control systems, such as hijacking its control and commanding it to maneuver and thus burn off the limited fuel onboard. Second, an attacker can disable or destroy the capability of a satellite to perform its mission. This includes kinetically destroying or damaging satellite components or entire satellites, as well as nonkinetic effects like dazzling or blinding sensors and damaging electrical circuits and processors.

There are four broad categories of counterspace weapons:[5]

1. *Kinetic physical counterspace weapons* attempt to directly strike a satellite or detonate a warhead near it. There are two main types of weapons in this category: direct-ascent ASATs (DA-ASATs), which launch from Earth, and co-orbital ASATs, which are space based.

2. *Nonkinetic physical weapons* physically affect satellites or their ground systems without coming in physical contact with the target. Weapon types in this category include lasers, high-powered microwave (HPM) weapons, and chemical obscurants. Detonating a nuclear device in space, which would create a high-radiation environment that would damage satellites, may also fall into this category.

3. *Electronic weapons* target the electromagnetic spectrum through which data is transmitted and received. This includes jamming and spoofing signals.

4. Finally, *cyber weapons* in the context of counterspace target both the data itself and the systems that use, transmit, and control the data.

One can also create counterspace effects by attacking satellite ground stations with terrestrial weapons.

A rendezvous and proximity operation (RPO) involves intentionally maneuvering a space object to bring it close to another object. RPOs can be benign in intent, but they can also be used to position a weapon close to another satellite, enabling kinetic and nonkinetic attacks.[6]

5 These categories are adapted from Todd Harrison, Kaitlyn Johnson, and Makena Young, *Defense against the Dark Arts in Space: Protecting Space Systems from Counterspace Weapons* (Washington, D.C.: Center for Strategic and International Studies (CSIS); Rowman & Littlefield, 2021).

6 For a framework for cooperative and noncooperative RPOs in GEO, see Kaitlyn Johnson, Thomas G. Roberts, and Brian Weeden, "Mitigating Noncooperative RPOs in Geosynchronous Orbit," *Æther* 1, no. 4, Winter 2022.

The counterspace threat posed by China and Russia creates a challenge for the United States. Previously, the U.S. military could think of space as a sanctuary and assume space superiority. Under those assumptions, it placed an array of intelligence, communications, and other capabilities on orbit to support global force projection. Today, however, it must increasingly work to ensure its own access. If an adversary were to disrupt U.S. space access, U.S. military operations and options could be severely affected. A disruption of U.S. space capabilities could also have significant societal and economic impacts. One analysis has suggested that a total loss of GPS could have a financial impact of up to $45 billion over the course of a month, depending on severity and timing.[7]

In addition to other national actors, the number of commercial actors in space has risen, presenting both opportunities for and challenges to the U.S. military. On the one hand, commercial interest in space brings the opportunity to incorporate potentially cutting-edge technology into national security programs at possibly lower prices.[8] U.S. and perhaps allied commercial capabilities can also support a resilient space ecosystem by providing complementary or reserve capabilities that could be used in the case of disruption of certain mission sets. On the other hand, a growing private presence in space also brings challenges. For example, the U.S. military may not be the only target of adversarial ASAT threats: Rivals could also target commercial satellite functions, with the potential to interrupt everything from commercial navigation and payment processes to internet access and weather forecasting. Given the role these functions play in everyday life, the U.S. military may be called upon to help protect these capabilities. The growth in dual-use technology, commercial actors' support of military operations, and blurred lines between private- and government-owned and -operated assets could complicate assessments of threats and potential responses.

Increased activity in space and a greater number of actors participating in space have contributed to a more congested space environment.[9] The number of satellites in orbit has grown rapidly over the past several years (see Figure 3), with particularly notable growth in

7 Alan C. O'Connor et al., *Economic Benefits of the Global Positioning System (GPS): Final Report*, RTI Report 0215471 (Research Triangle Park, NC: RTI International, 2019), 14–2.

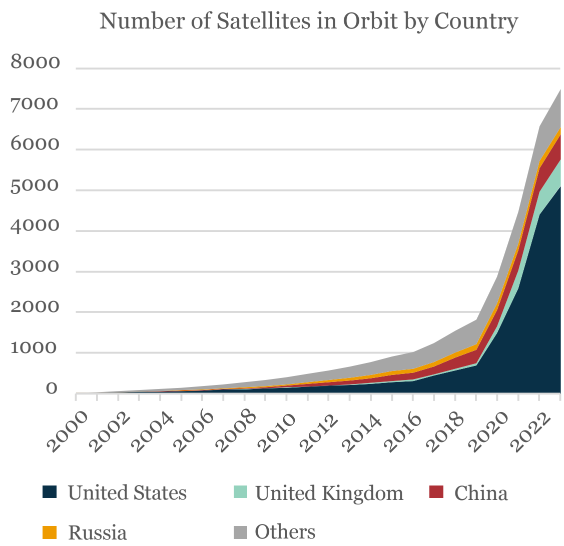
8 These effects are most likely to be felt in areas in which there is a commercial market. For more on the USSF's plans to integrate commercial technology, see USSF, *U.S. Space Force Commercial Space Strategy* (USSF, April 8, 2024).

9 The *2011 National Security Space Strategy* described space as more "congested, competitive, and contested." DoD and Office of the Director of National Intelligence, National Security Space Strategy: Unclassified Summary," Washington, DC: U.S. Department of Defense and Office of the Director of National Intelligence, January 2011. Others have asserted that space is more "diverse, disruptive, disordered, and dangerous." Harrison, Johnson, and Young, *Defense against the Dark Arts*, 2. On governance of space, see also Nina M. Armagno and Jane Harman, "Securing Space: A Plan for U.S. Action," Task Force Report (Washington, DC: Council on Foreign Relations, February 2025).

It should be noted that the congestion levels vary by orbit, with LEO being the most heavily congested. This is likely to have implications for decisions about future space architectures. Sandra Erwin, "Space Industry Undeterred by Congestion and Debris," *SpaceNews*, February 7, 2023, https://spacenews.com/space-industry-undeterred-by-congestion-and-debris/; and Alison Snyder, "Congestion in Earth's Orbit Is Getting Even Worse," Axios, May 5, 2024, https://www.axios.com/2024/05/05/satellites-crowded-orbit-spacex.

LEO.[10] Space junk and debris from man-made objects (including obsolete satellites, abandoned rocket parts, and paint chips that have fallen off rockets) also contribute to an increasingly congested space environment.[11] NASA has identified more than 25,000 objects larger than 10 cm in space and believes there are more than 100 million particles larger than 1 mm in orbit.[12] On average, debris moves at about 10 km per second (roughly 22,000 miles per hour) and can move as fast as 60 km per second (more than 134,000 miles per hour), so even extremely small objects can cause serious damage if they collide with other objects in space.[13]

FIGURE 3: GROWTH IN THE NUMBER OF SATELLITES IN ORBIT OVER TIME



Data from UCS, "UCS Satellite Database," 2023.

In the context of this new space environment, the *Defense Space Strategy*, released in 2020, emphasized building a comprehensive military advantage in space and maintaining "space superiority" to ensure freedom of operations in the space domain.[14] Doing so while facing two increasingly capable space competitors is no easy task.

10 See, for example: Congressional Budget Office, "Large Constellations of Low-Altitude Satellites: A Primer," Congressional Budget Office, May 2023, https://www.cbo.gov/publication/59175#footnote-021; and United States Government Accountability Office, *Large Constellations of Satellites: Mitigating Environmental and Other Effects*, United States Government Accountability Office, GAO-22-105166, September 2022, https://www.gao.gov/products/gao-22-105166;

11 See, for example: European Space Agency Space Debris Office, *ESA's Annual Space Environment Report*, European Space Agency (March 31, 2025), https://www.sdo.esoc.esa.int/environment_report/Space_Environment_Report_latest.pdf.

12 NASA Orbital Debris Program Office, "Frequently Asked Questions," NASA, accessed on June 11, 2024, https://orbitaldebris.jsc.nasa.gov/faq/.

13 Miria M. Finckenor and Kim K. de Groh, "A Researcher's Guide to: Space Environmental Effects," NASA ISS Research Integration Office, September 2020, 15, https://www.nasa.gov/science-research/for-researchers/a-researchers-guide-to-space-environmental-effects/.

14 DoD, *Defense Space Strategy Summary* (Washington, DC: DoD, June 2020).

Thus far, U.S. space officials have emphasized an approach based on resilience.[15] Will a strategy underpinned by resilience accomplish that goal under the conditions of a two-rival environment, or are new approaches necessary? USSF officials and documents have recently begun to discuss the need to be able to deny adversaries' use of space during times of terrestrial war, potentially creating opportunities to explore new deterrence options.[16] Furthermore, USSF has adopted as part of its Competitive Endurance initiative the mission of counterspace campaigning.[17] Details about what this means and what is necessary to achieve it, however, are unclear.

This report examines the space threat landscape to inform discussions about U.S. space strategy. It first describes Chinese and Russian space doctrine and investments, establishing that these U.S. adversaries have significant space and counterspace capabilities. Second, the report analyzes the overall space threat environment by positing that the United States may have to compete with and deter aggression from both actors simultaneously.

The report then asks whether the United States is positioned to solve this two-rival space problem. Approaches based on resilience have likely changed the cost calculations for adversaries—particularly in kinetically targeting assets in LEO—and increased the survivability of U.S. space-based capabilities in the case of deterrence failure and war. However, the current resilience-based approach risks failing to deter Chinese and Russian aggression in space. Furthermore, a focus on resilience is latent and is limited in its ability to support other goals the United States has in space. Although resilience does help provide stronger continuity or reconstitution of services should deterrence fail and these services be attacked, a resilience-based approach alone is insufficient to ensure U.S. freedom of action in space.

15 Gen. B. Chance Saltzman, USSF Chief of Space Operations, laid out this logic in 2023, saying the service needs to "shift [the offense–defense] balance by making an attack on satellites impractical, even self-defeating, discouraging an adversary from taking such actions in the first place." To do so, he emphasized "investing in resilient space order of battle." He also said, "The Space Force is investing heavily in shifting to more resilient space architectures." Theresa Hitchens, "Space Force Chief Outlines 3-Part 'Competitive Endurance' Theory Aimed at 'Space Superiority,'" *Breaking Defense*, March 7, 2023, https://breakingdefense.com/2023/03/space-force-chief-outlines-3-part-competitive-endurance-theory-aimed-at-space-superiority/.

In Frank Kendall's introduction to a Congressional report on Space Force strategy, he wrote that the Department of the Air Force is "focusing on a resilient space architecture" to protect U.S. space capabilities and to "deny a potential adversary's use of space systems" to attack U.S., allied, and partner forces. Frank Kendall, *Comprehensive Strategy for the Space Force*, Report to Congressional Committees (Arlington, VA: Department of the Air Force, August 2023).

Furthermore, even if the adversary launched the attack, building in resilience should lessen the negative impacts on U.S. performance.

16 For example, the 2024 *White Paper on Competitive Endurance* discussed the need for "counter-targeting capabilities" to "protect the Joint Force from space-enabled attack." USSF, *White Paper on Competitive Endurance* (USSF, January 11, 2024), 5.

In 2025, the USSF released a space warfighting framework: USSF, "Space Warfighting: A Framework for Planners" (Washington, DC: USSF, March 2025).

17 USSF, *White Paper on Competitive Endurance*.

In addition to investments in resilience, the United States should embrace a more proactive approach in space. To provide more deterrent options and enable other missions, the USSF should also invest in counterspace capabilities that can be selectively demonstrated to communicate that, should an adversary take a specified action, the United States could respond by threatening adversary capabilities. The development and selective disclosure of counterspace capabilities would provide the United States more flexibility and a greater number of options for managing peacetime space competition and, if necessary, conflict. The core of these capabilities should not cause debris and should be discriminate to reduce the risk of collateral damage and to maximize options to coerce adversaries. These investments should be matched by continued efforts at establishing and enforcing norms. Ultimately, these capabilities and a more proactive approach to shaping the space environment would provide the United States with options for conflict in case deterrence should fail and introduce ways to impose costs on rivals. A U.S. approach to space that balances resilience with proactive counterspace capabilities would provide the United States with a more flexible, sustainable, and effective framework to achieve its stated goal: space superiority.

CHAPTER 2

Chinese Military Space Activity and Investments

The USSF's 2023 *Comprehensive Strategy for the Space Force* described China as the "pacing challenge" in space, with the vice chief of space operations remarking in 2021 that the PRC was "fielding operational systems at an incredible rate."[18] The People's Liberation Army (PLA), which identifies space as key to both deterrence and military victory, has invested heavily in space and counterspace capabilities, quickly becoming a serious threat to U.S. space capabilities and terrestrial operations.

The PRC's national space program dates to the 1950s, with the PRC's first public mentions of space and counterspace capabilities occurring in the 1970s.[19] The 1990s, however, transformed how the Chinese Communist Party (CCP) understood the military value of space. The U.S. military's performance in the 1991 Gulf War, the 1995–1996 Taiwan Strait Crisis, U.S. modernization driven by the Revolution in Military Affairs (RMA) based upon the growth and spread of information technologies, and the development of concepts such as Network Centric Warfare all shaped the PLA's approach to space by highlighting the role space could play in supporting Command, Control, Communications, Computers, Intelligence,

18 *Comprehensive Strategy for the Space Force*, 2; and Josh Rogin, "A Shadow War in Space is Heating Up Fast," *Washington Post*, December 1, 2021.

19 For a broader history of the Chinese space program, see, for example, James Clay Moltz, *Asia's Space Race: National Motivations, Regional Rivalries, and International Risks* (New York: Columbia University Press, 2011); S. Chandrashekar, *China's Space Programme: From the Era of Mao Zedong to Xi Jinping* (Singapore: Springer, 2022); Brian Harvey, *China's Space Program—From Conception to Manned Spaceflight* (Berlin Heidelberg: Springer, 2004); and Brian Harvey, *China in Space: The Great Leap Forward* (Springer Nature, 2019). See also DoD, *Military and Security Developments Involving the People's Republic of China 2023*, Annual Report to Congress (Washington, DC: DoD, 2023), 98.

Surveillance, and Reconnaissance (C4ISR).[20] The Gulf War was especially impactful, as Chinese policymakers and analysts scrutinized the role GPS and other space systems played in supporting the United States' victory.[21] The PLA, recognizing the growing importance of information support at all levels of warfare, prioritized developing "informationized" systems with the goal of winning "informationized local wars" by using a systems-of-systems approach to employ information to the PLA's advantage across domains.[22] PLA strategists concluded that space capabilities were key to enabling informationized warfare and began rapidly investing in their own space architecture and developing concepts for how to best take advantage of space for its own benefit and to the detriment of adversaries.[23]

Space Strategy, Doctrine, and Organization

Although the PRC officially advocates for the peaceful use of space, Chinese government documents and statements make it clear that the CCP sees space as a domain of competition with the United States.[24] For example, its 2019 *National Defense White Paper* described

20 See, for example, James S. Johnson, "China's Vision of the Future Network-Centric Battlefield: Cyber, Space and Electromagnetic Asymmetric Challenges to the United States," *Comparative Strategy* 37, no. 5, October 20, 2018: 373–90, https://doi.org/10.1080/01495933.2018.1526563.

21 Dean Cheng, "China's Military Role in Space," *Strategic Studies Quarterly* 6, no. 1, Spring 2012; and Michael Dahm, "China's Desert Storm Education," *Proceedings* 147, no. 3, March 2021, https://www.usni.org/magazines/proceedings/2021/march/chinas-desert-storm-education.

22 Edmund Burke et al., *People's Liberation Army Operational Concepts* (RAND Corporation, 2020); M. Taylor Fravel, "China's New Military Strategy: 'Winning Informationized Local Wars,'" *China Brief (Jamestown Foundation)* 15, no. 13 (July 2, 2015), https://jamestown.org/program/chinas-new-military-strategy-winning-informationized-local-wars/; Kevin McCauley, "System of Systems Operational Capability: Key Supporting Concepts for Future Joint Operations," *China Brief (Jamestown Foundation)* 12, no. 19 (October 5, 2012), https://jamestown.org/program/system-of-systems-operational-capability-key-supporting-concepts-for-future-joint-operations/; and Brendan S. Mulvaney, "PLA Views on the Information Domain" (Montgomery, AL: China Aerospace Studies Institute, January 2025).

The 1990s were not the only period from which Chinese leadership drew lessons about the importance of information. For example, Toshi Yoshihara documented how lessons learned from World War II helped PLA leaders conclude intelligence can be used as a force multiplier and that "through superior intelligence and its proper exploitation, the PLA can more than make up for its relative weakness in material power [against strong actors, like the United States]." Toshi Yoshihara, *Chinese Lessons from the Pacific War: Implications for PLA Warfighting* (Washington, DC: Center for Strategic and Budgetary Assessments, 2023), 29.

23 Dean Cheng, "Chinese Concepts of Space Security: Under the New Circumstances," in Kai-Uwe Schrogl, ed., *Handbook of Space Security: Policies, Applications and Programs* (Cham, Switzerland: Springer International Publishing, 2020), 527–53, https://doi.org/10.1007/978-3-030-23210-8_132.

24 Kevin Pollpeter et al., *China's Space Narrative: Examining the Portrayal of the U.S.–China Space Relationship in Chinese Sources and Its Implications for the United States* (Montgomery, AL: China Aerospace Studies Institute, 2020); and Howard Wang, Gregory Graff, and Alexis Dale-Huang, *China's Growing Risk Tolerance in Space: People's Liberation Army Perspectives and Escalation Dynamics* (RAND Corporation, 2024). For a list of example documents and more, see, for example, Mark Stokes et al., *China's Space and Counterspace Capabilities and Activities* Prepared for the U.S.-China Economic and Security Review Commission (Washington, DC: Project 2049 Institute; Pointe Bello, March 30, 2020), 9. The PRC has been, alongside Russia, pursuing United Nations resolutions on the "non-weaponization" of space. Bradley Bowman and Jared Thompson, "Russia and China Seek to Tie America's Hands in Space," *Foreign Policy*, March 31, 2021, https://foreignpolicy.com/2021/03/31/russia-china-space-war-treaty-demilitarization-satellites/.

outer space as a "critical domain in international strategic competition."[25] According to one popularly cited timeline created by the China Aerospace Science and Technology Corporation, the primary contractor for the country's space program, China aims to be "an all-round world-leading country in space equipment and technology" by 2045.[26]

Until recently, the PLA's military space activities were run by the PLA Strategic Support Force (PLASSF).[27] In April 2024, the PLA's Central Military Commission announced that it was disbanding the PLASSF and replacing it with the Aerospace Force, Cyberspace Force, and Information Support Force, leaving the Chinese military with four services (the People's Liberation Army, Navy, Air Force, and Rocket Force) and four arms (the Aerospace Force, the Cyberspace Force, the Information Support Force, and the Joint Logistics Support Force).[28] It appears the Aerospace Force will take the lead on PLA space operations and absorb the PLASSF's Space Systems Department.[29] Although much of the U.S. press focused on the creation of the Information Support Force, the China Aerospace Studies Institute's Brendan Mulvaney speculated that the order in which the arms were formally announced may indicate the Aerospace Force is the "senior force."[30] If true, the Aerospace Force's status could signal the importance the PLA places on space. The State Council's State Administration for Science, Technology, and Industry for National Defense (SASTIND) coordinates and manages civilian space activities, allocating R&D funds for space and working with the PLA's acquisition efforts.[31] The China National Space Administration (CNSA), a subsidiary of SASTIND, is the public face of the country's civilian space activities and

25 State Council Information office of the People's Republic of China, *China's National Defense in the New Era* (Beijing: Foreign Languages Press Company [distributed by Andrew S. Erickson], 2019), https://www.andrewerickson.com/2019/07/full-text-of-defense-white-paper-chinas-national-defense-in-the-new-era-english-chinese-versions/.

26 Ma Chi, "China Aims to Be World-Leading Space Power by 2045," *China Daily*, November 17, 2017. Also available at Embassy of Switzerland in China, "Science, Technology, Education and Health News from China" (Embassy of Switzerland in China, November 2017), 8.

27 Although it is now slightly outdated, Stokes et al. provided a very detailed guide of the PRC's space organizations. Stokes et al., *China's Space and Counterspace Capabilities and Activities*.

28 Gordon Arthur, "China Dissolves Strategic Support Force, Focused on Cyber and Space," *Defense News*, April 23, 2024. For three analyses of the reorganization, see Matt Bruzzese and Peter W. Singer, "Farewell to China's Strategic Support Force. Let's Meet Its Replacements," *Defense One*, April 28, 2024, https://www.defenseone.com/ideas/2024/04/farewell-chinas-strategic-support-force-lets-meet-its-replacement/396143/; Brendan S. Mulvaney, "The PLA's New Information Support Force," China Aerospace Studies Institute, April 22, 2024, https://www.airuniversity.af.edu/CASI/Display/Article/3749754/the-plas-new-information-support-force/; and Meia Nouwens, "China's New Information Support Force," International Institute for Strategic Studies, May 3, 2024, https://www.iiss.org/online-analysis/online-analysis/2024/05/chinas-new-information-support-force/.

29 Arthur, "China Dissolves Strategic Support Force."

30 Mulvaney, "PLA's New Information Support Force."

31 DIA, *Challenges to Security in Space: Space Reliance in an Era of Competition and Expansion* (DIA, 2022), 10.

international space cooperation.[32] Unlike in the United States, *taikonauts* (Chinese astronauts) report to a military agency, not the civilian space organization.[33]

The foremost goal of the Chinese space program is to support military operations on Earth.[34] The 2020 *Science of Military Strategy* made clear that the PLA sees space as central for warfare: "The dominance of space has been inseparable from the outcome of the war."[35] The PLA's vision of future conflict, to include "intelligentized" or informationized warfare, postulates using space-based assets to support targeting; communications; position, navigation, and timing (PNT); space jamming; and space protection.[36] Furthermore, space capabilities are seen as providing strategic early warning of any U.S. intervention in the region, with satellite reconnaissance often viewed by Chinese analysts as a key way to assess the intentions and operations of U.S. forces.[37] Space capabilities will also play a role in supporting Chinese global operations, with satellites being critical enablers of beyond-line-of-sight operations.[38] Given the perceived importance of space, Chinese writing often speaks about seeking "space dominance" in order to "establish an advantage in outer space, ensuring one's own freedom of action in space while denying an opponent the same."[39]

Chinese approaches to space are informed by a desire to not just take advantage of the domain for its own purposes but also to deny others that advantage.[40] PLA analysts assess that the United States relies more heavily on space than China does.[41] Thus, the PLA perceives the ability to disrupt or destroy U.S. space assets as an asymmetric advantage

32 DIA, *Challenges to Security in Space 2022*, 10.

33 Taylor A. Lee and Peter W. Singer, "China's Space Program Is More Military Than You Might Think," *Defense One*, July 16, 2021, https://www.defenseone.com/ideas/2021/07/chinas-space-program-more-military-you-might-think/183790/.

34 Cheng, "China's Military Role in Space;" and Stokes et al., *China's Space and Counterspace Capabilities and Activities*, 17–19.

35 China Aerospace Studies Institute, *Science of Military Strategy 2020: In Their Own Words* (Montgomery, AL: China Aerospace Studies Institute, 2022), 145.

36 Dean Cheng, "Space and the Evolving Chinese Military," in Bruce W MacDonald, ed., *Crisis Stability in Space: China and Other Challenges* (Washington, DC: Foreign Policy Institute of the Johns Hopkins University Paul H. Nitze School of Advanced International Studies, 2022); Kevin Pollpeter, Michael Chase, and Eric Heginbotham, *The Creation of the PLA Strategic Support Force and Its Implications for Chinese Military Space Operations* (RAND Corporation, 2017), chaps. 2–3; and Stokes et al., *China's Space and Counterspace Capabilities and Activities*, 19.

37 Stokes et al., *China's Space and Counterspace Capabilities and Activities*, 14.

38 DoD, *Military and Security Developments Involving the People's Republic of China 2023*, ix, 98; and Stokes et al., *China's Space and Counterspace Capabilities and Activities*, 14, 19–20.

39 Cheng, "Space and the Evolving Chinese Military," 34.

40 The 2020 *Science of Military Strategy* asserted, "Western countries headed by the United States have clearly gained unprecedented war advantages from space." China Aerospace Studies Institute, *Science of Military Strategy 2020*, 145.

41 In 2013, some Chinese sources assessed that the U.S. military relied on satellites for all of its navigation requirements, 80–90 percent of its communication requirements, and 70–90 percent of its intelligence requirements. Pollpeter, Chase, and Heginbotham, *Creation of the PLA Strategic Support Force*, 7.

and a driving force behind military competition with the United States.[42] In addition to disrupting command and control networks, Chinese military analysts see denying or disrupting U.S. access to space as having the potential to interrupt the use of precision-guided weapons, restrict long-range kill chains, and "blind and deafen the enemy."[43] The PLA sees information dominance as an important contributor to successful military operations, and space and counterspace capabilities can be used not only to increase one's own information but also to degrade or deny others' access to information.[44]

It thus appears the PLA sees counterspace operations as a means to weaken any U.S. intervention in a regional conflict, including perhaps by preemptively targeting space capabilities in the lead-up to an operation in the Indo-Pacific.[45] The USSF has assessed that the PLA "intends on leveraging space capabilities to disrupt U.S. intervention in a regional crisis or conflict."[46] Additionally, the PLA could use counterspace operations to impose costs on the United States during peacetime. Indeed, Chinese military analysts discussing Russian counterspace weapons programs have highlighted counterspace weapons as a cost-effective way of "offsetting the opponent's advantage" and of compelling the United States to "invest more resources in protecting the space system."[47]

Chinese concepts of defense and deterrence view activities in the space domain as potential deterrent mechanisms. The Chinese term commonly used for deterrence, *weishe*, encompasses a wider definition than the English term.[48] Whereas the English word refers to efforts to maintain the status quo by convincing a target to not take a given action, *weishe* is closer to a combination of deterrence and compellence, suggesting a more proactive stance.[49]

42 Brian Brown, "The Challenge of Joint Space Operations," *Proceedings* 150, no. 1, January 2024, https://www.usni.org/magazines/proceedings/2024/january/challenge-joint-space-operations; and C. Todd Lopez, "Nominee to Lead Space Force Testifies Goals, Priorities Before Senate Committee," DoD, September 13, 2022, https://www.defense.gov/News/News-Stories/Article/Article/3157116/nominee-to-lead-space-force-testifies-goals-priorities-before-senate-committee/.

43 DoD, *Military and Security Developments Involving the People's Republic of China 2023*, 98.

44 For more on information dominance, see, for example, Burke et al., *People's Liberation Army Operational Concepts*, 6–12; and Mulvaney, *PLA Views on the Information Domain*.

45 Jiemin Hou, "Offensive Defense People's Liberation Army Logic of Preemption in Space," *Æther* 1, no. 4, Winter 2022.

46 USSF, *White Paper on Competitive Endurance*, 3.

47 Jonas Vidhammer Berge and Henrik Stålhane Hiim, "Killing Them Softly: China's Counterspace Developments and Force Posture in Space," *Journal of Strategic Studies*, August 27, 2024, 8, https://www.tandfonline.com/doi/full/10.1080/01402390.2024.2388658.

48 Nathan Beauchamp-Mustafaga, "Exploring Chinese Thinking on Deterrence in the Not-So-New Space and Cyber Domains," in Roy D. Kamphausen, ed., *Modernizing Deterrence: How China Coerces, Compels, and Deters* (Seattle: The National Bureau of Asian Research, 2023); Nathan Beauchamp-Mustafaga et al., *Deciphering Chinese Deterrence Signalling in the New Era: An Analytic Framework and Seven Case Studies* (RAND Corporation, May 27, 2021); Dean Cheng, "Chinese Views on Deterrence," *Joint Force Quarterly* 60, no. 1, 2011; and Dean Cheng, "An Overview of Chinese Thinking about Deterrence," in Frans Osinga and Tim Sweijs, eds., *NL ARMS Netherlands Annual Review of Military Studies 2020: Deterrence in the 21st Century—Insights from Theory and Practice* (The Hague: T.M.C. Asser Press, 2021), 177–200, https://doi.org/10.1007/978-94-6265-419-8_10.

49 See, for example, Pollpeter, who translated *weishe* as coercion and examined its application to space. Kevin Pollpeter, *Coercive Space Activities: The View from PRC Sources* (Montgomery, AL: China Aerospace Studies Institute, 2024).

Similarly, "active defense" is a Chinese military concept that "adopts the principles of strategic defense in combination with offensive action at the operational and tactical levels."[50] Applying these concepts to the space domain suggests China may take preemptive action in space to protect its interests and sovereignty on Earth and in orbit.[51]

The PLA also likely sees counterspace capabilities as useful not just for degrading U.S. capabilities but also for deterring the United States from intervening in regional military conflicts by holding U.S. space assets at risk prior to the conflict.[52] A textbook for the Academy of Military Sciences described *space deterrence* as "the use of threatened or actual limited use of space force, backed up by powerful space forces, to shock and awe or curb the adversary's military operations against them."[53] Another defined space deterrence as the use of threats in space to deter a range of behaviors, seemingly both in space and on Earth: "military actions that force the other party to dare not take hostile actions or escalate actions by displaying space power or expressing determination to use space power, including earth-to-space deterrence operations, day-to-day deterrence operations, and space-to-earth deterrence options."[54] A lecture from the academy listed four stages of space deterrence: demonstrations of space strength, space military exercises, changing the disposition of forces, and an "overawing space strike."[55] Thus, the Chinese approach to counterspace actions focuses not just on degrading or denying U.S. capabilities during or in the run-up to a conflict, but also on deterring outside intervention during a regional conflict.[56] The 2013 *Science of Military Strategy* and other PLA writings saw space capabilities as particularly vulnerable to coercion because they are so important not just for military operations but also for economic performance.[57]

50 DoD, *Military and Security Developments Involving the People's Republic of China 2023*, 37.

51 Cheng, "Chinese Concepts of Space Security;" and Hou, "Offensive Defense."

52 DoD, *Military and Security Developments Involving the People's Republic of China 2023*, ix, 98; Pollpeter, Chase, and Heginbotham, *Creation of the PLA Strategic Support Force*; and Stokes et al., *China's Space and Counterspace Capabilities and Activities*, 14.

53 As cited in Krista Langeland and Derek Grossman, *Tailoring Deterrence for China in Space* (RAND Corporation, 2021), 29.

54 China Aerospace Studies Institute, *Science of Military Strategy 2020*, 148.

55 China Aerospace Studies Institute, *Lectures on the Science of Space Operations: In Their Own Words* (Montgomery, AL: China Aerospace Studies Institute, 2022), 154–57; and Cheng, "Overview of Chinese Thinking About Deterrence," 186–87.

56 DoD, *Space Policy Review and Strategy on Protection of Satellites* (Washington, DC: DoD, September 2023), 2.

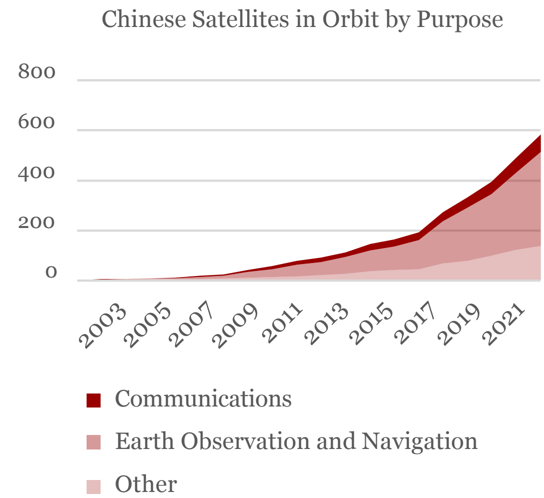
57 Pollpeter, *Coercive Space Activities*, 9–10.

Chinese Military Space Capabilities

The United States still has, by far, the greatest number of satellites in orbit, but China is rapidly increasing its orbital footprint in both quantity and quality.[58] Between the end of 2015 and mid-2025, the number of Chinese satellites on orbit has grown by more than 900 percent.[59] As of May 2023, the Chinese satellite inventory—including both government and commercial satellites—consisted of 54 percent Earth observation satellites, 19 percent technology development, 12 percent communications, 8 percent navigation and global positioning, and 7 percent other uses, according to data self-reported by the satellites' operators (see Figure 4).[60]

Most Chinese satellites are operated by government entities, with roughly 60 percent operated by the government or military as of May 2023.[61] The rest, approximately 40 percent, are operated by civil or commercial actors.[62] It is important to note, however, that many Chinese satellites, whether officially publicly or privately owned, could potentially be used to support military applications. Supported by Beijing's strategy of Military-Civil Fusion (MCF), the space industry is closely interwoven with government entities and applications.[63] Similar to other industries in China, it is possible

FIGURE 4: COMPOSITION OF CHINESE SATELLITE INVENTORY



Data from UCS, "UCS Satellite Database 2023."

58 As of May 2023, the United States (government, commercial, and other) accounted for approximately 5,000 satellites in orbit. China accounted for 618. Union of Concerned Scientists (UCS), "UCS Satellite Database," UCS, May 1, 2023, https://www.ucsusa.org/resources/satellite-database.

59 United States Space Force, "Space Threat Fact Sheet," September 2025, https://www.spaceforce.mil/About-Us/Fact-Sheets/Fact-Sheet-Display/Article/4297159/space-threat-fact-sheet/.

60 For the sake of consistency, all satellite quantity data in this report relies on the UCS Satellite Database updated on May 1, 2023. All data is reported as listed in the UCS database.

61 Included in this figure are configurations that include the government or military but also another user type. In this case, only two such categories were listed—government/civil and government/commercial. The satellites in these categories only added up to 1 percent of the total number of Chinese satellites on orbit. UCS, "UCS Satellite Database 2023."

62 UCS, "UCS Satellite Database 2023."

63 On military-civil fusion (MCF), see Alex Stone and Peter Wood, *China's Military–Civil Fusion Strategy* (Montgomery, AL: China Aerospace Studies Institute, 2020), https://www.airuniversity.af.edu/CASI/Display/Article/2217101/chinas-military-civil-fusion-strategy/. On the relationship between MCF and the PLA's talent requirements, see *Natalie A. Herbert, Achieving the PLA's Strategic Support Force Talent Needs through MCF* (Montgomery AL: China Aerospace Studies Institute, February 2021).

that the Chinese government can force private space companies to provide data or otherwise serve purposes of the CCP.[64] For the United States, the close connection between Chinese civil and military satellites means that attributing the operators and intentions of any behavior from ostensibly commercial satellites could be complicated.

Positioning, Navigation, and Timing

Beijing sees the development of its own global navigation satellite system (GNSS) as critical for the country's economic growth and its defense, with President Xi Jinping once calling BeiDou, China's national GNSS system, "one of the most important achievements China has made in the 40 years of reform and opening."[65] In addition to providing military and domestic economic utility, China appears to be using BeiDou as an economic and diplomatic tool to develop and deepen relationships with other countries, potentially weaning traditional U.S. partners off GPS and gaining leverage for future negotiations.[66]

Built as an alternative to GPS, global BeiDou coverage was completed in 2020 and reportedly provides better coverage than GPS in some locations.[67] The system differs from GPS and other GNSS constellations in that it uses an additional radio band that can support short-form messaging in addition to providing PNT services.[68] BeiDou can offer two-way messaging—not just broadcasting signals but also sending and receiving messages. This means, for example, that BeiDou could monitor individuals' locations, though doing this at scale is currently constrained by factors, including messaging capacity and appropriate ground monitoring stations.[69]

BeiDou, like other GNSSs, provides the Chinese military with several capabilities related to PNT, including enabling guided missiles to strike targets with increased precision. Vitally, the completion of BeiDou allows China to say that it no longer relies on other states for real-time navigation signals, mitigating CCP leadership concerns about the potential for disruption of critical PNT services by the United States and others during times of crisis or

64 For a brief overview of the relevant laws and the U.S. National Counterintelligence and Security Center's assessment of their implications, see U.S. National Counterintelligence and Security Center, "Safeguarding Our Future," U.S. National Counterintelligence and Security Center, June 20, 2023, https://www.dni.gov/files/NCSC/documents/SafeguardingOurFuture/FINAL_NCSC_SOF_Bulletin_PRC_Laws.pdf.

65 Sarah Sewall, Tyler Vandenberg, and Kaj Malden, *China's BeiDou: New Dimensions of Great Power Competition* (Cambridge, MA: Belfer Center for Science and International Affairs, February 2023), 9.

66 Sewall, Vandenberg, and Malden, *China's BeiDou*.

67 Andrew Jones, "Final Beidou-3 Satellite Reaches Operational Orbit, China's Launch Sites Gear Up for July Missions," *SpaceNews*, June 30, 2020, https://spacenews.com/final-beidou-3-satellite-reaches-operational-orbit-chinas-launch-sites-gear-up-for-july-missions/; and Sewall, Vandenberg, and Malden, *China's BeiDou*.

68 David H. Milner, Stephen Maksim, and Marissa Huhmann, "BeiDou: China's GPS Challenger Takes Its Place on the World Stage," *Joint Force Quarterly* 105, 2nd Quarter 2022; and Sewall, Vandenberg, and Malden, *China's BeiDou*, 17-19.

69 Sewall, Vandenberg, and Malden, *China's BeiDou*, 17–19.

conflict.[70] During the 1995–1996 Taiwan Strait Crisis, the PLA had to rely on the U.S. GPS for military purposes, a fact one senior Chinese officer called an "unforgettable humiliation" that convinced the China to develop its own GNSS "no matter how huge the cost."[71] In addition to its space-based PNT, sources suggest China may be building a network of optical fiber and enhanced long-range navigation (eLoran) sites to provide ground-based precision navigation.[72]

Intelligence, Surveillance, and Reconnaissance

The PLA operates a robust space-based intelligence, surveillance, and reconnaissance (ISR) capability, with the U.S. Defense Intelligence Agency (DIA) estimating in 2022 that the PLA owned and operated about half of the world's ISR satellite systems.[73] The PLA continues to improve its monitoring and observation capabilities. Recent improvements include digital camera technology, space-based radar for all-weather observation, and electronic reconnaissance satellites that monitor radar and radio transmissions.[74] The Chinese ISR satellite architecture appears to be optimized for coverage of the Indo-Pacific and for overwatch of areas and activities of particular interest to the PLA, though China does also have global ISR capabilities.[75] General B. Chance Saltzman, the chief of space operations of the USSF, recently emphasized that over half of China's satellites are designed to watch over U.S. and allied forces in the western Pacific.[76]

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70 Jeremy Page, "Beijing Launches GPS Rival," *Wall Street Journal*, December 27, 2011.

71 Minnie Chan, "'Unforgettable Humiliation' Led to Development of GPS Equivalent," *South China Morning Post*, November 12, 2009, https://www.scmp.com/article/698161/unforgettable-humiliation-led-development-gps-equivalent.

72 Enhanced long-range navigation (eLoran) builds on Loran, a hyperbolic radio navigation system developed during World War II. For a brief history of Loran, see, for example: Marvin May, Part I: World War II and LORAN's Beginnings," *ION Newsletter* (Institute of Navigation), Summer 2010, https://www.ion.org/museum/files/historian_summer_2010.pdf

Thad Allen, Kathleen H. Hicks, and Polly E. Trottenberg, "Report of the 30th National Space-Based PNT Advisory Board Meeting," National Space-Based Positioning, Navigation, and Timing Advisory Board, July 19, 2024, 4, https://www.gps.gov/governance/advisory/recommendations/2024-07-PNTAB-chair-memo.pdf; Selam Gebrekidan, John Liu, and Chris Buckley, "One Satellite Signal Rules Modern Life. What If Someone Knocks It Out?," *New York Times*, March 28, 2024; Dana Goward, "China Leads World with Plan for 'Comprehensive' PNT," *GPS World*, November 15, 2019, https://www.gpsworld.com/china-leads-world-with-plan-for-comprehensive-pnt/; Dana Goward, "China Finishing 'High-Precision Ground-Based Timing System'—A Worry for the United States," *GPS World*, September 5, 2023, https://www.gpsworld.com/china-finishing-high-precision-ground-based-timing-system-a-worry-for-the-united-states/; Jesse Khalil, "China Completes National eLoran Network," *GPS World*, October 7, 2024, https://www.gpsworld.com/china-completes-national-eloran-network/; Mitch Narins, "The Global Loran/eLoran Infrastructure Evolution: A Robust and Resilient PNT Backup for GNSS," Space-Based PNT Advisory Board, June 3, 2014, 27–28, https://www.gps.gov/governance/advisory/meetings/2014-06/narins.pdf; and Chaozhong Yang, Shifeng Li, and Zhaopeng Hu, "Analysis of the Development Status of eLoran Time Service System in China," *Applied Sciences* 13, no. 23 (2023).

73 DIA, *Challenges to Security in Space 2022*, 11.

74 DIA, *Challenges to Security in Space 2022*, 11; and Stokes et al., *China's Space and Counterspace Capabilities and Activities*, 28.

75 DIA, *Challenges to Security in Space 2022*, 11.

76 Greg Hadley, "Advancing in Space, China Poses Growing Threat, USSF Leaders Warn," *Air & Space Forces Magazine*, March 28, 2024, https://www.airandspaceforces.com/ussf-leaders-china-space-threaten-us/.

The PRC has a mix of satellites across orbits to provide this coverage. For example, in late 2023, the Yaogan-41 remote-sensing satellite was launched in GEO. Although ostensibly a civilian satellite intended for benign purposes like crop yield estimation, some Western observers have assessed that it is primarily a military reconnaissance satellite placed to observe the western Pacific.[77] Artificial intelligence (AI) technology could also support Chinese identification and tracking, with one recent Chinese study reportedly claiming that new AI technology applied to images derived from the country's LEO Jilin-1 satellite achieved a 95 percent success rate in identifying small objects, including moving ones.[78] This combination of surveillance satellites and technology could provide China with the ability to identify and track objects as small as cars throughout the region.[79] Chinese commercial capabilities may also supplement military- and government-owned satellites.

Satellite Communications

Satellite communications (SATCOM), which among other purposes enables beyond-line-of-sight connectivity, will become increasingly important for the PLA as it seeks to operate further from its borders.[80] As of March 2023, China officially coded 73 of the satellites in its architecture as communications satellites, including at least 30 that were listed as operated by the government or military.[81]

China possesses communications satellites that can transmit large amounts of data, and Chinese satellite entities continue to invest in more advanced capabilities.[82] For example, Chinese researchers are experimenting with next-generation capabilities like space-based quantum-enabled communications, which theoretically could provide significantly more secure communications.[83] In 2020, a team of Chinese scientists claimed they had used a quantum communications satellite to establish a link between two ground stations in China located more than 1,120 km apart, demonstrating a capability to connect stations at a

77 Sandra Erwin, "Why Space Force Is Growing More Alarmed by China's Eyes in the Sky," *SpaceNews*, February 16, 2024, https://spacenews.com/why-space-force-is-growing-more-alarmed-by-chinas-eyes-in-the-sky/; Clayton Swope, "No Place to Hide: A Look into China's Geosynchronous Surveillance Capabilities," CSIS, January 19, 2024, https://www.csis.org/analysis/no-place-hide-look-chinas-geosynchronous-surveillance-capabilities; and "China's Satellites Are Improving Rapidly. Its Army Will Benefit," *The Economist*, March 7, 2024.

78 "China's Satellites Are Improving Rapidly. Its Army Will Benefit," *The Economist*, March 7, 2024.

79 Swope, "No Place to Hide."

80 For more on China's globalizing military, see Toshi Yoshihara and Jack Bianchi, *Seizing on Weakness: Allied Strategy for Competing with China's Globalizing Military* (Washington, DC: Center for Strategic and Budgetary Assessments, 2021).

81 UCS, "UCS Satellite Database 2023."

82 Stokes et al., *China's Space and Counterspace Capabilities and Activities*, 35–36; and Mark A. Stokes and Dean Cheng, *China's Evolving Space Capabilities: Implications for U.S. Interests* (Washington, DC: Project 2049 Institute, April 26, 2012), 35–37.

83 Gunter D. Krebs, "QSS (QUESS, Mozi, Micius)," Gunter's Space Page, accessed on May 6, 2024, https://space.skyrocket.de/doc_sdat/qss.htm; and Karen Kwon, "China Reaches New Milestone in Space-Based Quantum Communications," *Scientific American*, June 25, 2020, https://www.scientificamerican.com/article/china-reaches-new-milestone-in-space-based-quantum-communications/.

distance more than ten times further than previous optic fiber-based quantum technology could.[84] The experiment reportedly used entanglement-based quantum key distribution, sending cryptographic keys in the form of entangled photons to the ground stations, a process which would alert the intended recipients of any attempted intrusion because any third-party efforts to intercept the keys would result in a change to the quantum state of the photons.[85] In 2025, Chinese researchers reported that they had used a much smaller satellite to connect a location in China with a location in South Africa, representing a step toward miniaturization that could lead to greater scalability.[86] Despite these successes, the progress towards building a usable quantum communications network is still in early stages and there are major hurdles to adopting a quantum network at scale.[87] Furthermore, there are significant challenges with implementing quantum key distribution, including vulnerabilities to attack caused by hardware imperfections, and even if it is implemented perfectly, quantum key distribution may still only be a partial solution, requires special purpose equipment, and poses other costs and risks.[88]

China also appears to aspire to become a world provider of SATCOM, with satellite communications appearing to be a strength of China's commercial space industry.[89] Chinese entities anticipate developing at least seven new SATCOM constellations in LEO, including

84 Launched in 2016, the satellite—Micius—was the world's first dedicated quantum communications satellite.

Juan Yin et al., "Entanglement-based secure quantum cryptography over 1,120 kilometers," *Nature* 582 (2020); Kwon, "China Reaches New Milestone;" and Dave Makichuk, "China Claims Quantum Supremacy with Satellite Test," *Asia Times*, June 16, 2020, http://asiatimes.com/2020/06/chinese-team-claim-quantum-supremacy-with-satellite-test/.

85 Andrew Jones, "China Plans to Take 'Hack-Proof' Quantum Satellite Technology to New Heights," Space.com, October 30, 2023, https://www.space.com/china-quantum-communications-satellite-higher-orbit-plans; Kwon, "China Reaches New Milestone"; and Yin et al., "Entanglement-based."

86 Elizabeth Gibney, "Mini-Satellite Paves the Way for Quantum Messaging Anywhere on Earth," *Nature*, March 19, 2025, https://doi.org/10.1038/d41586-025-00581-7; and Yang Li et al., "Microsatellite-Based Real-Time Quantum Key Distribution," *Nature*, March 19, 2025, 1–8, https://doi.org/10.1038/s41586-025-08739-z.

87 DIA, *Challenges to Security in Space 2022*, 12. See also Francesco Chiti, Roberto Picchi, and Laura Pierucci, "A Survey on Non-Terrestrial Quantum Networking: Challenges and Trends," *Computer Networks* 252, October 2024, https://doi.org/10.1016/j.comnet.2024.110668.

88 French Cybersecurity Agency, "Should Quantum Key Distribution be Used for Secure Communications?," French Cybersecurity Agency, May 26, 2020, https://cyber.gouv.fr/en/publications/should-quantum-key-distribution-be-used-secure-communications; French Cybersecurity Agency, Federal Office for Information Security, Netherlands National Communications Security Agency, and Swedish National Communications Security Authority, Swedish Armed Forces, "Position Paper on Quantum Key Distribution," French Cybersecurity Agency, Federal Office for Information Security, Netherlands National Communications Security Agency, and Swedish National Communications Security Authority, Swedish Armed Forces, https://cyber.gouv.fr/sites/default/files/document/Quantum_Key_Distribution_Position_Paper.pdf; Matt Swayne, "Study Finds Security Flaw in World's First Quantum Satellite," *Quantum Insider*, June 3, 2025, https://thequantuminsider.com/2025/06/03/study-finds-security-flaw-in-worlds-first-quantum-satellite/; and U.S. National Security Agency/Central Security Service, "Quantum Key Distribution (QKD) and Quantum Cryptography (QC)," U.S. National Security Agency/Central Security Service, https://www.nsa.gov/Cybersecurity/Quantum-Key-Distribution-QKD-and-Quantum-Cryptography-QC/.

89 Ryan Nelson, Taylor Rhoten, and Brian MacCarthy, "Eastern Stars Rising: The Rise of China's Commercial Space Industry," *War on the Rocks*, July 29, 2025, https://warontherocks.com/2025/07/eastern-stars-rising-the-rise-of-chinas-commercial-space-industry/.

megaconstellations.[90] For example, the Guo Wang megaconstellation, with a planned 13,000 satellites, is positioned as a likely competitor to Starlink.[91]

Space Domain Awareness

The Chinese government has been working to improve its space domain awareness (SDA) and space situational awareness (SSA).[92] China has a "robust network" of space surveillance sensors consisting of a variety of telescopes, radars, and other sensors (see Figure 5).[93] This network includes the Xian Satellite Tracking and Control Center, fixed land-based sites, "at least one mobile system," and several tracking ships.[94] In 2023, the PLASSF established a new base charged with identifying, tracking, and analyzing foreign space objects, in addition to supporting the domestic space object catalog.[95]

The PLA has also worked to increase its access to sensors outside China. For example, China leads the Asia-Pacific Space Cooperation Organization (APSCO). As part of an APSCO space surveillance initiative known as the Asia–Pacific Ground-Based Optical Space Object Observation System (APOSOS), China provided telescopes to Peru, Pakistan, and Iran. All tasking and data for APOSOS, whose assets give close to full coverage of LEO and GEO, run through the Chinese Academy of Science's National Astronomical Observatory of China.[96] The PLA also has access to ground stations in more than 15 countries and in Antarctica, and Russia and China are reportedly cooperating on an early warning system.[97]

The Chinese government, moreover, plans to continue to invest in deep space situational awareness and communications.[98] Chinese academics with connections to the military have

90 DIA, *Challenges to Security in Space 2022*, 12.

91 Juliana Suess, "Guo Wang: China's Answer to Starlink?," Royal United Services Institute, May 3, 2024, https://www.rusi.org/explore-our-research/publications/commentary/guo-wang-chinas-answer-starlink.

92 Space situational awareness (SSA) refers to local and operator-specific awareness, whereas space domain awareness (SDA) refers to knowledge of the broader space domain. Sandra Erwin, "Air Force: SSA Is No More; It's 'Space Domain Awareness,'" *SpaceNews*, November 14, 2019, https://spacenews.com/air-force-ssa-is-no-more-its-space-domain-awareness/; and Marcus Holzinger, "Space Situational or Domain Awareness? Know the Difference!," Ex Inani, Omni, December 23, 2022, https://www.marcusholzinger.com/space-situational-or-domain-awareness-know-the-difference/. On the strategic value of SDA, see, for example, Kevin Pollpeter, *Space Domain Awareness as a Strategic Counterweight* (Montgomery, AL: China Aerospace Studies Institute, November 2021).

93 DIA, *Challenges to Security in Space 2022*, 16.

94 Stokes et al., *China's Space and Counterspace Capabilities and Activities*, 26–27.

95 Kristin Burke, *The PLA's New Base for Space Situational Awareness: Opportunities and Challenges for the U.S.* (Maxwell AFB, AL: China Aerospace Studies Institute, September 2023).

96 DIA, *Challenges to Security in Space 2022*, 16.

97 DIA, *Challenges to Security in Space 2022*, 16; and Dmitry Stefanovich, "Russia to Help China Develop an Early Warning System," *The Diplomat*, October 25, 2019, https://thediplomat.com/2019/10/russia-to-help-china-develop-an-early-warning-system/.

98 Kristin Burke, *China's Space Situational Awareness Capabilities for Beyond GEO* (Maxwell AFB, AL: China Aerospace Studies Institute, September 2022).

frequently written about the possibility of the United States conducting operations in graveyard orbits (orbits far from common operational orbits that are primarily used to reduce the chance that objects reaching the end of their operational life collide with operational spacecraft), potentially indicating concern in Beijing that China may have insufficient ability to monitor activity just above GEO.[99] In addition to a series of ground-based systems—including optical telescopes, lasers, radio telescopes (including the world's largest), and radar—China has invested in several space-based systems, including telescopes, microwave sensors, and radar, to improve its SSA beyond GEO.[100] A report by the China Aerospace Studies Institute's Kristen Burke suggested China may be more dependent on its space-based SSA sensors than the United States because the United States has a more extensive ground network of SSA radars and telescopes.[101]

FIGURE 5: KEY CHINESE SPACE SITES AS OF 2022

Image from DIA, *Challenges to Security in Space 2022*, 15.

99 Burke, *China's Space Situational Awareness Capabilities,* 2.

100 Burke, *China's Space Situational Awareness Capabilities*.

101 Kristin Burke, *China's Different Approach to Space Situational Awareness* (Maxwell AFB, AL: China Aerospace Studies Institute, December 2024).

Launch Capabilities

China has put significant resources into advancing its space launch vehicle (SLV) capabilities, working to compete in the global space launch services market and ensure China has reliable, independent means to access space.[102] According to PRC government figures, Chinese spending on R&D for "spacecraft manufacturing" increased from $22.6 million in 2000 to $386.6 million in 2016.[103] Unlike many other nations, nearly all Chinese satellites currently in orbit were launched on indigenously made rockets, with its Long March family of rockets carrying most Chinese space launches (see Figure 6).[104] To support its efforts at building megaconstellations, China has invested in new manufacturing practices and sites that can build more rockets more quickly.[105] For example, in 2023, it was reported that China was constructing an assembly plant that aimed to produce 50 Long March-8 rockets per year using pulse assembly line techniques.[106]

FIGURE 6: CHINESE SPACE LAUNCH VEHICLES

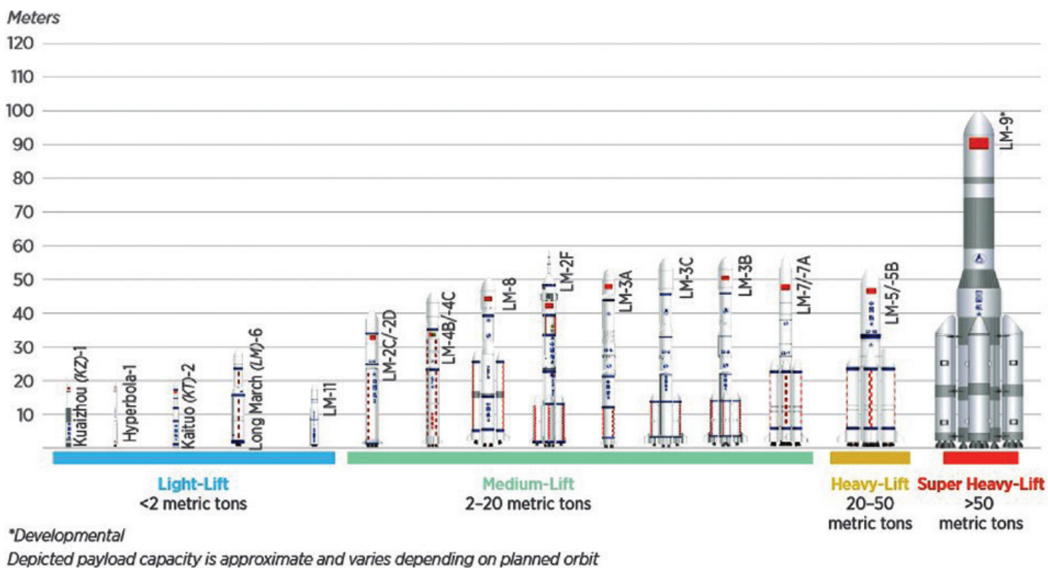


Image from DIA, *Challenges to Security in Space 2022*, 14.

102 DIA, *Challenges to Security in Space 2022*, 14.

103 China Power Team, "How Is China Advancing Its Space Launch Capabilities?," China Power, November 5, 2019, https://chinapower.csis.org/china-space-launch/.

104 China Power Team, "How Is China Advancing."

105 Stephen Chen, "China Is Supersizing Its Rocket Industry—And It's Coming for Starlink," *South China Morning Post*, May 25, 2023, https://www.scmp.com/news/china/science/article/3221831/china-supersizing-its-rocket-industry-and-its-coming-starlink.

106 Chen, "China Is Supersizing Its Rocket Industry."

The Chinese government has been investing in new types of SLVs, including modular and quick-response vehicles. Modular SLVs can be configured to the requirements of each customer, potentially leading to increased launch vehicle reliability and overall cost savings for launching campaigns.[107] China has also been investing in quick-response SLVs that can expedite launches due to their transportability via road and rail and the fact that they can be stored launch ready for longer periods of time than medium- and heavy-lift SLVs. These quick-response SLVs could provide China with the capability to rapidly reconstitute degraded LEO space capabilities, although each vehicle is only able to launch relatively small payloads.[108] In Congressional testimony, Kevin Pollpeter described "operationally responsive launch capabilities" as one of three dual-use space capabilities the Chinese military was developing.[109]

Investments are not just focused on smaller launch vehicles. For example, the China Academy of Launch Vehicle Technology, one of the largest developers and manufacturers of Chinese launch vehicles, is developing the Long March-9, a super heavy-lift launch vehicle designed to support lunar and Mars missions.[110] The China Aerospace Science and Technology Corporation (CASC), a state-owned enterprise that is a lead contractor for the Chinese space program, has also announced investments in large-diameter reusable rockets, seemingly competing with Chinese commercial rocket companies.[111]

The growing number of launches has spurred investments in new launch facilities and capabilities. In 2019, China demonstrated the ability to launch a Long March-11 from a sea-based platform, a capability that could allow China to launch closer to the equator than its land-based launch sites, increasing the rocket's capacity and potentially reducing launch costs.[112] As of February 2024, China had conducted ten sea launches with support from expanded sea launch facilities at Haiyang.[113] The Haiyang Eastern spaceport plans to conduct more than

107 DIA, *Challenges to Security in Space 2022*, 14.

108 DIA, *Challenges to Security in Space 2022*, 15.

109 The others were space-based C4ISR and counterspace capabilities. Kevin Pollpeter, "Testimony before the U.S.-China Economic and Security Review Commission Hearing on 'China in Space: Strategic Competition,'" (U.S.-China Economic and Security Review Commission, China in Space: Strategic Competition, Washington, DC, April 2019), https://www.uscc.gov/sites/default/files/Kevin%20Pollpeter%20USCC%2025%20April.pdf.

110 Andrew Jones, "China Reveals Details for Super-Heavy-Lift Long March 9 and Reusable Long March 8 Rockets," *SpaceNews*, July 5, 2018, https://spacenews.com/china-reveals-details-for-super-heavy-lift-long-march-9-and-reusable-long-march-8-rockets/; and Mike Wall, "China planning to build its own version of SpaceX's Starship," Space.com, November 8, 2024, https://www.space.com/china-long-march-9-spacex-starship-rocket.

111 Andrew Jones, "China to Debut Large Reusable Rockets in 2025 and 2026," *SpaceNews*, March 5, 2024, https://spacenews.com/china-to-debut-large-reusable-rockets-in-2025-and-2026/.

112 DIA, *Challenges to Security in Space 2022*, 14–15.

113 Andrew Jones, "China Launches 20 Satellites on Separate Inland and Sea Rocket Launches," *SpaceNews*, February 4, 2024, https://spacenews.com/china-launches-20-satellites-on-separate-inland-and-sea-rocket-launches/; and DoD, *Military and Security Developments Involving the People's Republic of China 2023*, 102.

ten sea launches in 2025, with officials reportedly proposing a goal of 100 launches per year supported by the spaceport starting in 2027.[114]

The Chinese government is not the only entity in the country with launch success; there is a growing commercial launch capability and capacity as well. For example, 2023 was an important year for China's commercial launch activities.[115] Over that summer, Beijing Tianbing Technology (also known as Space Pioneer) conducted the country's first commercial space launch, and LandSpace launched the world's first methane–liquid oxygen rocket.[116] In January 2024, Chinese company Orienspace sea launched its Gravity-1 rocket, the most powerful Chinese commercial rocket to conduct a successful orbital mission.[117] The Chinese government, recognizing the potential for commercial growth, is expanding government-owned space launch sites to accommodate more commercial launches, though bottlenecks for spaceport access remain.[118]

The Commercial Sector

The commercial space sector in China has expanded rapidly over the past decade and appears to be on a continued trajectory of growth, with the U.S. intelligence community writing that China's commercial space sector is "growing quickly with aspiration to be a major global competitor to U.S. and European space companies."[119] Until the mid-2010s, space activity in China was largely state owned and state run, overwhelmingly dominated by the China Aerospace Science & Industry Corporation Limited and CASC. In 2014, the CCP issued a policy directive known as Document 60, which was aimed at encouraging investments and growth in seven key areas, including civil space infrastructure. The document is often credited with opening the space sector to commercial companies in China.[120] Following Document 60, the Chinese government released a series of policies and documents

114 Andrew Jones, "Chinese Sea Launch Sends 10 Navigation Enhancement Satellites into Orbit," *SpaceNews*, January 13, 2025, https://spacenews.com/chinese-sea-launch-sends-10-navigation-enhancement-satellites-into-orbit/.

115 Kari A. Bingen, "2024: The Year That Launched China's Commercial Space Sector?," in Craig Cohen and Alexander Kisling, eds., *2024 Global Forecast: A World Dividing* (Washington, DC: CSIS, 2024), 20–21.

116 Bingen, "2024: The Year That Launched China's Commercial Space Sector?," 20–21.

117 Mike Wall, "China's Record-Breaking Gravity-1 Rocket Aces Amazing Debut Launch from Ship at Sea [Video]," Space.com, January 11, 2024, https://www.space.com/china-orienspace-gravity-1-rocket-launch-success-video; and The Maritime Executive, "Video: Chinese Company Launches Massive Solid-Fuel Rocket at Sea," The Maritime Executive, January 14, 2024, https://maritime-executive.com/article/video-chinese-company-launches-massive-solid-fuel-rocket-from-sea.

118 Clayton Swope et al., *Space Threat Assessment 2024* (Washington, DC: CSIS, 2024), 9; and Andrew Jones, "China to Leverage Growing Commercial Space Sector to Launch Megaconstellations," *SpaceNews*, April 19, 2024, https://spacenews.com/china-to-leverage-growing-commercial-space-sector-to-launch-megaconstellations/.

119 Office of the Director of National Intelligence, *Annual Threat Assessment of the U.S. Intelligence Community* (Office of the Director of National Intelligence, March 2025), 15.

120 The actual impact of Document 60 itself is debated, though it is clear that since the mid-2010s, Chinese commercial space activity has grown significantly. Irina Liu et al., *Evaluation of China's Commercial Space Sector* (Washington, DC: IDA Science & Technology Policy Institute, 2019), 14.

encouraging growth in the space industry.[121] Tracing exact investment figures in the Chinese space industry is difficult, but multiple estimates suggest significant growth.[122]

The Chinese commercial space sector is wide ranging. A 2019 report identified 78 Chinese commercial space companies across sectors such as satellite manufacturing, launch, remote sensing, communications, data analytics, and ground systems.[123] In addition to the launch activities described above, Chinese commercial space companies are rapidly improving their space-based imagery capabilities. For example, in 2021, the National Geospatial-Intelligence Agency assessed that Chinese companies led in three of nine categories of imagery capabilities—matching the number of categories in which U.S. companies led.[124]

The Chinese commercial space sector benefits from government support at the national and local level. For example, in late 2023, Shanghai announced ambitions to build a space information industry in the city worth almost $30 billion by 2025, envisioning a manufacturing capacity capable of constructing 50 commercial rockets and 600 satellites per year. To incentivize companies to come to Shanghai and invest in space, the Shanghai government plans to offer industrial funds and favorable policies.[125] Indeed, until 2018, funding from provincial and city governments was the primary source of capital for Chinese commercial space companies.[126] Despite providing significant funding, one report found that local governments tend not to have a direct hand in companies' activities.[127]

The central government, however, does seem to play a larger role in signaling government priorities to commercial entities and activities.[128] The policy of military–civil fusion and other structures and processes means the line between government owned and privately owned is often blurred. For example, the generally accepted definition of what is commercial

121 For a list of policies and documents, see, for example, Kathryn Walsh, Ian Christensen, and Rob Ronci, *Lost without Translation: Identifying Gaps in U.S. Perceptions of the Chinese Commercial Space Sector* (Washington, DC: Secure World Foundation, 2021), 8.

122 Liu et al., *Evaluation of China's Commercial Space Sector*, 30–31; and Blaine Curcio, "A Rising Chinese Space Sector: Expectations vs Reality," Satellite Markets & Research, June 1, 2022, https://www.satellitemarkets.com/market-trends/rising-chinese-space-sector-expectations-vs-reality.

123 Liu et al., *Evaluation of China's Commercial Space Sector.*

124 Bingen, "2024: The Year That Launched China's Commercial Space Sector?," 21.

125 Andrew Jones, "Shanghai to Foster Commercial Space Ecosystem," *SpaceNews*, November 30, 2023, https://spacenews.com/shanghai-to-foster-commercial-space-ecosystem/.

126 Walsh, Christensen, and Ronci, *Lost without Translation*, 29.

127 Walsh, Christensen, and Ronci, *Lost without Translation*, 30.

128 Liu et al., *Evaluation of China's Commercial Space Sector*, 18; and Walsh, Christensen, and Ronci, *Lost without Translation*, 30.

in China is that a company is not entirely state owned.[129] Most commercial companies in China have state funding or involvement.[130]

Although the Chinese commercial space sector does seem to be broadly on a positive trajectory, challenges exist. For example, any U.S. efforts to restrict Chinese access to advanced technology will make it more difficult for the PRC to procure key components and technologies. Chinese researchers have noted the need to prioritize developing the ability to indigenously manufacture technologies the United States has embargoed, prioritizing them for research.[131] There have also been efforts to seek overseas investment in emerging sectors to increase "technological self-reliance."[132]

Despite efforts to build a buffer against embargoes and sanctions, the PLA and Chinese companies continue to rely on the acquisition of foreign technologies to supplement domestic research.[133] This acquisition occurs by overt and covert means, leading to continued concerns about intellectual property theft by Chinese intelligence agencies and companies. For example, in August 2023, U.S. officials claimed Chinese intelligence actors were attempting to steal critical technologies from U.S. space companies.[134]

Even with official central and provincial support of the commercial industry, the Chinese commercial space sector may still face pressure arising from a lack of support from parts of the government bureaucracy and from concerns about potential competition with state-owned enterprises (SOEs). Within government policies, there is a tension between privileging SOEs as "national champions" on the one hand and encouraging the growth of a private sector that competes with them on the other.[135] A 2019 report found that Chinese commercial space companies did not receive contracts from the central government on the same scale as those in the United States and that Chinese SOEs were unlikely to want to cede market share to the new actors.[136] Other potential challenges include a lack of business

129 Blaine Curcio and Alura Winfrey, "Developments in China's Commercial Space Sector," National Bureau of Asian Research, August 24, 2021, https://www.nbr.org/publication/developments-in-chinas-commercial-space-sector/. On the discussion of "commercial space," see also Walsh, Christensen, and Ronci, *Lost without Translation*, 7.

130 Curcio and Winfrey, "Developments in China's Commercial Space Sector."

131 Frank Tang, "U.S. Technology Embargo List Is Blueprint for Chinese Research, Official Says," *South China Morning Post*, September 17, 2020, https://www.scmp.com/economy/china-economy/article/3101948/us-technology-embargo-list-gives-china-blueprint-home-grown.

132 Orange Wang, "China Unveils Road Map to Boost 'Technological Self-Reliance' amid Tech War," *South China Morning Post*, July 26, 2021, https://www.scmp.com/economy/china-economy/article/3142586/us-china-tech-war-beijing-calls-chinese-firms-seize-overseas.

133 DIA, *Challenges to Security in Space 2022*, 10.

134 Julian E. Barnes, "Intelligence Agencies Warn Foreign Spies Are Targeting U.S. Space Companies," *New York Times*, August 18, 2023. See also Erin C. Conaton, "Preventing China's DeepSeek in Space," *Defense News*, February 5, 2025, https://www.defensenews.com/opinion/2025/02/05/preventing-chinas-deepseek-in-space/.

135 Qian Jiwei, "Can Commercial Space Programmes Take Off in China?," ThinkChina, April 18, 2022, https://www.thinkchina.sg/technology/can-commercial-space-programmes-take-china.

136 Liu et al., *Evaluation of China's Commercial Space Sector*, 87.

sophistication, a lack of clarity about customers, a brand image sales problem, labor market pressures, and a lack of regulations and policies.[137]

Space Exploration and Deep Space

The PRC is increasingly interested in moving beyond Earth's orbit and into deep space. China's cislunar programs are a source of pride and status.

In 2003, China became the third country to achieve independent human spaceflight, and it has continued to show interest in exploring space. In 2022, China completed its three-module space station, Tiangong. Currently capable of hosting three taikonauts for six-month rotations, China intends to expand the space station and include foreign partners.[138] In 2023, China announced plans to place taikonauts on the moon by the end of the decade and to build a permanent research station with Russia on the lunar south pole in the 2030s.[139] In support of these efforts, CASC is currently developing a next-generation crewed spacecraft (the Mengzhou) to take taikonauts beyond LEO, a lunar lander, and a new rocket (the Long March-10).[140]

The Chinese lunar exploration program, with its Chang'e series of lunar probes, has made a series of advances in the last decade. In 2013, the Chang'e 3 became the first spacecraft to conduct a soft lunar landing since 1976.[141] In 2019, the Chang'e 4 mission made history by landing a rover on the far side of the Moon.[142] A year later, the Chang'e 5 mission solidified China's capability to land on the lunar surface and send material back to Earth.[143] China is planning to continue the mission series.

137 Liu et al., *Evaluation of China's Commercial Space Sector*, 83–91.

138 The Planetary Society, "Tiangong, China's Space Station," The Planetary Society, accessed on May 8, 2024, https://www.planetary.org/space-missions/chinese-space-station; Andrew Jones, "China to Send New Modules and Co-Orbiting Spacecraft to Tiangong Space Station," *SpaceNews*, October 4, 2023, https://spacenews.com/china-to-send-new-modules-and-co-orbiting-spacecraft-to-tiangong-space-station/; Andrew Jones and Daisy Dobrijevic, "China's Space Station, Tiangong: A Complete Guide," Space.com, August 24, 2021, https://www.space.com/tiangong-space-station; and Associated Press, "China Plans to Land Astronauts on Moon before 2030, Expand Space Station, Bring on Foreign Partners," *Associated Press*, May 29, 2023.

139 Associated Press, "China Plans to Land Astronauts;" Marsha Freeman, *Systems and Infrastructure Needed to Enable a Chinese Crewed Lunar Landing* (Montgomery, AL: China Aerospace Studies Institute, July 2022); and Tereza Pultarova, "Russia, China Reveal Moon Base Roadmap but No Plans for Astronaut Trips Yet," Space.com, June 17, 2021, https://www.space.com/china-russia-international-lunar-research-station.

140 Andrew Jones, "China Names the Spacecraft That Will Put Its Astronauts on the Moon," Space.com, February 29, 2024, https://www.space.com/china-names-spacecraft-astronaut-moon-missions.

141 Leonard David, "China Lands On the Moon: Historic Robotic Lunar Landing Includes 1st Chinese Rover," Space.com, December 14, 2013, https://www.space.com/23968-china-moon-rover-historic-lunar-landing.html.

142 Sarah Kaplan, Gerry Shih, and Rick Noack, "China Lands Spacecraft on the Far Side of the Moon, a Historic First," *Washington Post*, January 3, 2019.

143 The Planetary Society, "Chang'e-5: China's Moon Sample Return Mission," The Planetary Society, accessed on May 26, 2024, https://www.planetary.org/space-missions/change-5.

China has also demonstrated interest in and the capability to explore lunar orbits, including by exploring Lagrange points, points of equilibrium in space that allow small objects to remain relatively stationary within an orbit, reducing the need for orbital corrections and thus fuel (see Callout Box 2). In 2018, China became the first country to place a communications relay satellite in a halo orbit around L2, a Lagrange point on the far side of the moon.[144] The satellite, launched in support of the Chang'e missions, was built to relay transmissions from the far side of the moon back to Earth.[145] In 2024, a second Chinese satellite, Queqiao-2, entered lunar orbit, part of a planned constellation to support lunar navigation and communication services.[146] This constellation of relay satellites is expected to serve as a bridge for missions to other planets, including Mars and Venus.[147]

CALLOUT BOX 2: LAGRANGE POINTS

Lagrange points are points in space where the gravitational forces of two bodies produce points of equilibrium. These points are relatively stable, allowing small objects placed in them to remain in position. There are five Lagrange points in a two-body system. Those for the Earth and the sun are illustrated below.

FIGURE 7: LAGRANGE POINTS BETWEEN THE EARTH AND THE SUN

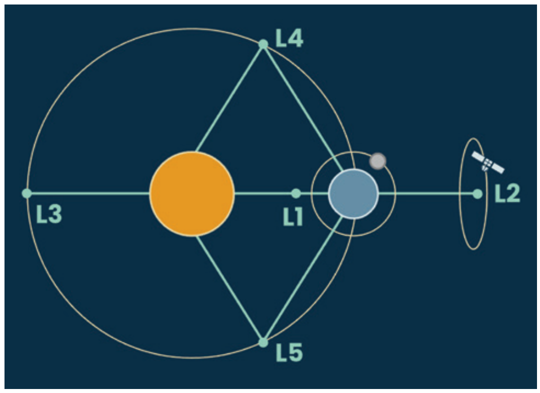


Image is illustrative. Distances are not to scale. Image inspired by NASA, "What Is a Lagrange Point," NASA, https://science.nasa.gov/resource/what-is-a-lagrange-point/.

Cislunar space has the potential to become a region of growing importance for not only scientific exploration but also for bolstering SDA and supporting lunar activities.[148] As activity increases on the moon's surface, access to PNT for lunar guidance, communications, and deep space situational awareness will be vital. Additionally, developing cislunar reconnaissance assets that face Earth could prove useful for monitoring

144 Andrew Jones, "Chang'e-4 Relay Satellite Enters Halo Orbit around Earth–Moon L2, Microsatellite in Lunar Orbit," *SpaceNews*, June 14, 2018, https://spacenews.com/change-4-relay-satellite-enters-halo-orbit-around-earth-moon-l2-microsatellite-in-lunar-orbit/.

145 Jones, "Chang'e-4 Relay Satellite Enters Halo Orbit."

146 Andrew Jones, "China's Queqiao-2 Relay Satellite Enters Lunar Orbit," *SpaceNews*, March 25, 2024, https://spacenews.com/chinas-queqiao-2-relay-satellite-enters-lunar-orbit/.

147 Albee Zhang and Ryan Woo, "China Launches Signal Relay Satellite for Mission to Moon's Hidden Side," *Reuters*, March 20, 2024.

148 Shawn Willis, "To the Moon: Strategic Competition in the Cislunar Region," *Aether,* Special Edition, Winter 2023. The military value of cislunar space is debated. For example, Swope and Gleason contended most cislunar activities will have a civilian focus with no clear compelling strategic military value outside of surveillance. Clayton Swope, *Salmon Swimming Upstream: Charting a Course in Cislunar Space* (Washington, DC: CSIS, 2024).

satellites orbiting earth, particularly because satellites tend not to face outward and thus operators may not have complete situational awareness about assets deeper in space.[149] Although technical difficulties certainly complicate constellations in cislunar space, if they are paired with rendezvous and proximity capabilities, satellites stationed in cislunar space could theoretically approach GEO assets without being seen and conduct kinetic and nonkinetic actions against adversarial satellites.[150]

Chinese Counterspace Capabilities

The PLA is investing in and demonstrating a range of ASAT capabilities. In 2021, now-retired Space Force General David Thompson, at the time the vice chief of space operations, warned that China was launching reversible attacks against U.S. satellites on a daily basis.[151] The next year, U.S. Space Command (USSPACECOM) Commander General James H. Dickinson told the Senate Armed Services Committee, "In the next 5–10 years the PLA's Strategic Support Force (SSF) will field a range of counterspace weapons with a mature space and counterspace infrastructure to directly challenge U.S. space superiority and threaten the United States in all orbital regimes."[152] These capabilities, combined with a doctrine that emphasizes early action and a clear focus on competing with the United States, suggest that China could hold U.S. space capabilities at risk.

DA-ASAT Capabilities

China is one of four countries that has successfully tested a DA-ASAT system, launching in 2007 a ballistic missile interceptor kinetic kill vehicle against an aged weather satellite in LEO.[153] The test, which generated an estimated 3,000 pieces of trackable debris, received global attention and condemnation.[154] The Secure World Foundation estimates China has

149 On some of the difficulties of situational awareness in cislunar space, see Spencer Kaplan, *Eyes on the Prize: The Strategic Implications of Cislunar Space and the Moon* (Washington, DC: CSIS, 2020), 5.

150 Spencer Kaplan, *Eyes on the Prize*.

On some of the challenges of cislunar sensors, see M. J. Holzinger, C. C. Chow, and P. Garretson, *A Primer on Cislunar Space* (Air Force Research Laboratory, 2021), 15–18.

151 Joseph Trevithick, "U.S. Satellites Are Being Attacked Every Day According to Space Force General," *The Drive*, November 30, 2021, https://www.thedrive.com/the-war-zone/43328/u-s-satellites-are-being-attacked-everyday-according-to-space-force-general.

152 James H. Dickinson, "Fiscal Year 2023 Priorities and Posture of United States Space Command," Presentation to the Senate Armed Services Committee, March 1, 2022, https://www.armed-services.senate.gov/imo/media/doc/USSPACECOM%20FY23%20Posture%20Statement%20SASC%20FINAL.pdf, 6.

153 Brian Weeden, "2007 Chinese Anti-Satellite Test Fact Sheet," Secure World Foundation, November 23, 2010, https://swfound.org/media/9550/chinese_asat_fact_sheet_updated_2012.pdf.

154 Weeden, "2007 Chinese Anti-Satellite Test Fact Sheet;" and Ewen MacAskill, Michael White, and Brian Whitaker, "Western Protests Flood In Over Chinese Satellite Killer," *The Guardian*, January 20, 2007.

conducted ten additional DA-ASAT tests since 2007, though these have not created trackable orbital debris.[155]

Open-source reporting from the Secure World Foundation suggests China has at least one and as many as three DA-ASAT programs, designed either for dedicated counterspace purposes or for midcourse missile defense that could also provide counterspace capabilities.[156] The 2007 test used an SC-19 (also known as the DN-1), which is believed to be a modified version of the DF-21 ballistic missile.[157] Reportedly, the SC-19 was also tested in 2010 and 2013, successfully intercepting a suborbital ballistic target.[158] China appears to have conducted a test of what could be a second ASAT missile system meant to reach higher orbits: In 2013, China launched a rocket on a trajectory toward GEO in what the Chinese Academy of Sciences said was a high-altitude scientific research mission.[159] Although unconfirmed, analysts suggest this could have been a test of a new road-mobile ballistic missile related to China's ASAT program.[160] The third possible DA-ASAT program may be attached to a series of tests of a system known publicly as DN-3, which could be an upgraded version of the SC-19/DN-1 or an adaptation of the SC-19 for missile defense.[161]

At least one of these systems appears to have reached operational status. In 2019, Director of National Intelligence Daniel Coats said the PLA "has an operational ground-based ASAT missile intended to target low-Earth-orbit satellites," and a 2023 report from the U.S. National Space Intelligence Center and the National Air and Space Intelligence Center said the PLA "routinely trains with an operational variant" of the SC-19.[162] The Secure World

155 Brian Weeden and Victoria Samson, eds., *Global Counterspace Capabilities: An Open Source Assessment* (Washington, DC: Secure World Foundation, 2024), 03-15–16.

156 Brian Weeden, *Chinese Direct Ascent Anti-Satellite Testing* (Washington, DC: Secure World Foundation, July 2023); Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-11.

157 Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-12.

158 Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-12.

159 Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-13–14.

160 Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-13–14.

In 2015, a DoD publication suggested the launch could have tested capabilities relevant for counterspace missions: "The launch profile was not consistent with traditional space-launch vehicles, ballistic missiles or sounding rocket launches used for scientific research. It could, however, have been a test of technologies with a counterspace mission in geosynchronous orbit." DoD, *Military and Security Developments Involving the People's Republic of China 2015*, Annual Report to Congress (U.S. Department of Defense, April 7, 2015), 14.

A 2023 DOD document described the launch and its trajectory as "suggesting [China] may have a missile capable of destroying satellites in geostationary Earth orbit." National Space Intelligence Center and the National Air and Space Intelligence Center, *Competing in Space*, 2nd ed. (National Space Intelligence Center; National Air and Space Intelligence Center, December 2023), 11.

161 Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-15.

162 Daniel R. Coats, *Statement for the Record: Worldwide Threat Assessment of the US Intelligence Community* (Washington, DC: Senate Select Committee on Intelligence, January 29, 2019), 17; National Space Intelligence Center and the National Air and Space Intelligence Center, *Competing in Space*, 11; Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-15.

Foundation has assessed that Chinese DA-ASAT capabilities against LEO targets are likely mature, though Chinese DA-ASAT capability against deeper space targets (MEO and beyond) is likely still in experimental or developmental phases.[163]

Orbital Weapons Capabilities

China is developing several capabilities on orbit that could be used for counterspace purposes.[164] Although these capabilities could have benign applications, some also demonstrate dual-use capabilities that could pose a threat to U.S. and allied space systems. For example, the SJ-17 satellite was the first Chinese satellite to have a robotic arm, a technology that could be used to grapple other satellites.[165] China, according to a DIA publication on space, is also developing satellite inspection and repair capabilities, which could be used for counterspace purposes.[166] Together, these developments suggest that China is developing capabilities that could threaten adversary satellites via on-orbit rendezvous and proximity operations (RPOs).

Chinese satellites have conducted a series of RPOs that outside observers have been able to track (see Figure 8).[167] The first known Chinese RPO was conducted in 2010, when two satellites in LEO seemed to bump into each other.[168] Since then, the techniques seem to have improved and missions expanded. For example, in 2018, SJ-17 rendezvoused with a Chinese communications satellite that had experienced an anomaly in its orbital trajectory. SJ-17 stayed with the communications satellite as it maneuvered back to its original location, suggesting SJ-17 was used to inspect the communications satellite and monitor attempts to recover its path.[169] In December 2018, China launched the TJS-3 satellite into GEO. Among other unusual activity, TJS-3 has reportedly parked itself relatively close to multiple satellites, including a Russian Luch satellite and, according to the Secure World Foundation, U.S. national security satellites.[170] In another example of maneuvering capabilities, China launched a pair of satellites into GEO in December 2021. They remained in proximity to each

163 Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-11.

164 DIA, *Challenges to Security in Space 2022*, 18.

165 DIA, *Challenges to Security in Space 2022*, 18; and DOD, *Military and Security Developments Involving the People's Republic of China 2023*, 103.

166 DIA *Challenges to Security in Space 2022*, 18.

167 For an overview, see Victoria Samson and Laetitia Cesari, *Global Counterspace Capabilities: An Open Source Assessment* (Washington, DC: Secure World Foundation, 2025), 03—01-12. Recent CSIS Space Threat Assessment reports have also detailed Chinese RPOs. See, for example, Swope et al., *Space Threat Assessment 2024*, 10.

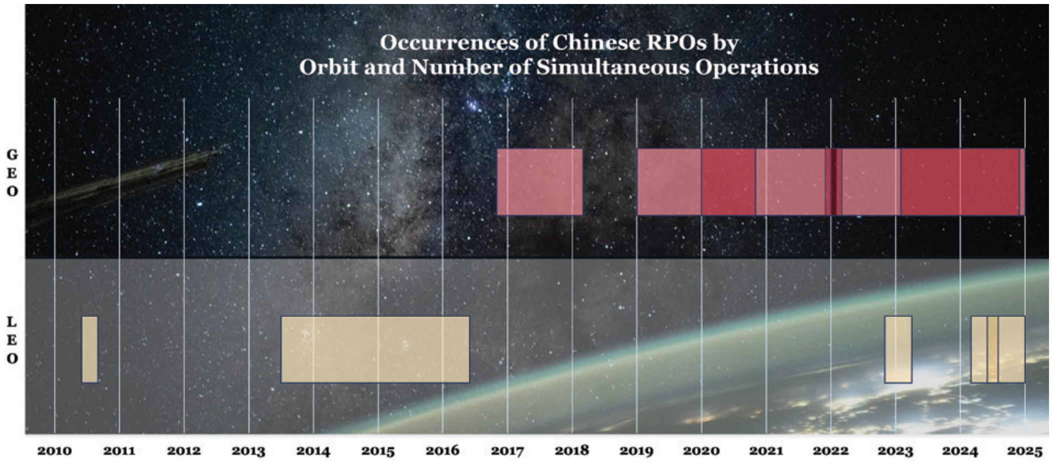
168 Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-–01.

169 Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-–06. See also Thomas G. Roberts, "Unusual Behavior in GEO: SJ-17," *Aerospace Security,* Center for Strategic and International Studies, September 1, 2022, https://aerospace.csis.org/data/unusual-behavior-in-geo-sj-17/.

170 Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-–07; Samson and Cesari, *Global Counterspace Capabilities 2025*, 03-08–09. See also Andrew Jones, "A Chinese Spacecraft Has Been Checking Out U.S. Satellites High above Earth," Space.com, March 3, 2023, https://www.space.com/chinese-spacecraft-tjs-3-inspecting-us-satellites.

other, indicating they had maneuvering capability and may have been conducting an RPO.[171] In 2022, a U.S. space surveillance satellite reportedly maneuvered to approach the pair, and the two satellites seemed to maneuver in response, splitting up and later rotating around the GEO belt in opposite directions.[172] In 2024, China reportedly maneuvered five different space objects around each other in LEO, conducting activity General Michael A. Guetlein, the vice chief of space operations, described as practicing "dogfighting."[173]

FIGURE 8: FREQUENCY OF RECENT CHINESE RPOS



Each gradient of color represents a different number of simultaneous operations taking place. The lightest yellow indicates one ongoing operation in LEO, and the darker yellow indicates two ongoing operations in LEO. The lightest red indicates one ongoing operation in GEO, the middle red indicates two ongoing operations in GEO, and the darkest red indicates three ongoing operations in GEO. This is a graphical depiction of occurrences of recent assessed Chinese RPOs. Locations of each figure do not necessarily reflect an exact altitude of each occurrence.

Data derived from Samson and Cesari, Global Counterspace Capabilities 2025, 03-11, which was published in April 2025. Data visualized through December 2024. See Appendix A for more details, including descriptions of each included RPO. Background image from: NASA, "The Milky Way appears above Earth's bright atmospheric glow," NASA Image and Video Library, August 23, 2025, https://images.nasa.gov/details/iss073e0516005.

China has demonstrated other dual-use on-orbit capabilities. For example, China has been reportedly experimenting with debris removal.[174] In 2021, a payload China launched into LEO purportedly carried out an experiment using a large net to capture a tethered target

171 Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-08–09.

172 Swope et al., *Space Threat Assessment 2024*, 10; Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-08–09; and Debra Werner, "An In-Orbit Game of Cat and Mouse: Close Approaches Prompt Calls for Communications and Norms," *SpaceNews*, June 16, 2022, https://spacenews.com/an-in-orbit-game-of-cat-and-mouse-close-approaches-prompt-calls-for-communications-and-norms/.

An animated video depicting the incident can be seen at SpaceNews, "USA 270/Shiyan12 Encounter," YouTube, 2022, https://www.youtube.com/watch?v=H0ZlgmdjXjw.

173 Simone McCarthy, "China Is Practicing 'Dogfighting' with Satellites as It Ramps Up Space Capabilities: US Space Force," *CNN*, March 21, 2025, https://www.cnn.com/2025/03/21/china/china-space-force-dogfighting-satellites-intl-hnk/index.html.

174 Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-–04.

simulating debris, though it is difficult to verify this claim.[175] In 2022, a Chinese satellite with a robotic arm, SJ-21, pulled a derelict Chinese navigation satellite into a high graveyard orbit above the geostationary belt.[176] In January 2025, China launched the SJ-25, which the manufacturer (a subsidiary of the China Aerospace Science and Technology Corporation) described as for satellite fuel replenishment and life extension.[177]

China is also developing a spaceplane, the Shenlong.[178] In September 2020, China launched an experimental Shenlong spaceplane that may have deployed at least one small satellite on orbit, though few facts about the activity are publicly available.[179] In August 2022, China launched a second Shenlong spaceplane, which appears to have released a new object and then performed a series of RPOs with the object, including repeated docking, deployment, and formation flying.[180] In December 2023, China launched a Shenlong spaceplane for the third time. Highlighting the difficulty of SSA, public reporting has debated whether the plane released objects or whether detected objects were debris.[181]

Since at least 2006, Chinese academics affiliated with the government have been researching engineering requirements associated with space-based kinetic weapons that could target terrestrial objects from orbit.[182] Among other topics, the research on space-based kinetic weapons has included the topics of reentry, payload separation, and delivery vehicles.[183]

175 Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-–04; Andrew Jones, “China launches space mining test spacecraft on commercial rideshare mission,” *SpaceNews*, April 27, 2021, https://spacenews.com/china-launches-space-mining-test-spacecraft-on-commercial-rideshare-mission/.

176 Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-–08; and DoD, *Military and Security Developments Involving the People’s Republic of China 2023*, 103.

177 Andrew Jones, “China Launches Shijian-25 Satellite to Test On-Orbit Refueling and Mission Extension Technologies,” *SpaceNews*, January 6, 2025, https://spacenews.com/china-launches-shijian-25-satellite-to-test-on-orbit-refueling-and-mission-extension-technologies/.

178 Namrata Goswami and Peter Garretson, “The Strategic Implications of China’s ‘Divine Dragon’ Spaceplane,” *The Diplomat*, January 12, 2024, https://thediplomat.com/2024/01/the-strategic-implications-of-chinas-divine-dragon-spaceplane/.

179 Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-–05.

180 Joseph Trevithick, “Chinese Spaceplane Docked with Another Object Multiple Times Data Indicates,” *The War Zone*, May 9, 2023, https://www.twz.com/chinese-spaceplane-docked-with-another-object-multiple-times-data-indicates; and Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-–05.

181 Theresa Hitchens, “Hide and Seek: Despite Sharper Eyes on the Heavens, Sneaky Sats Can Still Find Shadows,” *Breaking Defense*, June 7, 2024; Andrew Jones, “China’s Secretive Spaceplane Raises Its Orbit, but Yet to Deploy Satellites,” *SpaceNews*, January 31, 2024, https://spacenews.com/chinas-secretive-spaceplane-raises-its-orbit-but-yet-to-deploy-satellites/; and Brett Tingley, “China’s Space Plane Apparently Deployed 6 ‘Mysterious Wingmen’ in Orbit,” Space.com, June 10, 2024, https://www.space.com/china-space-plane-depoyed-mystery-objects; Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-–05; and Samson and Cesari, *Global Counterspace Capabilities 2025*, 03-5–06.

182 DIA, *Challenges to Security in Space 2022*, 18.

183 DIA, *Challenges to Security in Space 2022*, 18.

In summer 2021, reporting emerged claiming China had tested a "nuclear-capable hypersonic missile."[184] Initial reporting of the event was inconsistent, but in November 2021, Saltzman, then deputy chief of space operations, confirmed the tests involved a fractional orbital bombardment system (FOBS).[185] The same month, General John Hyten, then vice chairman of the Joint Chiefs of Staff, confirmed that the missile "went around the world, dropped off a hypersonic glide vehicle that glided all the way back to China, that impacted a target in China."[186] In subsequent publications, the Department of Defense has asserted that China conducted the first fractional orbital launch of an intercontinental ballistic missile with a hypersonic glide vehicle (HGV), demonstrating the greatest distance flown (approximately 40,000 km) and longest flight time (approximately 100 or more minutes) of any Chinese land attack weapons system to date.[187]

Although not a counterspace weapon itself, a FOBS does move through space.[188] A FOBS uses a rocket to boost a warhead delivery system into LEO. The warhead delivery system then circles the globe in LEO until it de-orbits through the atmosphere to engage its terrestrial target. The Chinese FOBS technology and concept itself is not entirely new: the Soviet Union, seeking a capability that could circumvent U.S. early warning radars that looked toward the North Pole, deployed FOBS capable of carrying nuclear warheads from the late 1960s through the early 1980s.[189]

184 Demetri Sevastopulo and Kathrin Hille, "China Tests New Space Capability with Hypersonic Missile," *Financial Times*, October 16, 2021; and Demetri Sevastopulo, "China Conducted Two Hypersonic Weapons Tests This Summer," *Financial Times*, October 20, 2021.

185 Theresa Hitchens, "It's a FOBS, Space Force's Saltzman Confirms amid Chinese Weapons Test Confusion," *Breaking Defense*, November 29, 2021.

For an analysis of the reporting, see Todd Harrison et al., *Space Threat Assessment 2022* (Washington, DC: CSIS, 2022), 23–24.

186 David Martin, "Exclusive: No. 2 in U.S. Military Reveals New Details about China's Hypersonic Weapons Test," *CBS News*, November 16, 2021, https://www.cbsnews.com/news/china-hypersonic-weapons-test-details-united-states-military/.

187 DIA, *Challenges to Security in Space 2022*, 18; and DoD, *Military and Security Developments Involving the People's Republic of China 2015*, 103.

188 Harrison et al. concluded in 2022 that "nothing in the reporting suggests that this is a weapon that would be stationed in space for periods longer than one orbit, nor does it indicate that the weapon would be capable of targeting satellites. The test underscores the need for the United States and its allies to improve defenses against hypersonic weapons, but it does not appear to be a new development in space or counterspace weapons." Harrison et al., *Space Threat Assessment 2022*, 23–24.

189 Jeffrey Lewis, "China's Orbital Bombardment System Is Big, Bad News—But Not a Breakthrough," *Foreign Policy*, May 16, 2024, https://foreignpolicy.com/2021/10/18/hypersonic-china-missile-nuclear-fobs/; and Asif A. Siddiqi, "The Soviet Fractional Orbiting Bombardment System (FOBS): A Short Technical History," *Quest* 7, no. 4, Spring 2000. For a brief discussion of U.S. responses to the Soviet FOBS, see Aaron Bateman, *Weapons in Space: Technology, Politics, and the Rise and Fall of the Strategic Defense Initiative* (Cambridge, MA: MIT Press, 2024), 16.

The PLA test was novel because it de-orbited an HGV as the delivery vehicle for a potential warhead.[190] Although a FOBS can be more detectable than a traditional missile because it spends more time at a higher altitude, its path can also be unpredictable because it is difficult to assess where and when it will de-orbit. Adding an HGV amplifies the difficulty of tracking due to its maneuverability.[191] A FOBS/HGV hybrid, thus, could pose challenges in tracking and interception.

Directed Energy Weapons

Public information about any potential Chinese deployment of directed energy weapons (DEW) capabilities are sparse, though analysts at the Secure World Foundation have assessed that China has a robust DEW R&D program.[192] China has been pursuing laser capabilities—which could be used for counterspace and other applications—since at least the 1980s.[193] Open-source research has suggested there are at least five main sites supporting China's development and fielding of DEW, with the main facility seemingly at a complex near the Korla Missile Test Facility in Xinjiang.[194]

According to the DIA, over the past two decades, Chinese defense researchers have proposed both reversible and nonreversible counterspace DEWs.[195] There are public reports of at least two possible demonstrations of Chinese counterspace DEW capabilities. In 2005, a team of Chinese scientists documented a reportedly successful test of a vehicle-mounted laser against a satellite in LEO.[196] The next year, in 2006, U.S. defense officials claimed China illuminated a U.S. satellite.[197] A DIA publication has asserted China has multiple ground-based

190 Cameron Tracy, "De-Hyping China's Missile Test," *The Equation*, UCS, October 21, 2021, https://blog.ucsusa.org/guest-commentary/de-hyping-chinas-missile-test/; and Mark Zastrow, "How Does China's Hypersonic Glide Vehicle Work?," Astronomy, November 4, 2021, https://www.astronomy.com/space-exploration/how-does-chinas-hypersonic-glide-vehicle-work/.

191 Hitchens, "It's a FOBS;" and Zastrow, "How Does China's Hypersonic Glide Vehicle Work?"

192 Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-19–21.

193 U.S.-China Economic and Security Review Commission, "China's Pursuit of Advanced Weapons," in *2017 Report to Congress* (Washington, DC: U.S.-China Economic and Security Review Commission, 2017), 563. Other analysts trace efforts back to the 1960s: Richard D. Fisher, Jr., *China's Progress with Directed Energy Weapons*, Testimony before the U.S.-China Economic and Security Review Commission, China's Advanced Weapons, February 23, 2017, https://www.uscc.gov/sites/default/files/Fisher_Combined.pdf.

194 Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-19–20. See also Brian G. Chow and Henry Sokolski, "U.S. Satellites Increasingly Vulnerable to China's Ground-Based Lasers," *SpaceNews*, July 10, 2020, https://spacenews.com/op-ed-u-s-satellites-increasingly-vulnerable-to-chinas-ground-based-lasers/.

195 DIA, *Challenges to Security in Space 2022*, 17.

196 Fisher, *China's Progress*, 6; Bill Gertz, "How China's Mad Scientists Plan to Shock America's Military: Super Lasers, Railguns and Microwave Weapons," *The National Interest,* Center for the National Interest, March 10, 2017, https://nationalinterest.org/blog/the-buzz/how-chinas-mad-scientists-plan-shock-americas-military-super-19737; and Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-19.

197 SpaceNews, "NRO Confirms Chinese Laser Test Illuminated U.S. Spacecraft," *SpaceNews*, October 3, 2006, https://spacenews.com/nro-confirms-chinese-laser-test-illuminated-us-spacecraft/; Glenn Kessler, "Bachmann's Claim That China 'Blinded' U.S. Satellites," *Washington Post*, October 4, 2011.

laser weapons of varying power levels, including a currently "limited" capability to employ laser systems against satellite sensors, and that by the late-mid to late 2020s, China may field higher power systems that could extend the threat to target nonoptical satellites.[198]

Electronic Warfare and Cyber Capabilities

Chinese electronic warfare (EW) and cyber warfighting concepts and capabilities play a considerable role in the way in which the PLA plans to achieve information dominance.[199] Secure World Foundation analysts have assessed that there is significant evidence of Chinese R&D of counterspace EW capabilities and some evidence that those capabilities have been deployed.[200]

China is assessed by Brian Weeden and Victoria Samson as being proficient at jamming GNSS downlinks.[201] Although attribution of jamming can be difficult, there are several examples of reported jamming in the Indo-Pacific region. For example, in 2018, satellite imagery circulated that suggested the presence of PLA jamming equipment on Mischief Reef.[202] In just one day in 2019, GNSS spoofing affected more than 300 ships in Shanghai and the Huangpu River.[203] In 2023, pilots were warned about Chinese warships jamming radio signals and GPS over large swaths of the Indo-Pacific.[204] There has also been evidence of PRC investments in capabilities to jam synthetic aperture radar (SAR) satellites and SATCOM, in addition to exercising jamming and anti-jamming techniques.[205] However, as

198 DIA, *Challenges to Security in Space 2022*, 17.

199 Marcus Clay, "To Rule the Invisible Battlefield: The Electromagnetic Spectrum and Chinese Military Power," War on the Rocks, January 22, 2021, http://warontherocks.com/2021/01/to-rule-the-invisible-battlefield-the-electromagnetic-spectrum-and-chinese-military-power/; B. A. Friedman, "Finding the Right Model: The Joint Force, the People's Liberation Army, and Information Warfare," *Journal of Indo-Pacific Affairs* 6, no. 3, April 2023; Elsa B. Kania and John K. Costello, "The Strategic Support Force and the Future of Chinese Information Operations," *The Cyber Defense Review*, Spring 2018; and U.S.–China Economic and Security Review Commission, "China's Cyber Capabilities: Warfare, Espionage, and Implications for the United States," in U.S.–China Economic and Security Review Commission*, 2022 Report to Congress of the U.S.-China Economic and Security Review Commission* (Washington, DC: U.S. Government Publishing Office, 2022).

200 Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-17–19.

201 Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-17–18.

202 J. Michael Dahm, "Electronic Warfare and Signals Intelligence," Johns Hopkins University Applied Physics Laboratory, August 2020, https://www.jhuapl.edu/sites/default/files/2022-12/EWandSIGINT.pdf; and Scott Neuman and Anthony Kuhn, "Beijing Reportedly Installs Communications Jamming Equipment in South China Sea," *NPR*, April 10, 2018, https://www.npr.org/sections/thetwo-way/2018/04/10/601075294/beijing-reportedly-installs-communications-jamming-equipment-in-south-china-sea.

203 Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-18; and Mark Harris, "Ghost Ships, Crop Circles, and Soft Gold: A GPS Mystery in Shanghai," *MIT Technology Review*, November 15, 2019, https://www.technologyreview.com/2019/11/15/131940/ghost-ships-crop-circles-and-soft-gold-a-gps-mystery-in-shanghai/.

204 Mostafa Rachwani, "Qantas Pilots Told to Fly through Radio Interference Reportedly Coming from Chinese Warships," *The Guardian*, March 17, 2023.

205 Weeden and Samson, *Global Counterspace Capabilities 2024*, 03-18; and DIA, *Challenges to Security in Space 2019* (Washington, DC: DIA, 2019), 17.

of April 2025, Secure World Foundation analysts have found no public evidence of the PLA using counterspace EW in military operations.[206]

There has been evidence of Chinese cyberattacks against satellite networks. In 2023, for example, Microsoft revealed a Chinese state-affiliated cyber operation that targeted critical infrastructure in Guam and elsewhere in the United States.[207] Among other infrastructure, SATCOM have been specifically mentioned as targets in reporting about the incident.[208] Such attacks are not necessarily new: in 2011, it was reported that in 2007 and 2008, at least two U.S. government satellites experienced interference from cyberattacks.[209] News reports suggested that the attacks were suspected to have been conducted by Chinese actors and routed through a commercial satellite station in Norway that NASA used for data transfers.[210] In 2014, NOAA experienced a breach of its satellite system from a cyberattack believed to have originated in China.[211] In 2018, a cyber security company revealed attacks against a satellite communications operator and a geospatial imaging and mapping organization, tracking the origins of the attack to computers within China.[212]

Assessment of Capabilities

Overall, it is clear that China is investing heavily in both its space and counterspace capabilities. Its space architecture is built to support terrestrial operations, particularly those in the Indo-Pacific. China also has growing counterspace capabilities that could be used to attempt to deter the United States or to interfere with ongoing U.S. operations (see Figure 9). Chinese doctrinal emphasis on preemption suggests that, if a terrestrial conflict were on the horizon, U.S. space capabilities would be targeted early, putting U.S. mobilization and kill chains at risk.[213]

However, the PLA's increasing reliance on space for terrestrial use may also limit its behavior. Although its doctrine emphasizes preemption and escalation dominance, the PLA

206 Samson and Cesari, *Global Counterspace Capabilities 2025*, 03-19.

207 Zeba Siddiqui and Christopher Bing, "Chinese Hackers Spying on U.S. Critical Infrastructure, Western Intelligence Says," *Reuters*, May 24, 2023.

208 Microsoft Threat Intelligence, *Sophistication, Scope, and Scale: Digital Threats from East Asia Increase in Breadth and Effectiveness* (Microsoft Threat Intelligence, September 2023), 5.

209 U.S.–China Economic and Security Review Commission, *2011 Report to Congress* (Washington, DC: U.S. Government Publishing Office, 2011), 216.

210 Charles Arthur, "Chinese Hackers Suspected of Interfering with U.S. Satellites," *The Guardian*, October 27, 2011; Jim Wolf, "China Key Suspect in U.S. Satellite Hacks: Commission," *Reuters*, October 28, 2011.

211 Mary Pat Flaherty, Jason Samenow, and Lisa Rein, "Chinese Hack U.S. Weather Systems, Satellite Network," *Washington Post*, April 16, 2023.

212 Threat Hunter Team, "Thrip: Espionage Group Hits Satellite, Telecoms, and Defense Companies," Symantec, June 19, 2018, https://symantec-enterprise-blogs.security.com/blogs/threat-intelligence/thrip-hits-satellite-telecoms-defense-targets.

213 Hou, "Offensive Defense;" and Wang, Graff, and Dale-Huang, *China's Growing Risk Tolerance*.

may be more hesitant to do so if the Chinese leadership fears doing so would disrupt its own space capabilities. This also suggests the Chinese government may be cautious about using kinetic space weapons because doing so would create debris that could harm its own assets. As a result, the PLA may emphasize soft-kill capabilities.[214] The levels of dependence could be context dependent, however. For example, if the PLA were only focused on fighting on China's periphery, with predominantly interior lines of communication and thus less militarily dependent on space, the PLA could be more willing to take risks.

FIGURE 9: ASSESSED STATUS OF CHINESE COUNTERSPACE CAPABILITIES BY THE SECURE WORLD FOUNDATION'S 2025 *GLOBAL COUNTERSPACE CAPABILITIES* REPORT

	R&D	Testing	Operational	*Overall Status*
DA-ASAT				
LEO	*Significant*	*Significant*	*Significant*	*Significant*
MEO/GEO	*Some*	*Some*	*(No data)*	*Some*
Co-Orbital Weapons				
LEO	*Significant*	*Uncertain*	*(No data)*	*Significant*
MEO/GEO	*Some*	*(No data)*	*(No data)*	*Some*
Other Capabilities				
Directed Energy	*Significant*	*Some*	*(No data)*	*Some*
Electronic Warfare	*Significant*	*Significant*	*Significant*	*Significant*
Space Situational Awareness	*Significant*	*Significant*	*Significant*	*Significant*

Image derived from assessments and figures by Samson and Cesari, *Global Counterspace Capabilities 2025*, xviii and xxiii.

As long as the PLA judges, however, that threatening U.S. space assets will bring it more benefits than costs, China's space capabilities will represent a significant threat to U.S. space capabilities. The trajectory of China's space program continues unabated, suggesting the threat will expand into the near- and medium-term future, if not beyond.

214 Berge and Hiim, "Killing Them Softly."

CHAPTER 3

Russian Military Space Activity and Investments

Russia has a rich space history, but it is not the space power it once was. Constrained by resource limitations and structural disadvantages, the Russian space program currently lacks the potential of the U.S. and Chinese programs. Russia will, however, continue to be a major space actor and pose a threat to U.S. space systems. Indeed, Russian space capabilities remain notable, and its mature and growing ASAT capabilities are tailored toward the United States. Thus, Russia will remain a significant counterspace threat to the United States even as Russia's own space capabilities begin to lag others. This combination of strong ASAT capabilities and weaker space capabilities could suggest Russia may be more risk acceptant in space than China as Moscow works to compete asymmetrically in space.

The Soviet Union's space program is one of the great prides of Russian history. The USSR put the first artificial satellite in orbit, sent the first man into space, conducted the first spacewalk, built the first permanently crewed space station, and established the first dedicated military space force. While competing in the Cold War-era Space Race, it built a substantial space knowledge and industrial base, both capitalizing on and underpinning Soviet science and engineering education to build a high-end workforce.[215]

After the collapse of the Soviet Union, the Russian space program faced several challenges.[216] The dissolution of the USSR meant the complex network of subcontractors supplying everything from electronics to rocket fuel and engines were spread across the newly independent

215 For more on the Soviet space program, see Asif A. Siddiqi, *Challenge to Apollo: The Soviet Union and the Space Race, 1945–1974* (Washington, DC: NASA, 2000).

216 See, for example, Brian Harvey, *Russia in Space: The Failed Frontier?* (London: Springer London, 2001); and Maxim V. Tarasenko, "Transformation of the Soviet Space Program after the Cold War," *Science & Global Security* 4, no. 3, August 1, 1994, 339–61, https://doi.org/10.1080/08929889408426406. On science in Russia after the collapse, see Loren R. Graham and Irina Dezhina, *Science in the New Russia: Crisis, Aid, Reform* (Bloomington: Indiana University Press, 2008).

Soviet republics, with many facilities located outside Russia. Resources made available to the space program atrophied as the Russian state fell into disarray.[217] Employment in the industry dropped, in part due to long periods of unpaid wages.[218] Notably, Russia lost not only many of its active space capabilities but also the opportunity cost of years of reduced R&D levels and the technical and organizational ability to easily restart that long-term R&D.

Under Vladimir Putin, the Russian space industry began to recover.[219] Supported by national economic growth in the 2000s, the space program received a larger budget, and the space industry was restructured, experimenting with different management structures and levels of government control. The program produced some success as it received more money and attention. For example, the Russian space community restored *Globalnaya Navigatsionnaya Sputnikovaya Sistema* (GLONASS), Russia's satellite navigation system. Russian leadership has also publicly lauded several new developments in space-based and space-effect capabilities, such as hypersonic weapons, laser technologies, and EW.[220]

Despite these successes, the Russian space program has faced a series of setbacks and recent failures. The industry is plagued by systemic delays, and multiple programs have been cancelled after years of investment.[221] Quality control is questionable across the field, and much infrastructure is due to be upgraded: In 2013, for example, analysts estimated that 90 percent of space industrial infrastructure in Russia was more than 20 years old.[222] Modernization and replacement of infrastructure has been a priority, but it is unclear how successful these Russian government efforts have been.[223]

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217 Symbolic of the program's struggles, Russia de-orbited the Mir space station in 2001 due in large part to a lack of funding. Anatoly Zak, "The Era of Russia's Space Station Mir Coming to an End," *Spaceflight Now*, October 3, 2000, https://spaceflightnow.com/news/n0010/03mir/.

218 James Moltz, "The Changing Dynamics of Twenty-First-Century Space Power," *Strategic Studies Quarterly* 12, no. 1, April 2019, 72, https://doi.org/10.5038/1944-0472.12.1.1729.

219 Bertrand de Montluc, "Russia's Resurgence: Prospects for Space Policy and International Cooperation," *Space Policy* 26, no. 1, February 1, 2010, 15–24, https://doi.org/10.1016/j.spacepol.2009.12.002.

220 See, for example, Tony Wesolowsky, "'You Have Failed To Contain Russia': Putin in Fiery Address," *Radio Free Europe/Radio Liberty*, March 1, 2018; Reuters, "Russia Leads the World in Hypersonic Missiles Tech, Putin Says," *Reuters*, December 12, 2021; and Associated Press, "Putin Hails New Russian Laser Weapons," *Associated Press*, May 17, 2019.

221 The next generation Angara-A5 rockets are a good example of systemic delays. They have been in development since the 1990s, but only flew its first test launch in 2014. In 2025, Angara-A5 carried its first operational payload—more than three decades after it was first proposed. Aviation Week Staff, "Heavy Angara A5 Orbits First Payloads from Plesetsk," *Aviation Week*, June 19, 2025, https://aviationweek.com/space/launch-vehicles-propulsion/heavy-angara-a5-orbits-first-payloads-plesetsk; France 24, "60 Years after Gagarin, Russia Lags in the Space Race," *France 24*, April 7, 2021, https://www.france24.com/en/live-news/20210407-60-years-after-gagarin-russia-lags-in-the-space-race; Anatoly Zak, "Angara-5 to replace Proton," Russian Space Web, June 22, 2025, https://www.russianspaceweb.com/angara5.html; Zak, "Angara-5 carries its first payloads," Russian Space Web, July 22, 2025, https://www.russianspaceweb.com/angara5-flight5.html.

222 Marco Aliberti and Ksenia Lisitsyna, *Russia's Posture in Space: Prospects for Europe* (Springer, 2018), 15.

223 Florian Vidal, *Russia's Space Policy: The Path of Decline*? (Paris: IFRI, January 2021).

Space Strategy, Doctrine, and Organization

The Russian military views space as key to contemporary and future warfare.[224] Russian understandings of modern warfare emphasize the role of information, in part due to the need to conduct military operations across a vast geographic area and the considerable information requirements of precision weapons.[225] The Russian military thus emphasizes achieving information superiority as a key objective and sees space as a warfighting domain that can be a decisive factor in modern warfare due to its role in enabling information superiority, particularly during the initial phases of conflict.[226] The most recent *Russian Military Doctrine*, published in 2014, described military conflict as "exerting simultaneous pressure on the enemy throughout the enemy's territory in the global information space, airspace, and outer space, on land and sea."[227] Russia's concept to counter U.S. air power considers a single aerospace theater of military operations.[228] Although it focuses on the air domain, space operations are a subset of the concept.[229] Some Russian analysts anticipate offensive counterspace operations that could precede offensive operations in other domains in order to degrade an adversary's command and control.[230]

224 Michael Connell, *The Role of Space in Russia's Operations in Ukraine* (Arlington, VA: CNA, November 2023); Timothy Thomas, *Russian Combat Capabilities for 2020: Three Developments to Track* (McLean, VA: MITRE, December 2019), https://www.armyupress.army.mil/Portals/7/Legacy-Articles/documents/Thomas-Russian-Combat-Capabilities.pdf; and Weeden and Samson, *Global Counterspace Capabilities 2024*, chap. 2.

Although this report focuses on military capabilities and their application, for Russia, like China, space is tightly interwoven with great power status. In 2019, former Russian prime minister Dmitri Medvedev summarized Russian goals in space: "[Russian] leadership [in space] must be returned. This is not only a matter of prestige, but also of national security." Dmitry Medvedev, "О Развитии Государственной Корпорации По Космической Деятельности «Роскосмос» [On the Development of the State Corporation for Space Activities, Roscosmos]," June 13, 2019, http://government.ru/news/36999/#.

225 DIA, *Russia Military Power: Building a Military to Support Great Power Aspirations* (Arlington, VA: DIA, 2017), 35; and DIA, *Challenges to Security in Space 2022*, 21.

226 Connell, *Role of Space*; and DIA, *Russia Military Power,* 36.

On space as a warfighting domain, see, for example, Vladimir Borisovich Zarudnitsky, "Характер и Содержание Военных Конфликтов в Современных Условиях и Обозримой Перспективе [The Nature and Content of Military Conflicts in Present-Day Conditions and in the Foreseeable Future]," *Voennaya Mysl'*, no. 1, 2021, 41. Connell also provides some useful citations. Connell, *Role of Space*, 5.

227 The Embassy of the Russian Federation to the United Kingdom of Great Britan and Northern Ireland, "The Military Doctrine of the Russian Federation," Embassy of the Russian Federation to the UK, December 25, 2014, http://rusemb.org.uk/press/2029.

228 Michael Kofman et al., *Russian Military Strategy: Core Tenets and Operational Concepts* (Arlington, VA: CNA, August 2021), 55–65, especially 61.

229 Connell, *Role of Space*, 2.

230 See Igor Morozov, Sergey Baushev, and Oleg Kaminskiy, "Space and the Character of Modern Military Activities," *Vozdushno-kosmicheskaya i Oborona* [Air and Space Defense] 4, 2009, 48–56, as quoted in Connell, *Role of Space*, 2.

Russian analysts also assess that space and counterspace capabilities can be used as a means of deterrence and escalation control.[231] As with the Chinese approach to deterrence, the Russian concept differs in important ways from the Western definition. In the Russian literature, deterrence (most frequently translated as *sderzhivanie*) is broader than the prevention of an action primarily through threats of punishment and denial; rather, the Russian approach to deterrence emphasizes active engagement and a holistic approach across domains, the competition spectrum, and means.[232] Whereas the Western use of deterrence emphasizes signaling the threat through communication, *sderzhivanie* emphasizes signaling the threat through actual engagement.[233] Its meaning is, perhaps, closer to Western definitions of coercion. For example, Russia's "active defense strategy," a "defensive-offense" strategy similar to China's active defense concept described in Chapter 2, seeks to use demonstrations or limited use of force as a deterrent, but it also uses indirect means, surprise, decisiveness, and continuity to ensure that a technologically superior opponent does not win a conflict in its initial stages.[234]

These concepts, paired with a Russian perception that the United States has the advantage in space, may encourage the Russian military to disrupt U.S. space capabilities before terrestrial military engagements begin. Russian military thinkers believe the United States is more dependent on space-based information systems and technology than their own country, providing an asymmetry that can be exploited.[235] As in other domains, Russian military planners may recognize the country does not have the resources to go head to head against the United States.[236] Following this logic, a plausible strategy could seek not to compete directly with the United States but to instead disrupt U.S. advantages and threaten enough costs to deter what Russia views as aggressive behavior.[237] If Russian policymakers adopted this strategy, the Russian military could be expected to attempt to limit the technical superiority of the United States by focusing on counterspace capabilities and creating uncertainty about Russian intentions both in space and from space.[238] In the case of incipient conflict with the United States, Russia will likely seek to degrade U.S. access to its space-based systems in an attempt to decrease the U.S. information advantage.[239] Russia,

231 DIA, *Russia Military Power*, 36; DIA, *Challenges to Security in Space 2022*, 22.

232 Dmitry Adamsky, *The Russian Way of Deterrence: Strategic Culture, Coercion, and War* (Stanford, CA: Stanford University Press, 2023).

233 Adamsky, *Russian Way of Deterrence,* 30.

234 Kofman et al., *Russian Military Strategy*, i.

235 DIA, *Challenges to Security in Space 2022*, 21.

236 Moscow may also purposefully seek not to become too reliant on space. The DIA has asserted, "Moscow sees overreliance on space as a potential vulnerability and is determined to avoid becoming excessively dependent on space to conduct its national defense missions." DIA, *Challenges to Security in Space 2022*, 21.

237 DIA, *Russia Military Power*, 36.

238 Nicole J. Jackson, "Outer Space in Russia's Security Strategy," in Roger Kanet, ed., *Routledge Handbook of Russian Security* (London: Routledge, 2019), https://doi.org/10.4324/9781351181242-22.

239 DIA, *Challenges to Security in Space 2022*, 21.

seeing itself as less reliant on space, may be more willing to take risky behavior, including debris-creating activities.[240]

An additional important motivator for the Russian military space program is concerns about strategic stability. Space is intricately tied into Russian concepts of nuclear use and deterrence, with the Russian government viewing a U.S. first strike against nuclear forces from space-based weapons as a key security threat emanating from space.[241] In 2020, the Kremlin released a policy document about Russia's approach to nuclear deterrence that made clear reference to space-based systems, both nuclear and nonnuclear, including missile defense and DEW.[242] The document specifically called out the "creation and placement in space of missile defense and strike systems" as a threat.[243] The 2024 update to the document further specified that a "main…military threat" to be "neutralized by implementing nuclear deterrence" included "the development and deployment by a potential adversary of missile defense and anti-satellite warfare capabilities, as well as strike systems in outer space."[244] Russian authors and weapons designers have reportedly suggested that the U.S. withdrawal from the Anti-Ballistic Missile Treaty may have incentivized the development of ASAT weapons.[245]

The bureaucratic structure of Russian space activities, both military and commercial, has undergone several reorganizations since the end of the Cold War. In 2015, the Russian Armed Forces merged the air, space, and air defense forces under the Russian Aerospace Forces (*Vozdushno-Kosmicheskie Sily,* VKS), making the VKS one of three branches of the Russian Armed Forces.[246] Within the VKS, the Space Forces (*Kosmicheskie voyska Rossii*, KV) lead Russian military space activities. The KV's missions include SSA, early warning,

240 Bruce McClintock, "Russia's National Security Space Strategy: How to Avoid Repeating History," Italian Institute for International Political Studies, November 19, 2020, https://www.ispionline.it/en/pubblicazione/russias-national-security-space-strategy-how-avoid-repeating-history-28335.

241 Jackson, "Outer Space."

242 For one examination of the 2020 document, see Cynthia Roberts, "Revelations about Russia's Nuclear Deterrence Policy," War on the Rocks, June 19, 2020, https://warontherocks.com/2020/06/revelations-about-russias-nuclear-deterrence-policy/.

243 President of the Russian Federation, "Foundations of State Policy of the Russian Federation in the Area of Nuclear Deterrence," trans. CNA Russia Studies Program, June 2, 2020), 3.

244 President of the Russian Federation, "Fundamentals of the State Policy of the Russian Federation in the Area of Nuclear Deterrence," trans. Anna Davis and Richard Moss (Russia Maritime Studies Institute, November 19, 2024), 3–4.

245 Alexis A. Blanc et al., *Chinese and Russian Perceptions of and Responses to U.S. Military Activities in the Space Domain* (RAND Corporation, 2022), 25. See also: Bart Hendrickx, "Peresvet: A Russian Mobile Laser System to Dazzle Enemy Satellites," *The Space Review*, June 15, 2020, https://www.thespacereview.com/article/3967/1.

For Russian reactions to U.S. space activities, see Blanc et al., *Chinese and Russian Perceptions of and Responses to U.S. Military Activities*. On Russian ballistic missile defense, see: Keir Giles, *Russian Ballistic Missile Defense: Rhetoric and Reality* (Carlisle, PA: United States Army War College Press, 2015).

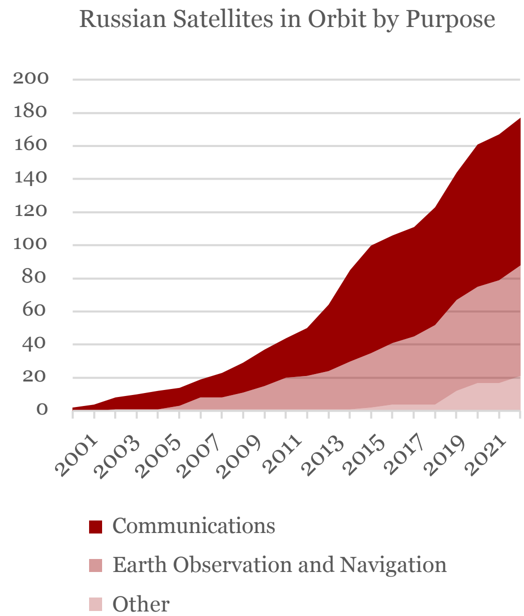
246 Russian Minister of Defense Sergei Shoigu said the reorganization was prompted "by a shift in the combat 'center of gravity' toward the aerospace sphere." Matthew Bodner, "Russian Military Merges Air Force and Space Command," *Moscow Times*, August 3, 2015.

satellite launches and operations (including of dual-use satellites under the military's control), and detection of (and, if necessary, defense from) threats to Russia in and from space.[247] The Roscosmos State Space Corporation coordinates civil and commercial space research and activities.[248]

Russian Military Space Capabilities

The Russian military has spent much of the last decade working to rebuild its space capabilities, and the DIA has described Russia's space program as "robust but more narrowly focused than China's."[249] Indeed, some Russian capabilities are strong, built in part on a long legacy of space research. Russia's space assets are, however, much less numerous than those of the United States and China. The 1990s set Russia's space program back considerably, and today a combination of budget issues, structural barriers, and the relatively low capacity of the Russian space industry limits Russia's space trajectory. Relations between the Ministry of Defense and the space industry also restrict what is available: Pavel Podvig, an expert on Russian strategic forces, has written, "The research, development, and acquisition

FIGURE 10: COMPOSITION OF RUSSIAN SATELLITE ARCHITECTURE



Data from UCS, "UCS Satellite Database 2023."

247 These missions do not include missile defense, which is delegated to the Air and Missile Defense Forces, one of the other three branches of the VKS. Pavel Podvig, "Russian Space Systems and the Risk of Weaponizing Space," in Samuel Bendett et al., ed. *Advanced Military Technology in Russia: Capabilities and Implications* (London: Chatham House, 2021), 35.

248 The Russian civilian federal space organization has undergone a series of restructures over the past 30 years. Following the dissolution of the Soviet Union, the organization began as the Russian Space Agency, though it was restructured in 1999 as the Russian Aviation and Space Agency, in essence merging the space and aviation industries. In 2004, a broader restructuring of Russian industry took place, and the Federal Space Agency (Roscosmos) was created, separating the space industry from the aviation industry. Approximately a decade later, there were efforts to separate the agency (and its policy functions) from the space industry, with plans to create a centralized corporation—the United Rocket and Space Corporation—to manage the industry. However, in 2015, these efforts were dismissed, and Roscosmos was restructured into a state corporation itself, putting the rocket and space industry under the control of the Roscosmos State Corporation and combining policymaking, priority setting, and strategic planning with the business activities under one entity.

249 DIA, *Challenges to Security in Space 2022*, 21.

process is driven largely by what the industry can offer rather than by what the military requests."[250] The limited resources available to the space industry and other constraints have forced the Russian military to prioritize its investments, focusing on expanding and improving legacy systems and existing PNT, ISR, and communications satellite structures. Resources are still spread thin. Russia will likely proceed with caution as it integrates space services into its military to avoid becoming overly dependent on space for its national security and defense.[251]

According to the Union of Concerned Scientists, as of May 2023 Russia had 181 satellites in orbit (see Figure 10).[252] More than 130 of those were categorized as government, military, or a mixture of dual-use civilian/commercial and state-operated assets—suggesting that more than 70 percent of Russian satellites are consistently available for state-enterprise activities.[253]

Positioning, Navigation, and Timing

Russia, like the United States and China, maintains its own GNSS. GLONASS originally reached full operational capability in the mid-1990s but deteriorated throughout the latter half of that decade as a result of poor financing and an inability to replace aging satellites. After a concerted effort, GLONASS was restored to operational condition in 2011; Podvig has asserted, however, that the Ministry of Defense only formally approved the system for military use in 2016.[254]

GLONASS is aging, and it appears Russia is having trouble modernizing the constellation. Pavel Luzin, a Russian space policy expert, assessed that, as of May 2024, 15 of the 26 active GLONASS satellites have exceeded their anticipated lifespans.[255] In 2022, one expert told journalists that "half of the GLONASS satellites can fall out [of orbit] at any moment."[256] There are plans to replace the old M-series satellites with the new K- and K2-series, with official plans expecting to launch 15 GLONASS-K satellites between 2022 and 2030.[257] Even

250 Podvig, "Russian Space Systems," 37.

251 DIA, *Challenges to Security in Space 2022*, 21.

252 UCS, "UCS Satellite Database 2023."

253 UCS, "UCS Satellite Database 2023."

254 DIA, *Challenges to Security in Space 2022*, 23; and Podvig, "Russian Space Systems," 37.

255 Pavel Luzin, "Russia's Satellite Constellation Deteriorates, Increasing Dependency on China," *Eurasia Daily Monitor* 21, no. 69, May 6, 2024, https://jamestown.org/program/russias-satellite-constellation-deteriorates-increasing-dependency-on-china/.

256 Mark Krutov and Sergei Dobrynin, "In Russia's War on Ukraine, Effective Satellites Are Few and Far Between," *Radio Free Europe/Radio Liberty*, April 11, 2022, https://www.rferl.org/a/russia-satellites-ukraine-war-gps/31797618.html.

257 Pavel Luzin, "Satellites of Stagnation," Riddle Russia, March 15, 2023, https://ridl.io/satellites-of-stagnation/.

if all were successfully launched, however, 15 may not be enough to replace all the satellites that need to be retired.[258]

Plans to modernize GLONASS have hit repeated delays due to a combination of inconsistent budgets, industrial practices, and the difficulty of acquiring foreign parts for satellites after the international community placed sanctions on Russia in response to its illegal annexation of Crimea in 2014 and its full-scale invasion of Ukraine in 2022.[259] Like other Russian satellites, GLONASS satellites have largely relied on foreign components that are now restricted. Before Russia's annexation of Crimea in 2014, some 65–70 percent of electronic components for Russian SLVs and satellites were imported.[260] By 2019, the inability to easily import required components was identified by some analysts as the reason serial production of next-generation GLONASS spacecraft was delayed.[261] There had been ambitions to produce GLONASS satellites entirely domestically by 2025, but new rounds of sanctions and export controls have likely made that process both more complicated and more urgent and possibly led to poorer quality, caused more delays, or both.[262] Luzin has assessed that, optimistically, GLONASS in coming years will only cover Russia and neighboring territories, with the military compensating by using GPS and BeiDou.[263]

Russia, cognizant of exposing itself to vulnerabilities by relying too heavily on space, has developed terrestrial redundancies to complement or replace space capabilities that could be denied.[264] For example, a 2019 plan for radio navigation in the Commonwealth of Independent States included integrating GLONASS with Russia's Chayka, a terrestrial radio navigation system similar to Loran-C.[265] Moscow has reportedly integrated Chayka

258 Luzin, "Satellites of Stagnation."

259 Pavel Luzin, "Russian Space Spending for 2023," *Eurasia Daily Monitor* 20, no. 25, February 10, 2023, https://jamestown.org/program/russian-space-spending-for-2023/; Luzin, "Satellites of Stagnation"; and Pavel Luzin, "GLONASS Program for 2021–2030," *Eurasia Daily Monitor* 18, no. 12, January 22, 2021, https://jamestown.org/program/glonass-program-for-2021-2030/.

260 Andrew W. Hull and David R. Markov, *Sino-Russian Defense Cooperation's Impact on Chinese Aerospace RD&A* (Montgomery, AL: China Aerospace Studies Institute, 2021), 19, https://www.airuniversity.af.edu/CASI/Display/Article/2872030/sino-russian-defense-cooperations-impact-on-chinese-aerospace-rda/.

261 Ivan Tkachev and Maxim Solopov, "Россия Отказывается От Серийного Производства Спутников ГЛОНАСС [Russia Is Denied Serial Production of GLONASS Satellites]," *RBC*, June 25, 2019, https://www.rbc.ru/society/25/06/2019/5d10ef6d9a79476950dcf15e; and OE Watch, "Russian Media: U.S. Sanctions Hinder GLONASS Modernization," *OE Watch*, December 2020.

262 Eugene Gerden, "Tough Times for Russian Navigation System," *GPS World,* February 29, 2024, https://www.gpsworld.com/tough-times-for-russian-navigation-system/; Luzin, "Russia's Satellite Constellation Deteriorates."

263 Pavel Luzin, *Russia's Space Program after 2024* (Philadelphia: Foreign Policy Research Institute, July 2024).

264 DIA, *Challenges to Security in Space 2022*, 21.

265 Dana Goward, "Russia-CIS Navigation Plan Emphasizes GNSS, Loran, Inertial," *GPS World*, April 10, 2020, https://www.gpsworld.com/russia-cis-navigation-plan-emphasizes-gnss-loran-inertial/; and Dana A. Goward and Gary M. Thomas, "Russia's New Navigation Plan Reveals a Fear of Jamming," C4ISRNet, April 21, 2020, https://www.c4isrnet.com/opinion/2020/04/20/russias-new-navigation-plan-reveals-a-fear-of-jamming/.

throughout critical regions in Russia as a backup for PNT services if GLONASS functions cease or are interrupted.[266]

It is difficult to fully assess the performance of GLONASS during the war in Ukraine from open-source reporting. Prior to the 2022 invasion, analysis from the 2015 Russian operation in Syria suggested the success of GLONASS targeting support was mixed and that the system needed to be improved.[267] It is unclear whether those improvements were achieved before the full-scale invasion of Ukraine, but there are indications that challenges still exist. Indirect evidence suggests GLONASS is not performing as well as desired and/or that data from GLONASS is not reaching operators effectively. For example, in May 2022, UK Minister of Defense Ben Wallace revealed that some downed Russian fighter jets were found with GPS receivers "taped to the dashboards," suggesting that some jets were using GPS as a supplement to or replacement for GLONASS.[268]

Intelligence, Surveillance, and Reconnaissance

Russia employs individual ISR satellites that are highly capable, but it lags behind the United States quantitatively.[269] For several years, space reconnaissance systems were neglected; only recently have they become a priority for the KV.

Compared to the United States and China, Russia has limited electro-optical (EO) reconnaissance capabilities and capacity. In the early 2000s through mid-2010s, Russia reportedly did not reliably have access to real-time optical reconnaissance satellites in orbit; until 2015, Russia still purportedly employed satellites that delivered imagery back to earth via film canister.[270] As of fall 2023, the KV had only three optical imaging satellites: two Persona satellites and one small experimental high-resolution EMKA satellite.[271] The two Persona satellites are reportedly capable of covering 1,300 kilometers with a spatial resolu-

266 Tracy Cozzens, "Russia Expected to Ditch GLONASS for Loran in Ukraine Invasion," *GPS World,* February 17, 2022, https://www.gpsworld.com/russia-expected-to-ditch-glonass-for-loran-in-ukraine-invasion/. From 2014, see also Narins, "The Global Loran/eLoran Infrastructure Evolution," 24–25.

267 Dmitry (Dima) Adamsky, "Russian Lessons from the Syrian Operation and the Culture of Military Innovation," *Marshall Center Security Insight*, no. 47, February 2020, https://www.marshallcenter.org/en/publications/security-insights/russian-lessons-syrian-operation-and-culture-military-innovation; Gustav Gressel, "Lessons from Russia's Intervention in Syria," European Council on Foreign Relations, February 5, 2016, https://ecfr.eu/article/commentary_lessons_from_russias_intervention_in_syria5085/; Anton Lavrov, *The Russian Air Campaign in Syria* (Arlington, VA: CNA, June 2018), 4; and Podvig, "Russian Space Systems," 38.

268 Bill Bostock, "Downed Russian Fighter Jets Are Being Found with Basic GPS 'Taped to the Dashboards,' UK Defense Minister Says," *Business Insider*, May 10, 2022, https://www.businessinsider.com/russia-su34-jets-basic-gps-receivers-taped-to-dashboards-uk-2022-5.

269 A DoD report assessed that "although Russia has a smaller fleet of satellites than China, Russia operates some of the world's most capable individual ISR satellites for optical imagery, radar imagery, signals intelligence, and missile warning." DoD, *Space Policy Review*, 3.

270 Bart Hendrickx, "Upgrading Russia's Fleet of Optical Reconnaissance Satellites," *Space Review*, August 10, 2020, https://www.thespacereview.com/article/4006/1.

271 Connell, *Role of Space,* 8.

tion of up to 50 to 30 centimeters.[272] In contrast, in 2020, the U.S. private satellite imaging firm Maxar began offering customers imagery with a spatial resolution of 15 centimeters.[273] The next generation of satellites meant to replace the Personas has already been delayed several times.[274] Potentially to bridge the gap, Russia launched three small, high-resolution, experimental EMKA satellites.[275] Two of the three launched have failed, however, leaving only one in operation as of fall 2023.[276]

To compensate for the lack of military optical reconnaissance capability and capacity, the Russian military could use or even rely on civil systems. For example, Roscosmos operates the Resurs and Kanopus families of imagery satellites, but their capabilities are "somewhat limited" by reportedly low-resolution imaging capabilities and revisit rates of every three to 15 days.[277] The Russian Armed Forces could also access the Bars-M cartography satellites, which could theoretically be used to identify large, fixed targets.[278]

The Russian military also lags behind the United States in radar imaging satellites, especially quantitatively. Although Russia launched Kondor-series SAR satellites in 2013 and 2014, both experienced failures shortly after reaching orbit.[279] It appears that thereafter the Russian military did not have any active SAR satellites in operation until 2021, when two PION-NKS SAR/SIGINT satellites were launched.[280] These satellites, built as part of the new Liana electronic-intelligence network described below, are optimized for maritime imaging. In 2023, Roscosmos successfully launched a civilian version of the Kondor-FKA, which the Russian Armed Forces may be able to use.[281] There are other programs reportedly in development, although these have faced delays.[282] One option Russia may pursue is to more

272 Connell, *Role of Space*, 8–9.

273 The 15 cm imagery was achieved by applying high-definition technology onto Maxar's native 30 cm imagery. Chris Formeller, "Introducing 15 cm HD: The Highest Clarity from Commercial Satellite…," Maxar Blog, November 12, 2020, https://blog.maxar.com/earth-intelligence/2020/introducing-15-cm-hd-the-highest-clarity-from-commercial-satellite-imagery.

274 Connell, *Role of Space,* 9.

275 Hendrickx, "Upgrading Russia's Fleet;" and Connell, *Role of Space*, 9.

276 Connell, *Role of Space*, 9.

277 Connell, *Role of Space*, 9. See also Pavel Luzin, "Russia's Space Satellite Problems and the War in Ukraine," *Eurasia Daily Monitor* 19, no. 76, May 24, 2022, https://jamestown.org/program/russias-space-satellite-problems-and-the-war-in-ukraine/.

278 Connell, *Role of Space*, 9; Luzin, "Russia's Space Satellite Problems;" and Anatoly Zak, *Russian Military and Dual-Purpose Spacecraft: Latest Status and Operational Overview* (Arlington, VA: CNA, 2019), 13.

279 Zak, *Russian Military and Dual-Purpose Spacecraft,* 11.

280 Connell, *Role of Space*, 9.

281 Anatoly Zak, "Roskosmos Launches Radar-Observation Satellite," Russian Space Web, July 5, 2024, https://www.russianspaceweb.com/kondor-fka.html.

282 Zak, *Russian Military and Dual-Purpose Spacecraft,* 11–12.

heavily emphasize smaller, simpler, more cost-effective satellites with shorter life spans, leaning more heavily on quantity than quality.[283]

Russia has also been working to reconstitute its SIGINT satellite architecture. The Liana architecture referenced above, for example, consists of two satellite types: the Pion-NKS, which appears to have an active radar, and a passive SIGINT satellite called Lotos.[284] Liana—a program first started in 1993—has faced a series of delays and technical challenges.[285] For example, there were reports that the first batch of Lotos-S satellites, initially launched in 2009, provided what one Russia space expert described as having "no advantages" over the Soviet-era system they were designed to replace.[286] The first Pion-NKS, which is optimized for the maritime domain and likely primarily serves the Russian Navy, did not launch until 2021.[287] Bart Hendrickx has identified what appears to be two possible projects for new SIGINT satellites, though very little is known about them publicly.[288]

Many analysts were surprised that Russia did not fully exploit what appeared to be its space advantage in the war in Ukraine, especially during the first months of the war in 2022.[289] Russia has seemed to be affected by at least two problems: its lack of capacity and difficulty in processing, exploiting, and disseminating satellite data. In Syria, the Russian military reportedly relied on a mix of military and civil reconnaissance satellites, including the Persona satellites and the Resurs and Kanopus EO satellites operated by Roscosmos.[290] The size of the campaign in Ukraine suggests that Russia's ISR needs may "far [outpace] the ability of the KV to provide."[291] Roscosmos is reportedly providing imaging support, and a Chinese firm was sanctioned by the United States for providing SAR imagery of Ukraine to the Wagner Group.[292] It is possible that the Russian military may seek access to Western commercial imagery by going through intermediaries and using other measures to evade sanctions.[293] Organizationally, though the KV operates the military's reconnais-

283 Luzin, *Russia's Space Program after 2024*.

284 Bart Hendrickx, "The Status of Russia's Signals Intelligence Satellites," *Space Review*, April 5, 2021, https://www.thespacereview.com/article/4154/1.

285 Hendrickx, "Status of Russia's Signals Intelligence Satellites."

286 Zak, *Russian Military and Dual-Purpose Spacecraft,* 17.

287 Connell, *Role of Space,* 9; Hendrickx, "Status of Russia's Signals Intelligence Satellites;" Podvig, "Russian Space Systems;" and Zak, *Russian Military and Dual-Purpose Spacecraft*, 17–19.

288 Hendrickx, "Status of Russia's Signals Intelligence Satellites."

289 See, for example, Robin Dickey and Michael P Gleason, "Space and War in Ukraine: Beyond the Satellites," *Æther* 3, no. 1, Spring 2024.

290 Connell, *Role of Space,* 10.

291 Connell, *Role of Space,* 10.

292 Connell, *Role of Space,* 11; and Andrew Jones, "U.S. Sanctions Chinese Satellite Firm for Allegedly Supplying SAR Imagery to Russia's Wagner Group," *SpaceNews*, January 27, 2023, https://spacenews.com/u-s-sanctions-chinese-satellite-firm-for-allegedly-supplying-sar-imagery-to-russias-wagner-group/.

293 Graeme Wood, "A Suspicious Pattern Alarming the Ukrainian Military," *The Atlantic*, March 18, 2024, https://www.theatlantic.com/international/archive/2024/03/american-satellites-russia-ukraine-war/677775/.

sance satellites, the General Staff's Main Directorate—the intelligence branch of the armed forces—handles most of the collection, processing, and dissemination of satellite-provided data.[294] Some analysts have suggested the hierarchal nature of the Russian armed forces has limited the ability of data to reach relevant frontline units.[295]

Satellite Communications

Russia has put significant effort into increasing its SATCOM capabilities over the last decade.[296] Although Russia now has a "diverse constellation" of commercial and military communications satellites, it still lags the capabilities of China and the United States.[297]

The Integrated Satellite Communication System (ESSS), with 46 military communications satellites as of fall 2023, is the main element of Russia's military communication system.[298] However, in 2022 Pavel Luzin assessed that more than 30 of these satellites had exceeded their intended shelf life.[299] The Russian military is beginning to field its third generation of satellites for ESSS in the form of the Sfera-S and Sfera-V, which are intended to operate in HEO and GEO, respectively.[300] The Sfera constellation is meant as a counterpoint to Starlink, with an original goal of fielding over 600 satellites.[301] This objective, however, seems out of reach given satellite production capacity in Russia and challenges with foreign imports of sensitive technologies.[302] The military also has access to the Blagovest constellation, the Strela-3M "store-and-dump" communications system, and data relay satellites.[303]

294 Connell, *Role of Space,* 8.

295 Dickey and Gleason, "Space and War in Ukraine." On the hierarchical nature of the Russian Armed Forces, see Katherine Kjellström Elgin, *More of the Same? The Future of the Russian Military and Its Ability to Change* (Washington, DC: Center for Strategic and Budgetary Assessments, 2024), 13–18.

296 Luzin, "Russia's Space Satellite Problems."

297 DIA, *Challenges to Security in Space 2022*, 23.

298 Connell, *Role of Space*, 11; and Podvig, "Russian Space Systems," 39.

299 Luzin, "Russia's Space Satellite Problems."

300 Connell, *Role of Space*, 11–12.

301 Connell, *Role of Space*, 12.

The goal seems to have been adjusted since its announcement, however, to a smaller number. Maxim Starchak, "Russia Wants 2,600 Satellites in Orbit by 2036. Is This Realistic?," *Defense News*, July 8, 2024, https://www.defensenews.com/space/2024/07/08/russia-wants-2600-satellites-in-orbit-by-2036-is-this-realistic/.

The project was originally called Ehfir. Allegedly, however, when Putin publicly announced the program's creation in 2018, he called the program "Sfera" during the speech. When he returned to the Kremlin the head of Roscosmos Dmitry Rogozin told him the name had already been changed to Sfera. Eric Berger, "Russia Renamed Its Ambitious Satellite Program after Putin Misspoke Its Name," Ars Technica, October 27, 2023, https://arstechnica.com/space/2023/10/russia-renamed-its-ambitious-satellite-program-after-putin-misspoke-its-name/.

302 Zak, *Russian Military and Dual-Purpose Spacecraft*, 24.

303 Zak, *Russian Military and Dual-Purpose Spacecraft*, 25–26; and Connell, *Role of Space*, 12.

Finally, the military can also use Russian civilian SATCOM systems, including communications satellites owned by state-owned companies.[304]

It is unclear whether Russia's SATCOM networks are sufficient to support the scale of Russia's military operations in Ukraine.[305] Russian units appear to be using the MK VTR-016, a ground-based mobile video transmission system, to connect with military and commercial communications satellites.[306] Given the large number of Russian troops spread over multiple fronts, one would expect a widespread distribution of MK VTR-016 or similar systems. However, it is unclear whether the Russian military has the capacity and logistical capability to handle such distribution.[307] Until Sfera becomes fully operational, the Russian military will likely rely on dated systems that may suffer from low bandwidth/high latency issues and may have too few satellite communication channels.[308]

Indeed, Russian communications patterns during the war suggest the Russian Armed Forces are struggling to communicate securely via their systems. There were early reports of poor communications security practices, including the use of unencrypted commercial radios or personal cell phones; in February 2024, the top Ukrainian military intelligence officer claimed Russia was also using Starlink.[309] These behaviors suggest the Russian military has a lack of communications alternatives, forces that are poorly trained and/or undisciplined, or both.[310] During the course of the war, Russian SATCOM networks have also been targets of cyberattacks and jamming.[311]

Space Domain Awareness

Russia operates a variety of telescopes, radars, and other sensors to support its space surveillance network, the Russian Space Surveillance System.[312] With a strong basis in Cold War infrastructure built for missile warning and defense, analysts from the Secure World Foundation have assessed that Russian SSA capabilities are likely "second only to the United

304 Connell, *Role of Space*, 12.

305 Connell, *Role of Space*, 13.

306 Connell, *Role of Space*, 12.

307 Connell, *Role of Space*, 13.

308 Connell, *Role of Space*, 13; and Luzin, "Russia's Space Satellite Problems."

309 James Marson and Thomas Grove, "Russia Using Thousands of Musk's Starlink Systems in War, Ukrainian General Says," *Wall Street Journal*, February 15, 2024, sec. World; and Thomas Grove et al., "The Black Market That Delivers Elon Musk's Starlink to U.S. Foes," *Wall Street Journal*, April 9, 2024.

310 Connell, *Role of Space*, 13; and Jack Detsch and Amy Mackinnon, "Ukraine Is Listening to (Almost) Everything Russian Troops Say," *Foreign Policy*, March 22, 2022, https://foreignpolicy.com/2022/03/22/ukraine-russia-military-radio/.

311 Joseph Menn, "Cyberattack Knocks Out Satellite Communications for Russian Military," *Washington Post*, June 30, 2023; and Paul Mozur and Aaron Krolik, "The Invisible War in Ukraine Being Fought over Radio Waves," *New York Times*, November 19, 2023.

312 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-33–36.

States."[313] The Russian SDA system is capable of searching for, tracking, and characterizing satellites in all Earth orbits, and some sensors also serve a ballistic missile early warning function.[314] Although Russia's catalog of objects in LEO is slightly smaller than the U.S. catalog, it has a "slightly more robust" catalog of objects in HEO and GEO.[315]

Russia's military SSA network is managed by the KV's 821st Main Space Reconnaissance Center.[316] Two of the most important space surveillance stations that Russia operates are Okno and Krona (see map in Figure 11).[317] The main Okno facility, which includes EO sensors to track objects in space, is based in Tajikistan.[318] There has been speculation about a second Okno facility in the Russian Far East, though few details are publicly available.[319] The Krona complexes in the North Caucasus and Russian Far East reportedly use EO and radar sensors to identify and track satellites.[320] In 2023, Russia brought online a new radar-based dedicated SSA system, Razvyazka, to catalog space objects.[321] There appear to be several other SSA systems and projects that are used as well as several under development.[322]

Russia may also benefit from international collaboration. Russia leads the International Scientific Optical Network, the largest foreign network of ground-based optical space sensors.[323] As part of the network, as of 2022, a Russian institute was coordinating sensor tasking and combining information from nearly 100 ground-based optical sensors across 16 countries.[324] Russia appears to be increasing partnership efforts, including with South Africa, where, in July 2023, Russia inaugurated a new optical-electronic station for tracking space objects.[325]

313 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-33.

314 DIA, *Challenges to Security in Space 2022*, 26–27.

315 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-33.

316 DIA, *Challenges to Security in Space 2022*, 26.

317 Thomas Allen, "Sourcebook on the Okno (в/ч 52168), Okno-S, Krona (в/ч 20096) and Krona-N (в/ч 20776) Space Surveillance Sites," November 19, 2014, FAS Space Policy Project, https://spp.fas.org/military/program/track/okno.pdf; and Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-33–36.

318 Clint Reach et al., *Russia's Evolution toward a Unified Strategic Operation: The Influence of Geography and Conventional Capacity* (RAND Corporation, 2023), 105, https://www.rand.org/pubs/research_reports/RRA1233-8.html.

319 Todd Harrison, Kaitlyn Johnson, and Thomas G. Roberts, *Space Threat Assessment 2018* (Washington, DC: CSIS, 2018), 14; Reach et al., *Russia's Evolution*, 105; and Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-34.

320 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-34.

There are reportedly plans to expand Krona facilities. Reach et al., *Russia's Evolution,* 105.

321 Swope et al., *Space Threat Assessment 2024*, 14; and Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-34.

322 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-35–36.

323 DIA, *Challenges to Security in Space 2022*, 27.

324 DIA, *Challenges to Security in Space 2022*, 27.

325 Swope et al., *Space Threat Assessment 2024*, 14.

FIGURE 11: KEY RUSSIAN SPACE SITES AS OF 2022

Image from DIA, *Challenges to Security in Space 2022*, 26.

Launch Capabilities

The rise of international government and civilian competitors and increasing Western distance from Russia due to its military aggression have reduced Russia's share of worldwide launch activity (see Figure 12). In a bid to improve its competitiveness and serve Russian national space needs, Russia is updating and modernizing its space launch capabilities, focusing on its medium- and heavy-lift launch fleets.

Between 2000 and 2014, Russia conducted somewhere around 40 percent of the world's orbital launches per year. That figure, however, began steadily dropping after Russia's annexation of Crimea; by 2023, it had dropped to just 9 percent (see Figure 12).[326] In 2022, 16 of Russia's 19 planned commercial launches for the year were cancelled due to Russia's full-scale invasion of Ukraine.[327]

In addition to the ramifications of Russia's geopolitical decisions, one major contributor to this trend has been the rise of the private sector and cheaper competitors. For example, between 2011 and 2020, NASA relied on Russia to transport astronauts to the International Space Station (ISS). In May 2020, however, U.S. astronauts were for the first time transported to the station on a spacecraft commercially built and operated in the United States.[328] NASA has since primarily used SpaceX's Crew Dragon, and other commercial options may also emerge. In 2018 NASA paid about $86 million per seat on the Soyuz spacecraft; NASA's Office of the Inspector General estimated in 2019 that the cost per seat on Crew Dragon was

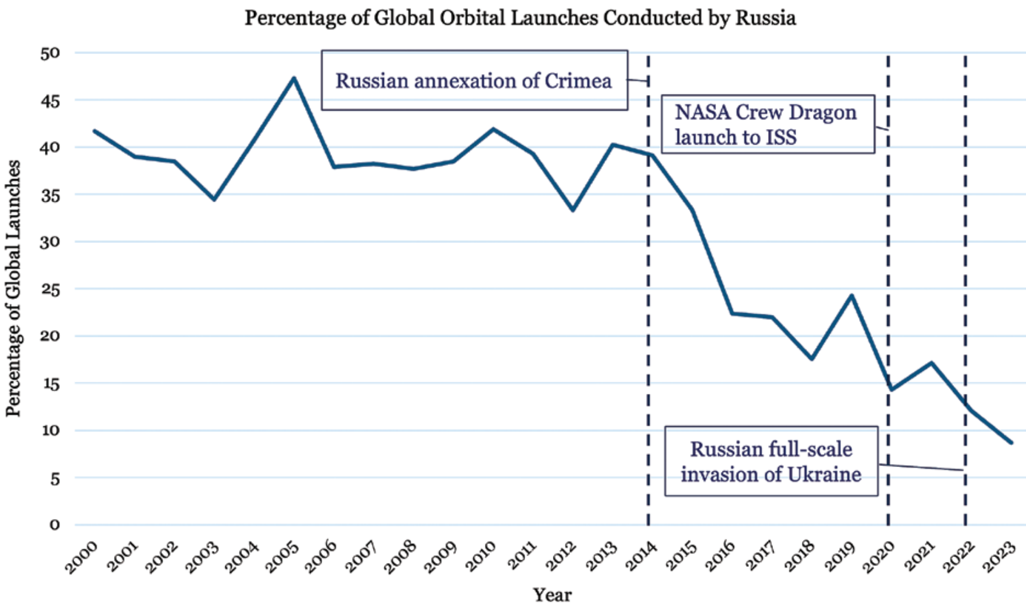
326 Gunter D. Krebs, "Chronology of Space Launches," Gunter's Space Page, accessed on May 15, 2024, https://space.skyrocket.de/directories/chronology.htm.

327 National Space Intelligence Center and the National Air and Space Intelligence Center, *Competing in Space,* 6.

328 NASA, "NASA Astronauts Launch from America in Historic Test Flight of SpaceX Crew Dragon," NASA, May 30, 2020, https://www.nasa.gov/news-release/nasa-astronauts-launch-from-america-in-historic-test-flight-of-spacex-crew-dragon/.

around $55 million, a figure likely to decrease as the program matures.[329] Roscosmos must now compete with cheaper satellite and crewed launchers, including those of several U.S. companies and other nations' programs.[330]

FIGURE 12: RUSSIA'S SHARE OF GLOBAL ORBITAL LAUNCHES



Data collected from Gunter D. Krebs, "Chronology of Space Launches," Gunter's Space Page, accessed May 15, 2024, https://space.skyrocket.de/directories/chronology.htm.

The changing space market could encourage Russia to develop new launch methods. Unlike China, however, Russia has not focused on lighter SLV designs, instead usually conducting multipayload launches on heavier spacecraft (see Figure 13).[331] Russia has put considerable effort toward modernizing the aging Soyuz-2 (which, though a proven workhorse of the Russian fleet, dates to 1966) and expanding the Angara heavy rocket family.[332] However, both projects have faced a number of failures and put pressure on an already tight industry

329 NASA Office of Inspector General, *NASA's Management of Crew Transportation to the International Space Station* (NASA, November 14, 2019).

330 Pawel Bernat, "Russia's Strategic Shift in Space Policy," Per Concordiam, December 6, 2021, https://perconcordiam.com/russias-strategic-shift-in-space-policy/; Harry W. Jones, "The Recent Large Reduction in Space Launch Cost" (Paper presentation, 48th International Conference on Environmental Systems, Albuquerque, NM, July 8, 2018), https://ttu-ir.tdl.org/server/api/core/bitstreams/d4074c60-2e50-4e92-a49b-e2fbc2be4b91/content; Joey Roulette, "Russia's Loss of Rocket Launch Business Becomes SpaceX's Gain," *New York Times*, March 21, 2022; Vidal, *Russia's Space Policy*; Matthew Weinzierl and Mehak Sarang, "The Commercial Space Age Is Here," *Harvard Business Review*, February 12, 2021, https://hbr.org/2021/02/the-commercial-space-age-is-here.

331 DIA, *Challenges to Security in Space 2022*, 26. For more on the Russian space launch program, see Elina Morozova, "Russian Space Launch Program," in Kai-Uwe Schrogl, ed., *Handbook of Space Security: Policies, Applications and Programs* (Cham: Springer International Publishing, 2020), 385–99, https://doi.org/10.1007/978-3-030-23210-8_128.

332 DIA, *Challenges to Security in Space 2022*, 24–26; and Bernat, "Russia's Strategic Shift."

budget. Pavel Luzin described the Angara family, which has been in development since 1995, as "old-fashioned even before [it reached] operational status."[333] Russia has also invested in modular SLVs and in a superheavy-lift SLV similar to the U.S. Saturn V or U.S. Space Launch System to support crewed missions.[334]

FIGURE 13: RUSSIAN SPACE LAUNCH VEHICLES

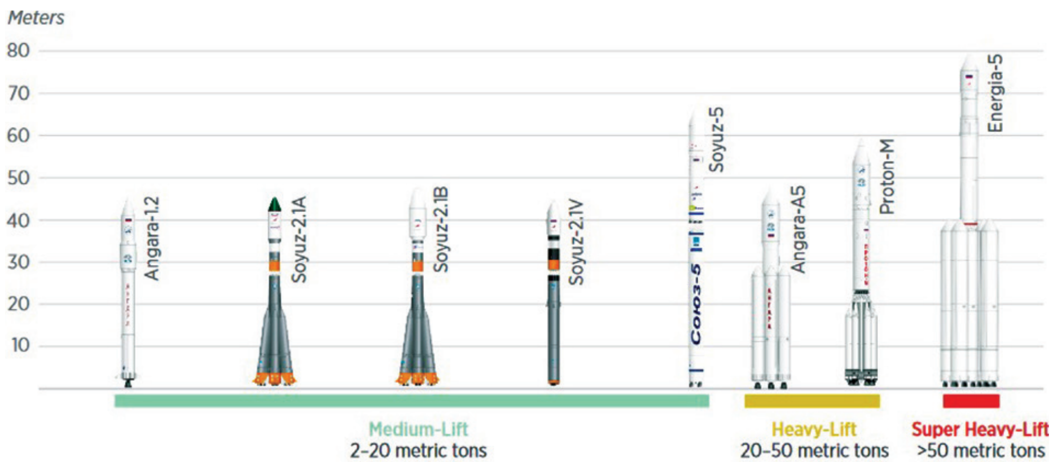


Image from DIA, *Challenges to Security in Space 2022*, p. 25.

Historically, Russia has conducted its launches from the Baikonur Cosmodrome in Kazakhstan and has faced difficulties expanding to other facilities.[335] To increase its launch facilities and decrease its reliance on foreign actors, Russia opened a new launch facility, the Vostochny Cosmodrome, in the Russian Far East. The Vostochny Cosmodrome was built to fully integrate the launch process: Everything from assembly to launch is meant to be done on site. The project was touted as one of the most important of Putin's presidency, but it has been plagued with corruption and delays, making large negative splashes across Russian

333 Pavel Luzin, "The Future of Roscosmos Unclear as Challenges Mount," *Eurasia Daily Monitor* 21, no. 28, February 23, 2024, https://jamestown.org/program/the-future-of-roscosmos-unclear-as-challenges-mount/.

334 DIA, *Challenges to Security in Space 2022*, 26.

335 The Baikonur facility costs Russia approximately $115 million in yearly rental payments, and Kazakhstan has previously sought to limit Russian access and frequency of use, particularly after 2013 when a Proton-M space rocket crashed to the ground a few seconds after launch, releasing a toxic cloud. Still, Russia recently signed a lease agreement to continue to rent the facilities at Baikonur until 2050. John C.K. Daly, "Beset by Cash Flow Problems, Russia and Kazakhstan Consider Leasing Baikonur Cosmodrome to Other Countries," *Eurasia Daily Monitor* 13, no. 127, July 14, 2016, https://jamestown.org/program/beset-by-cash-flow-problems-russia-and-kazakhstan-consider-leasing-baikonur-cosmodrome-to-other-countries/; Almaz Kumenov, "Kazakhstan: Russia to Keep Using Baikonur until at Least 2050," *Eurasianet*, May 12, 2021, https://eurasianet.org/kazakhstan-russia-to-keep-using-baikonur-until-at-least-2050; George Voloshin, "Kazakhstani-Russian Space Cooperation Further at Risk," *Eurasia Daily Monitor* 10, no. 173, September 30, 2013, https://jamestown.org/program/kazakhstani-russian-space-cooperation-further-at-risk/; and Mike Eckel, "Sunset For Baikonur? A Contract Dispute With Kazakhstan Flashes Warnings For Russia's Legendary Spaceport," *Radio Free Europe/Radio Liberty*, April 6, 2023.

media.[336] The first launch from the facility took place in 2016, but the first crewed flight, scheduled originally for 2018, was delayed until at least 2025.[337] Russia had pursued another launch option that appears to have been abandoned: Russia's commercial industry acquired the launch systems of Sea Launch—a project to build a mobile floating platform for space launches that had been jointly run by Russia, Ukraine, the United States, and Norway—but the company that purchased Sea Launch has suspended the program indefinitely.[338]

The Commercial Sector

Whereas many other countries appear to be decentralizing their space industries, Russia has instead increasingly centralized and nationalized its space industry, giving government a heavy role in the industry.[339] Russia's space industry is almost entirely state owned, with Roscosmos responsible for the management of the space industry and for carrying out Russia's civilian space program. As of 2022, the space industry included roughly 75 design bureaus, enterprises, and companies.[340]

There are efforts to create an environment for innovation for Russian space activities, with a primary push being the state-run Skolkovo Innovation Center, launched in 2010 with space and telecommunications as one of five core clusters. However, the number of start-ups coming out of Skolkovo has never reached the program's level of ambition.[341] Roscosmos in some ways seems to be actively discouraging new companies (which could become competitors) from growing and maturing. Only in 2016 did Roscosmos announce it would allow private companies to access the space services.[342] There have, furthermore, been reports

336 The only larger and more politically and economically significant infrastructure project Putin has presided over is the construction of the bridge connecting Russia with the Crimean Peninsula. Matthew Bodner, "The Long Road to Vostochny: Inside Russia's Newest Launch Facility," *SpaceNews*, January 30, 2019, https://spacenews.com/the-long-road-to-vostochny-inside-russias-newest-launch-facility/.

Pavel K. Baev, "Political Farce Russian-Style: Putin Complains about Corruption," *Eurasia Daily Monitor* 16, no. 162, November 18, 2019, https://jamestown.org/program/political-farce-russian-style-putin-complains-about-corruption/; and Madeline Roache, "Putin's Vostochny Project Meant to Reestablish Russia as a Space Superpower. Now It's Plagued by Corruption," *Time*, November 19, 2019.

337 TASS, "Vostochny Spaceport to Start Building Infrastructure for Crewed Launches in 2025," *TASS*, March 6, 2021, https://tass.com/science/1263407; Bart Hendrickx, "The Status of Russia's Human Spaceflight Program (Part 2)," *Space Review*, February 27, 2017, 2, https://www.thespacereview.com/article/3184/1.

338 Jeff Foust, "Sea Launch 'Frozen' after Ships Moved to Russia," *SpaceNews*, April 24, 2020, https://spacenews.com/sea-launch-frozen-after-ships-moved-to-russia/.

339 Moltz, "Changing Dynamics."

340 DIA, *Challenges to Security in Space 2022*, 22.

341 James Appell, "The Short Life and Speedy Death of Russia's Silicon Valley," *Foreign Policy*, May 6, 2015, https://foreignpolicy.com/2015/05/06/the-short-life-and-speedy-death-of-russias-silicon-valley-medvedev-go-russia-skolkovo/; and Masha Borak, "How Russia Killed Its Tech Industry," *MIT Technology Review*, April 4, 2023, https://www.technologyreview.com/2023/04/04/1070352/ukraine-war-russia-tech-industry-yandex-skolkovo/.

342 Bruce McClintock, "The Russian Space Sector: Adaptation, Retrenchment, and Stagnation," *Space & Defense* 10, no. 1, Spring 2017, 7.

of the space agency requiring detailed designs and models of proposed systems before discussing possible funding. One analyst reported in 2017 that obtaining a license to produce space assets can take a year—and the requirements necessary to obtain the license were classified, meaning permission had to be sought and granted from the Federal Security Service to see them.[343] Funding from sources outside the government, whether from Russian or international investors, remains difficult to obtain. Venture capitalists with an interest in space typically see the Russian projects as more costly and risky than other international space opportunities.[344] This gap is likely to grow over the next decade as the global commercial space market dramatically expands.[345] Russia now seems to be encouraging leading existing Russian enterprises to enter the space sector rather than encouraging the creation of start-ups.[346]

Several other factors seem to hinder the Russian space industry.[347] First, there are gaps in quality control and a lack of accountability, creating an environment in which low-quality products may be generated with little recourse. Second, Russia does not have a strong indigenous production of materiel required for space technology. In 2013, up to 80 percent of equipment on new Russian satellites had to be imported.[348] When combined with sanctions explicitly targeting the Russian space sector, Russia will need to import materiel from non-Western sources (which may be more expensive, lower quality, or both) or develop more domestic production. Misuse of funds, inefficiency, and corruption are also endemic throughout the Russian military and defense industry.[349] Some analysts critique the Russian space industry for a lack of vision, and the space talent pool appears to be shrinking.[350]

343 McClintock, "Russian Space Sector," 7; Center for Strategic Assessment and Forecasts, "Does Not Fit in the Orbit. The Global Space Industry is Experiencing a Boom That Russia Has Overslept," Center for Strategic Assessment and Forecasts, September 13, 2017, http://csef.ru/en/nauka-i-obshchestvo/306/ne-vpisalis-v-orbitu-mirovayakosmicheskaya-industriya-perezhivaet-bum-kotoryj-rossiya-uzhe-prospala-7943.

344 Vidal, *Russia's Space Policy*.

345 Vidal, *Russia's Space Policy*.

346 For example, Gazprom created a subsidiary called Gazprom Space Systems. Pavel Luzin, "The Commercial Space Sector and Russia's Space Strategy," *Eurasia Daily Monitor* 18, no. 159, October 20, 2021, https://jamestown.org/program/the-commercial-space-sector-and-russias-space-strategy/.

347 For these and other critiques, see, for example, Aliberti and Lisitsyna, *Russia's Posture in Space*; Luzin, *Russia's Space Program after 2024*; McClintock, "Russian Space Sector;" and Dmitry Popov, "Космос, Гниющий Изнутри: Россия Сходит с Орбиты [The Space Program Is Rotting from Within: Russia Descends from Orbit]," *MK*, December 13, 2021, https://www.mk.ru/social/2021/12/13/kosmos-gniyushhiy-iznutri-rossiya-skhodit-s-orbity.html.

348 Reuters, "Russia Bets on Sweeping Reform to Revive Ailing Space Industry," Reuters, December 26, 2013, https://www.reuters.com/article/markets/russia-bets-on-sweeping-reform-to-revive-ailing-space-industry-idUSL5N0J52K2/.

349 For a summary, see, for example, Elgin, *More of the Same?,* 21–23. For an examination more tailored to corruption in the space sector, see Zak, *Russian Military and Dual-Purpose Spacecraft*, 33–36.

350 Aliberti and Lisitsyna, *Russia's Posture in Space*; Matthew Bodner, "60 Years after Sputnik, Russia Is Lost in Space," *SpaceNews*, October 4, 2017, https://spacenews.com/60-years-after-sputnik-russia-is-lost-in-space/; Luba Katz et al., *Russia Space Talent* (Washington, DC: IDA Science & Technology Policy Institute, 2023); Luzin, *Russia's Space Program after 2024*; McClintock, "Russian Space Sector;" and Vidal, *Russia's Space Policy*.

Space Exploration and Deep Space

The Soviet Union's impressive history of spaceflight and space exploration plays a significant role in the legacy of Russia's space program today. In 2018, Dmitry Rogozin, then director general of Roscosmos, explained, "Russian space research is an element of our self-identification."[351] The Russian government continues to have high ambitions for its civil space program. In the last decade, however, Russian leaders have been more focused on the Russian military space program than its civil one, and the trajectory of Roscosmos and civil space exploration appears bleak.[352] Still, *Federal Space Program 2016–2025*, a decadal document that outlines goals and budgets for the country's space program, emphasized launch, human spaceflight, and space science and exploration, in addition to continued expansion of the country's satellite architecture.[353]

Russia is still a member of the International Space Station (ISS), though for the past few years Russian officials have periodically threatened to withdraw from the program.[354] As the ISS and its segments have aged, the Russian segment has faced several challenges. For example, in late July 2021, a Russian laboratory module attempting to dock caused the ISS to rotate after its thrusters mistakenly activated after connecting to the station.[355] The next month, Vladimir Solovyov—the chief engineer of Energia, the leading developer of Russia's portion of the ISS—estimated that 80 percent of the inflight systems in Russia's segment had

351 Mansur Mirovalev, "The Soyuz Launch Failure Exposes the Total Collapse of Russia's Space Empire," *Wired UK*, October 12, 2018, https://www.wired.co.uk/article/soyuz-rocket-launch-failure-emergency-landing.

352 McClintock, "Russia's National Security Space Strategy;" and Ramin Skibba, "Russia's Space Program Is in Big Trouble," *Wired*, March 28, 2023, https://www.wired.com/story/russias-space-program-is-in-big-trouble/. Some argue the focus on military applications over civil programs has a longer history in Russia and the Soviet Union. Bodner, "60 Years after Sputnik."

353 Aliberti and Lisitsyna, *Russia's Posture in Space*, 35–39.

354 For example, in June 2021, Rogozin said Russia would withdraw if the United States did not lift sanctions on Russia that impact the space program. In September of the same year, Rogozin said Russia would not pull out before the ISS is due to retire in the mid-2020s, stating: "This is a family, where a divorce within a station is not possible." After the February 2022 invasion of Ukraine, Rogozin tweeted about withdrawing from the station, though NASA's administrator Bill Nelson dismissed comments Rogozin has made by saying, "That's just Dmitry Rogozin. He spouts off every now and then. But at the end of the day, he's worked with us." Most recently, in 2023, Russian officials announced the country would leave the station in 2028. Reuters, "Russia Plans to Launch Own Space Station after Quitting ISS," *Reuters*, April 21, 2021; Jake Dean, "Russia Is Threatening to Leave the International Space Station. Why?," *Slate*, July 9, 2021; Kristin Fisher, "'Divorce Is Not Possible' with U.S. over Space Station, Says Russian Space Chief Who Threatened to Pull Out," *CNN*, September 2, 2021, https://www.cnn.com/2021/09/02/world/russian-space-chief-iss-nasa-roscosmos-scn/index.html; Andrew E. Kramer and Steven Lee Myers, "Russia, Once a Space Superpower, Turns to China for Missions," *New York Times*, June 15, 2021; Vishwam Sankaran, "Russia Reverses Threat to Walk Away from International Space Station by 2024," *The Independent*, April 13, 2023; and Maya Yang, "'That's Just Dmitry': NASA Plays Down Threat to ISS amid Ukraine War," *The Guardian*, March 19, 2022.

355 The arrival of Nauka module was also more than a decade late, following a series of technical and budget issues. Eric Berger, "Russia's Latest Space Station Incident Points to Larger Issues," *Wired*, August 3, 2021, https://www.wired.com/story/russia-space-station-nauka-issues/; Kenneth Chang, "It Was His Day Off. Then the Space Station Went for a Spin.," *New York Times*, August 2, 2021; and Joseph Guzman, "'Spacecraft Emergency' on International Space Station Worse Than Previously Thought," *The Hill*, August 4, 2021.

"reached the end of their service period" and that "irreparable failures" might occur.[356] In early 2024, the Russian segment experienced an air leak, though it did not appear to present a danger to the crew or to the station more broadly.[357]

Russia does plan to build its own space station as the ISS looks to de-orbit, though the viability of the project is in question. In 2023, Putin said the first segment of the Russian station should be launched in 2027, and Russian officials plan to send cosmonauts (Russian astronauts) to the station in 2028 and have the four-module core complete in 2030.[358] Construction, however, was only scheduled to begin in 2024.[359] The feasibility of Russia successfully launching the station by 2030, much less a major component by 2027, is doubtful given budgetary and other constraints.[360]

Russia also has ambitious lunar plans. In 2021, Roscosmos announced it would begin Moon exploration using lunar probes and modules, followed by a crewed program.[361] Two years later, Roscosmos announced it planned to send cosmonauts to the Moon and build a lunar base in the 2030s.[362] The program's success is in doubt. In 2023, Russia launched the Luna-25 in a bid to land on the south pole of the moon. The attempt failed, and the Luna-25 spacecraft crashed into the moon just days before an Indian spacecraft successfully did what the Luna-25 could not.[363] In 2016, a Russian space journalist described any talk of lunar and Mars missions, given the state of the Russian space program, as "just talks…aimed at the creation of impression inside and outside Russia that the country continues to be a 'great space power.'"[364]

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356 Agence France-Press, "State of Russia's ISS Segment Sparks Safety Concerns," *Moscow Times*, August 31, 2021, https://www.themoscowtimes.com/2021/08/31/state-of-russias-iss-segment-sparks-safety-concerns-a74944.

357 Associated Press, "Russia Acknowledges Continuing Air Leak from Its Segment of Space Station," *The Guardian*, February 28, 2024.

358 Reuters, "Putin Aims to Have Russian Space Station by 2027," *Reuters*, October 26, 2023; Reuters, "Russia Plans to Create Core of New Space Station by 2030," *Reuters*, July 2, 2024; and Jackson Ryan, "Russia Unveils Timeline for Building Its New Space Station, Starting in 2027," Space.com, July 23, 2024, https://www.space.com/russia-space-station-timeline-2027.

359 Luzin, "Future of Roscosmos Unclear."

360 Pavel Luzin, "A Russian Orbital Station: Dreams or Plans?," Riddle, May 31, 2021, https://www.ridl.io/en/a-russian-orbital-station-dreams-or-plans/.

361 Todd Harrison et al., *Space Threat Assessment 2021* (Washington, DC: CSIS, April 2021), 12–13, https://www.csis.org/analysis/space-threat-assessment-2021.

362 Reuters, "Russia Says It Plans to Send Cosmonauts to the Moon Next Decade: TASS," *Reuters*, November 15, 2023.

363 Associated Press, "Russia's Luna-25 Spacecraft Crashes into the Moon, Ending Its Bid to Reach the Lunar South Pole," *Associated Press*, August 20, 2023; Associated Press, "India Successfully Lands Chandrayaan-3 near the Moon's South Pole," *Associated Press*, August 23, 2023; and PBS, "Russia's Lunar Mission Failure Raises Questions about State of Space Program," *PBS NewsHour*, August 22, 2023, https://www.pbs.org/newshour/world/russias-lunar-mission-failure-raises-questions-about-state-of-space-program.

364 Yuri Karash, "Russian Space Program: Financial State, Current Plans, Ambitions and Cooperation with the United States" (Paper presentation, The Journey: Further Exploration for Universal Opportunities, The Space Congress Proceedings, May 26, 2016), 6, https://commons.erau.edu/cgi/viewcontent.cgi?article=3648&context=space-congress-proceedings.

Roscosmos continues to struggle with funding issues. In the first decade of the 2000s, the Russian space program went through what one analyst called a "resurgence," supported in part by a restoration of the civil space budget as the economy improved.[365] In 2014, the agency's annual budget was $4.2 billion, and Russia conducted 35 successful launches—more than both the United States and China.[366] The years that followed, however, began to demonstrate the challenges Roscosmos faced. In 2016, its budget was just $1.6 billion, only 8.5 percent of NASA's Fiscal Year (FY) 2016 budget.[367] Sanctions following the 2014 annexation of Crimea and then the 2022 full-scale invasion of Ukraine impacted Russian budgets and purchasing power.[368] At the same time, commercial launch options like SpaceX began to compete with Russia's own launch services, which had provided a substantial portion of the Roscosmos budget. The space budget announced in October 2021 cut spaceflight activities, and funding for scientific R&D was nearly zeroed.[369] By 2022, one analyst described the program as "falling back to Earth."[370]

Russian Counterspace Capabilities

Similar to the ways in which Russia has worked in the last decade or so to regain its space capabilities, Russia has worked to increase its counterspace capabilities, testing and demonstrating new capabilities and pulling old Cold War projects off the shelf.[371] In addition to testing kinetic counterspace weapons, there is evidence that Russia has employed nondestructive counterspace capabilities, including jamming. Given the asymmetry Russian analysts perceive between U.S. and Russian reliance on space, Russia may be more willing to aggressively pursue and possibly use counterspace weapons, including kinetic ones that could cause debris.

365 Bertrand de Montluc, "Russia's Resurgence: Prospects for Space Policy and International Cooperation," *Space Policy* 26, no. 1 (2010).

366 Moltz, "Changing Dynamics," 76.

Gunter's Space Page records Russia as conducting 36 launches that year, the US 23, and China 19. Krebs, "Chronology of Space Launches."

367 Karash, "Russian Space Program," 1.

368 Jeremy Grunert, "Sanctions and Satellites: The Space Industry after the Russo-Ukrainian War," War on the Rocks, June 10, 2022, https://warontherocks.com/2022/06/sanctions-and-satellites-the-space-industry-after-the-russo-ukrainian-war/; and Florian Vidal and Roman Privalov, "Russia in Outer Space: A Shrinking Space Power in the Era of Global Change," *Space Policy*, August 3, 2023, 101579, https://doi.org/10.1016/j.spacepol.2023.101579.

369 Eric Berger, "Putin Slashes Russia's Space Budget and Says He Expects Better Results," *Ars Technica*, October 8, 2021, https://arstechnica.com/science/2021/10/putin-slashes-russias-space-budget-and-says-he-expects-better-results/.

370 Marina Koren, "The Russian Space Program Is Falling Back to Earth," *The Atlantic*, October 14, 2022, https://www.theatlantic.com/science/archive/2022/10/us-russia-space-programs-spacex-collaboration-ukraine/671740/.

371 On Russia's historical counterspace programs, see, for example, Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-01. See also Laura Grego, *A History of Anti-Satellite Programs* (UCS, January 2012); and Matthew Mowthorpe, "The Soviet/Russian Antisatellite (ASAT) Programme during the Cold War and Beyond," *The Journal of Slavic Military Studies*, March 1, 2002, https://doi.org/10.1080/13518040208430510. For a history of space weapons and the Strategic Defense Initiative during the Cold War, see Bateman, *Weapons in Space*.

DA-ASAT Capabilities

Russia is actively developing at least three missile systems with ASAT applications, each of which has roots in Soviet-era programs: the Nudol ground-launched ballistic missile, the 78M6 Kontakt air-launched ballistic missile, and the S-500 ballistic missile defense system.[372] The most mature of these programs is the Nudol, a two-stage hit-to-kill missile designed to be launched from a road-mobile transporter erector launcher.[373] Officially described by the Russian government as a ballistic missile defense system, it clearly also has what a DIA publication has described as an "inherent counterspace capability," and even the Russian company leading the program has described the system as able to hold U.S. objects in LEO at risk.[374] In November 2021, Russia used the Nudol to target and destroy a retired Soviet satellite in LEO, conducting the country's first known exo-atmospheric hit-to-kill test of a ground launched DA-ASAT weapon and creating more than 1,500 pieces of trackable debris.[375] After the test, popular Russian television host Dmitry Kiselyov said the proven ASAT capabilities could "blind all their [NATO's] missiles, planes, and ships, not to mention the ground forces."[376] It is unclear if and when the system might become operational.[377]

The 78M6 Kontakt, also from the Soviet era, was an ASAT missile system intended to be launched from a variant of the MiG-31 fighter aircraft.[378] Although the program was put on hold during the 1990s, there are unconfirmed reports suggesting that it has been restarted.[379] In 2018, a photograph captured a MiG-31 carrying a large missile, which some

372 DIA, *Challenges to Security in Space 2022*, 28-9; Samson and Cesari, *Global Counterspace Capabilities 2025*, 02-18-24.

373 Reach et al., *Russia's Evolution*, 95.

374 DIA, *Challenges to Security in Space 2022*, 28. See also Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-18.

375 Brandon W. Kelley and Brian G. Chow, "Lessons to Learn from Russia's Nudol ASAT Test," *SpaceNews*, November 17, 2021, https://spacenews.com/op-ed-lessons-to-learn-from-russias-nudol-asat-test/; Thomas Nilsen, "Russia Hit Own Satellite with Missile from Plesetsk," *Independent Barents Observer*, November 16, 2021, https://thebarentsobserver.com/en/security/2021/11/russia-hit-own-satellite-missile-plesetsk; Ankit Panda, "The Dangerous Fallout of Russia's Anti-Satellite Missile Test," Carnegie Endowment for International Peace, November 17, 2021, https://carnegieendowment.org/2021/11/17/dangerous-fallout-of-russia-s-anti-satellite-missile-test-pub-85804; and DIA, *Challenges to Security in Space 2022*, 28.

376 Tracy Cozzens, "Russia Issues Threat to GPS Satellites," *GPS World*, November 29, 2021, https://www.gpsworld.com/russia-issues-threat-to-gps-satellites/.

377 Weeden and Samson, *Global Counterspace Capabilities 2024*, xix.

378 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-21–22.

379 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02–21.

analysts assessed could be related to an air-launched ASAT capability.[380] One VKS squadron commander said Russia would deploy an ASAT weapon on a MiG-31 ballistic missile "capable of destroying targets in near-space."[381] However, one researcher has suggested the MiG-31 activity may be linked instead to launching rockets for Burevestnik, a possible co-orbital ASAT program.[382]

The third program is the S-500 anti-ballistic missile system that is part of Russia's broader air defense network. It appears to include an exo-atmospheric interceptor capable of hitting objects in orbit, in addition to ballistic missiles before reentry.[383] In 2020, General Sergei Surovikin, at the time commander of the VKS, called the S-500 a "first generation space defense system."[384] In December 2021, TASS reported the S-550 had been deployed, but those reports were quickly questioned.[385]

Given the level of testing of these three systems, analysts from the Secure World Foundation have assessed that Russia may be within a few years of being able to field an operational DA-ASAT capability against LEO satellites.[386] They also assert that general assumptions about DA-ASATs suggest that Russia would only be able to target satellites that fly over an area where one of the systems is deployed and that once a weapon was launched, the target would have eight to 15 minutes of warning time.[387]

380 Bart Hendrickx, "Burevestnik: A Russian Air-Launched Anti-Satellite System," *The Space Review*, April 27, 2020, https://www.thespacereview.com/article/3931/1; Kyle Mizokami, "Russia's MiG-31 Spotted with Possible Anti-Satellite Missile," *Popular Mechanics*, October 1, 2018, https://www.popularmechanics.com/military/weapons/a23549729/russias-mig-31-spotted-with-possible-anti-satellite-missile/; Jenevieve Molenda, "Russian Air-Launched Missile Identified as Antisatellite Weapon," *Missile Threat*, CSIS, October 25, 2018, https://missilethreat.csis.org/russian-air-launched-missile-identified-as-antisatellite-weapon/; and Tyler Rogoway and Ivan Voukadnivov, "Russian MiG-31 Foxhound Carrying Huge Mystery Missile Emerges Near Moscow," *The War Zone*, September 29, 2018, https://www.twz.com/23936/exclusive-russian-mig-31-foxhound-carrying-huge-mystery-missile-emerges-near-moscow.

381 DIA, *Challenges to Security in Space 2022*, 29.

382 Hendrickx, "Burevestnik." This Burevestnik project should not be confused with the nuclear-powered cruise missile that Putin announced in 2018.

383 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-22.

384 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-22.

385 Joseph Trevithick, "No, Russia's S-550 Missile Defense System Hasn't Been Fielded," *The War Zone*, accessed on August 19, 2024, https://www.twz.com/43675/no-russias-s-550-missile-defense-system-hasnt-been-fielded. On the status of the S-550, see Maxim Starchak, "Where Is Russia's S-500 Air Defense System?," *Defense News*, October 5, 2023, https://www.defensenews.com/industry/2023/10/05/where-is-russias-s-500-air-defense-system/.

386 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-22.

387 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-22.

Orbital Weapons Capabilities

The Soviet Union had several programs to develop co-orbital ASAT capabilities, with kinetic co-orbital ASATs reaching operational status.[388] For example, the Istrebitel Sputnikov system was designed to launch an interceptor that would maneuver close to its target object and then explode to release shrapnel and damage or destroy the target.[389] Testing for the Istrebitel Sputnikov was conducted throughout the 1960s, and the Soviet Union declared the system operational in 1973.[390]

Since 2013, Russia has ramped up its testing and demonstration of RPO capabilities on orbit, demonstrating capabilities that could be dual use. Describing each instance is beyond the scope of this report; however, several incidents and programs are worth highlighting.[391] A full list of observed RPOs that the Secure World Foundation has catalogued is in Appendix A (see also Figure 14).

In 2017, for example, Russia deployed what it called an "inspector satellite."[392] However, its behavior has been what a DIA publication described as "inconsistent" with what one would expect from inspection or SSA activities.[393] This "inspector satellite," Cosmos 2521, was released from another satellite, Cosmos 2519, described by Russian officials as a "space platform."[394] Cosmos 2521 reportedly conducted a series of proximity operations experiments before releasing another satellite, Cosmos 2523, at high speed.[395]

388 Grego, *History of Anti-Satellite Programs*; Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-02–05; and Anatoly Zak, "Remembering That Time the Soviet Union Shot a Top-Secret Space Cannon While in Orbit," *Popular Mechanics*, October 24, 2022, https://www.popularmechanics.com/military/weapons/a18187/here-is-the-soviet-unions-secret-space-cannon/. See also Hugh Harkins, *Counter-Space Defence Co-Orbital Satellite Fighter: The Soviet Istrebitel Sputnik Anti-Satellite Complex* (United Kingdom: Centurion Publishing, 2017).

389 Victoria Samson, *Russian Co-Orbital Anti-Satellite Testing* (Washington, DC: Secure World Foundation, December 2024), 1; and Grego, *History of Anti-Satellite Programs*, 3.

390 Grego, *History of Anti-Satellite Programs,* 3; Harkins, *Counter-Space Defence Co-Orbital Satellite Fighter*; and Anatoly Zak, "IS Anti-Satellite System," Russian Space Web, March 5, 2024, https://www.russianspaceweb.com/is.html. For more on tests, see Brian Weeden and Emily Kunasek, "History of ASAT Tests in Space," February 5, 2025, Google, https://docs.google.com/spreadsheets/d/1e5GtZEzdo6xk41i2_ei3c8jRZDjvP4Xwz3BVsUHwi48/edit?gid=1252618705#gid=1252618705.

391 For a fuller description, see Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-05–16.

392 DIA, *Challenges to Security in Space 2022*, 29; Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-07.

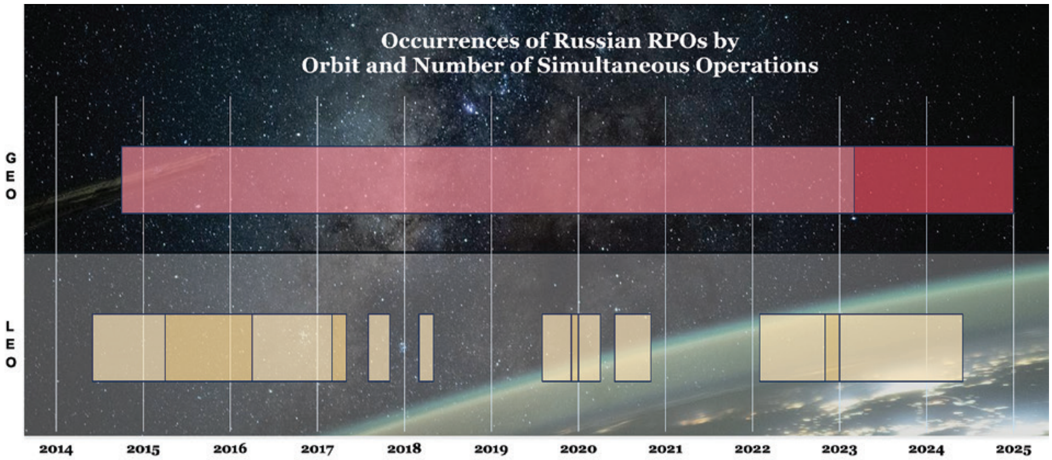
393 DIA, *Challenges to Security in Space 2022*, 29. See also: Mike Wall, "Space Weapon? U.S. Calls Out Russian Satellite's 'Very Abnormal Behavior,'" Space.com, August 15, 2018, https://www.space.com/41503-russian-satellite-possible-space-weapon.html.

394 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-07.

395 Jonathan McDowell, "Nivelir (Kosmos-2519 et al.): A New Series of Russian Military Satellites," Jonathan's Space Page, accessed on May 20, 2024, https://planet4589.org/space/plots/niv/index.html; and Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-07.

Cosmos 2521 and others may be part of a project called Nivelir, believed by Bart Hendrickx to be a program for inspection satellites. Bart Hendrickx, "Russia's Secret Satellite Builder," *The Space Review*, May 6, 2019, https://www.thespacereview.com/article/3709/1; Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-07–08. See also DIA, *Challenges to Security in Space 2022*, 29.

FIGURE 14: FREQUENCY OF RECENT RUSSIAN RPOS



Each gradient of color represents a different number of simultaneous operations taking place. The lightest yellow indicates one ongoing operation in LEO, while the darker yellow indicates two ongoing operations in LEO. The lightest red indicates one ongoing operation in GEO and the darkest red indicates 2 ongoing operations in GEO. This is a graphical depiction of occurrences of recent assessed Russian RPOs. Locations of each figure do not necessarily reflect an exact altitude of each occurrence.

Data derived from Samson and Cesari, *Global Counterspace Capabilities 2025*, 02-14-15, which was published April 2025. Data visualized through December 2024. See Appendix A for more details, including descriptions of each RPO. Background image from: NASA, "The Milky Way appears above Earth's bright atmospheric glow," NASA Image and Video Library, August 23, 2025, https://images.nasa.gov/details/iss073e0516005.

Russia has demonstrated this *matryoshka* (nesting doll) approach, with one or multiple satellites nested inside another, multiple times. For example, in November 2019, Russia launched a satellite named Cosmos 2542. Days later, Cosmos 2542 released another satellite, Cosmos 2543. This second satellite performed a number of close approaches and appears to have tracked a U.S. national security satellite, reportedly coming as close as 20 km.[396] The USSF chief of space operations at the time, General John W. Raymond, expressed his concern about the event, and the DIA described the RPO as "approaching close enough to create potentially dangerous operating conditions."[397] The U.S. vice chief of space operations at the time, General Thompson, told a reporter that a Russian satellite—possibly 2543—came so close to the U.S. national security satellite that the United States did not know whether the Russian satellite was attacking the U.S. satellite.[398]

In July 2020, Cosmos 2543 fired a projectile into space at a high velocity, prompting the U.S. military for the first time to publicly identify a space-based ASAT weapons test.[399] Raymond

396 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-09.

397 W.J. Hennigan, "Russian Craft Shadowing U.S. Spy Satellite, Space Force Commander Says," *Time*, February 10, 2020, https://time.com/5779315/russian-spacecraft-spy-satellite-space-force/; *Challenges to Security in Space 2022*, 29.

398 The article does not name Cosmos 2543 specifically, though the behavior described is consistent with the behavior of 2543. Rogin, "Shadow War in Space."

399 W.J. Hennigan, "America Really Does Have a Space Force. We Went Inside to See What It Does," *Time*, July 23, 2020, https://time.com/5869987/spaceforce/; and USSPACECOM, "Russia Conducts Space-Based Anti-Satellite Weapons Test," USSPACECOM, July 23, 2020, https://www.spacecom.mil/Newsroom/News/Article-Display/Article/2285098/russia-conducts-space-based-anti-satellite-weapons-test.

called the test “further evidence of Russia’s continuing efforts to develop and test space-based systems, and consistent with the Kremlin’s published military doctrine to employ weapons that hold U.S. and allied space assets at risk.”[400]

DIA has also identified two Russian satellites, Cosmos 2504 and Cosmos 2536, as “prototype Russian ASAT weapons that could kinetically kill satellites in LEO.”[401] Cosmos 2504 was launched in 2015 and conducted a series of maneuvers, changing its orbit several times.[402] Cosmos 2536 was launched four years later, in 2019, alongside Cosmos 2535, Cosmos 2537, and Cosmos 2538. Cosmos 2535 and 2536 conducted a series of RPOs, with nine debris objects released near the two satellites shortly before the RPO.[403] The other two satellites—Cosmos 2537 and 2538—did not maneuver, leading some analysts to believe they may be radar calibration targets.[404] In December 2019, Cosmos 2535 and 2536 continued RPO activities, leading to the release of six more debris objects.[405] Analysts from the Secure World Foundation calculated that by February 2021 the 2019 launch of these four satellites had been associated with 30 catalogued debris objects.[406] Bart Hendrickx, using open-source research, has suggested that these satellites may be part of a co-orbital ASAT program called Burevestnik that would involve launching ASATs into orbit from a MiG-31.[407] In May 2024, a U.S. official at the United Nations claimed Russia had launched a satellite that “the United States assesses is likely a counterspace weapon” in LEO and that the satellite was in a similar orbit as a U.S. government satellite.[408] Bart Hendrickx has suggested there is evidence that Russia’s Scientific Research Institute of Applied Chemistry and other research centers have investigated on-orbit aerosol obscurants that could block radiofrequency and

400 USSPACECOM, “Russia Conducts Space-Based Anti-Satellite Weapons Test.”

401 DIA, *Challenges to Security in Space 2022*, 29.

402 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-07–08; and Anatoly Zak, “Secret Mission of Kosmos-2504,” Russian Space Web, December 28, 2019, https://www.russianspaceweb.com/Cosmos-2504.html.

403 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-09.

404 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-09.

405 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-09. See also Brian Weeden, Russian *Military and Intelligence Rendezvous and Proximity Operations* (Washington, DC: Secure World Foundation, July 2023), 2, https://swfound.org/media/207609/fs23-06_russian-rpo_0723.pdf.

406 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-09.

407 Hendrickx, “Burevestnik”; and Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-08–10.

As stated earlier, this Burevestnik project should not be confused with the nuclear-powered cruise missile Putin in 2018.

408 Robert Wood, “Remarks before the Vote on a Russia-Drafted UN Security Council Resolution on Outer Space Security,” United Nations, May 20, 2024, https://usun.usmission.gov/remarks-before-the-vote-on-a-russia-drafted-un-security-council-resolution-on-outer-space-security/. See also Jeff Foust, “U.S. Claims Recently Launched Russian Satellite Is an ASAT,” *SpaceNews*, May 21, 2024, https://spacenews.com/u-s-claims-recently-launched-russian-satellite-is-an-asat/; and Greg Hadley and Chris Gordon, “Russia’s New Counterspace Weapon Is in the Same Orbit as a U.S. Satellite,” *Air & Space Forces Magazine*, May 21, 2024, https://www.airandspaceforces.com/russia-counterspace-weapon-near-us-satellite/.

optical signals to and from a satellite, which could hide Russian satellites or be used in an offensive attack.[409]

Russia has also conducted RPO activities in GEO.[410] In 2014, Russia launched a satellite known as Luch that has conducted a series of maneuvers to approach other satellites around the GEO belt.[411] As of early 2024, this Luch had parked near more than two dozen commercial communications satellites, sometimes staying with them for months.[412] In late 2017, these movements, according to the French defense minister, brought this Luch satellite "too close" to a French–Italian military communications satellite.[413] A second Luch satellite appears to be exhibiting similar behavior.[414] Kratos analysis has suggested the Luch satellites are likely being used for a SIGINT mission, collecting radiofrequency signals being uplinked to the satellites the Luch has parked near.[415] Furthermore, Russian press has reported Roscosmos is developing a satellite with orbital servicing capabilities that could be used for ASAT purposes in GEO.[416]

Although it is important to observe the technology Russia is testing and assess the threat it poses to the United States and its allies, it is also important to ask what signals Russia is trying to send and what effects it is trying to produce beyond developing the capability itself. For example, it is unclear how much intelligence Russia could have gained from Cosmos 2543's visual observations of the U.S. national security satellite.[417] It did succeed, however, in gaining the attention of the Western actors, serving perhaps to remind these states of

409 Bart Hendrickx, "Self-Defense in Space: Protecting Russian Spacecraft from ASAT Attacks," *The Space Review*, July 16, 2018, https://www.thespacereview.com/article/3536/1; and Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-08.

410 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-11–15.

411 Thomas G. Roberts, "Unusual Behavior in GEO: Luch (Olymp-K)," *Aerospace Security,* CSIS, September 1, 2022, https://aerospace.csis.org/data/unusual-behavior-in-geo-olymp-k/; and Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-11.

412 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-12.

413 John Leicester, Sylvie Corbet, and Aaron Mehta, "'Espionage': French Defense Head Charges Russia of Dangerous Games in Space," *Defense News*, September 7, 2018, https://www.defensenews.com/space/2018/09/07/espionage-french-defense-head-charges-russia-of-dangerous-games-in-space/.

414 Theresa Hitchens, "Second Russian Luch/Olymp Satellite Now Trailing Western Systems in Orbit," *Breaking Defense*, October 17, 2023, https://breakingdefense.sites.breakingmedia.com/2023/10/second-russian-luch-olymp-satellite-now-trailing-western-systems-in-orbit/.

415 Michael Clonts, "Espionage in Orbit: Satellite or Spy?," *Constellations*, Kratos Defense & Security Solutions, April 17, 2023, https://www.kratosdefense.com/constellations/articles/espionage-in-orbit-satellite-or-spy.

For more on Kratos's tracking of Luch and Luch 2, see Kratos Defense & Security Solutions, "Space Domain Awareness (SDA) Activities," accessed on April 7, 2025, https://www.kratosdefense.com/sdatracker. See also Samson and Cesari, *Global Counterspace Capabilities 2025*, 02-13–14.

416 DIA, *Challenges to Security in Space 2022*, 29.

417 Joseph Trevithick, "A Russian 'Inspector' Spacecraft Now Appears to Be Shadowing an American Spy Satellite," The Drive, January 30, 2020, https://www.thedrive.com/the-war-zone/32031/a-russian-inspector-spacecraft-now-appears-to-be-shadowing-an-american-spy-satellite.

Russia's ability to threaten in space and of its status as a space player.[418] As the vice chief of space operations at the time, Thompson, said about activity that appears related to Cosmos 2543: "[C]learly, the Russians were sending us a message."[419]

Directed Energy Weapons

Russia appears to be investing in advanced laser technologies and applications, building on research from the Soviet era. The DIA has assessed that Russia has capabilities that can blind sensors, is likely on track to field more capable DEWs in the mid- to late 2020s, and may field systems that could threaten the structures of all satellites, not just EO ISR satellites, by 2030.[420]

Work on an airborne laser system, the Sokol-Echelon, with roots in the 1980s appears to be ongoing, though there are recent reports the program may have been canceled.[421] During the 1980s, the Soviet Union launched a development program that sought to mount a laser onto the Beriev A-60, a modified transport aircraft.[422] In 2012, the Ministry of Defense announced resumption of the project, and Weeden and Samson assert that the system appears to have conducted several flight tests during the 2010s.[423] There is no public technical information about the laser with which the Sokol-Echelon may be fitted. However, given the difficulties of operating a laser from a moving aircraft, analysts from the Secure World Foundation suggest that it is unlikely that the laser could damage a satellite's structure; instead, it likely targets optical imaging sensors.[424]

Russia is also developing the Peresvet, a ground-mobile laser system.[425] Reportedly deployed to strategic missile divisions, the ground-mobile system is "designed to blind enemy optical tracking systems," and the Russian Defense Ministry has asserted it is capable of "fighting

418 The Luch satellite was openly criticized by the French minister of defense; once called out, Russia did not apologize for nor cease the behavior. Leicester, Corbet, and Mehta, "'Espionage;" and Roberts, "Unusual Behavior in GEO," September 1, 2022.

419 Rogin, "Shadow War in Space."

420 DIA, *Challenges to Security in Space 2022*, 28.

421 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-29–30; and Todd Harrison, Kaitlyn Johnson, and Thomas G. Roberts, *Space Threat Assessment 2018* (Washington, DC: Center for Strategic and International Studies, 2018), 15.

422 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-29; and Pavel Podvig, "Is Russia reviving an old laser ASAT project?" *Russian Strategic Nuclear Forces*, May 27, 2011, https://russianforces.org/blog/2011/05/is_russia_reviving_an_old_lase.shtml.

423 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-29–30. See also, Pavel Podvig, "Russia to resume work on airborne laser ASAT," *Russian Strategic Nuclear Forces,* November 13, 2012, https://russianforces.org/blog/2012/11/russia_to_resume_work_on_airbo.shtml.

424 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-30. See also, Harrison et al., *Space Threat Assessment 2018,* 15.

425 Hendrickx, "Peresvet."

satellites in orbit."[426] Russian sources have claimed the laser can target satellites up to 1,500 km, which would cover most of LEO.[427] In May 2022, Russian officials claimed Peresvet was being deployed to Ukraine, though there was no public evidence to support the claim as of early 2024.[428]

There are also indications that Russia may be developing other DEW capabilities to target satellites. For example, there may be signs that Russia could be placing laser dazzling or blinding capabilities at its Krona optical space surveillance system.[429] The nine International Laser Ranging Service Satellite network stations that Russia has could theoretically be used to dazzle optical imaging satellites, though there is no public evidence of this occurring.[430] Samson and Cesari find no available evidence that Russia is currently pursuing a space-based laser ASAT capability.[431]

Electronic Warfare and Cyber Capabilities

Given the large role that satellites play in C4ISR and PNT, the Russian military considers jamming a key feature of modern conflict, both preparing for its own signals to be attacked and working to interrupt others' signals.[432] The Russian military has undertaken several programs to increase its EW capabilities, fielding several ground-based EW systems.[433]

Most of Russia's EW programs have focused on systems that jam user terminals within tactical ranges, potentially interfering with the guidance systems.[434] In addition to fixed GPS jammers designed to reduce the accuracy of foreign unmanned aerial vehicles and cruise missiles targeting Russian sites, Russia has developed mobile systems integrated

426 DIA, *Challenges to Security in Space 2022*, 28.

427 Connell, *Role of Space*, 16.

428 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-31.

429 Bart Hendrickx, "Kalina: A Russian Ground-Based Laser to Dazzle Imaging Satellites," *The Space Review*, July 5, 2022, https://www.thespacereview.com/article/4416/1; Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-31–32.

430 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-32.

431 Samson and Cesari, *Global Counterspace Capabilities 2025*, 02-35.

432 For more on Russian electronic warfare, see Tracy Cozzens, "Russia Expected to Ditch GLONASS for Loran in Ukraine Invasion," *GPS World*, February 17, 2022, https://www.gpsworld.com/russia-expected-to-ditch-glonass-for-loran-in-ukraine-invasion/; Jonas Kjellén, *Russian Electronic Warfare: The Role of Electronic Warfare in the Russian Armed Forces* (Stockholm: FOI, Swedish Defense Research Agency, September 2018); Pavel Luzin, *Electronic Warfare: Russia's Approach* (Philadelphia: Foreign Policy Research Institute, February 2022); Roger N. McDermott, *Russia's Electronic Warfare Capabilities to 2025* (Tallinn, Estonia: International Centre for Defence and Security, September 2017); and Timothy Thomas, *Russia's Electronic Warfare Force: Blending Concepts with Capabilities* (MITRE, 2020).

433 For a detailed overview of Russian counterspace EW capabilities, see Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-23–29.

434 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-23.

within military EW units.[435] For example, the R-330Zh Zhitel provides local jamming of GPS signals.[436] Russia also appears to have a program meant to protect its own satellites from uplink jamming, though the Tobol program may also be used to jam uplinks for GPS.[437] Russian sources have claimed Russian forces have used Tirada-2, a mobile jamming system that allegedly targets uplinks and has roots in Cold-War era programs, to disrupt Starlink.[438]

Russia also possesses ground systems that can likely jam communications satellites uplinks over a wider area. For example, the Bylina system was purportedly designed to amplify the jamming of satellite communication channels.[439] It reportedly includes an automated system that can recognize assets, determine how to attack them, and issue orders to EW units in the field.[440] The mobile Krasukha-4 is meant to counter airborne early warning and control systems and other airborne radar, but it may also be effective against SAR satellites in LEO.[441] There are also reports of a newer strategic-level EW system, the Divnomorye, that could target airborne and space-based assets.[442]

Between 2014 and 2022, Russian forces used EW in Crimea and the Donbass to jam GPS signals and otherwise disrupt Ukrainian efforts.[443] The months following the February 2022

435 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-23.

436 Bryan Clark, "The Fall and Rise of Russian Electronic Warfare," *IEEE Spectrum*, July 30, 2022, https://spectrum.ieee.org/the-fall-and-rise-of-russian-electronic-warfare; Bohdan Tuzov, "Russia's Electronic Warfare Equipment," *Kyiv Post*, May 11, 2024, https://www.kyivpost.com/analysis/32435; and ODIN, "R-330Zh Zhitel Russian Cellular Jamming and Direction Finding System," OE Data Integration Network, accessed on August 19, 2024, https://odin.tradoc.army.mil/WEG/Asset/R-330Zh_Zhitel_Russian_Cellular_Jamming_and_Direction_Finding_System.

437 Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-26.

438 Connell, *Role of Space*, 15; Bart Hendrickx, "Russia Gears Up for Electronic Warfare in Space (Part 1)," *The Space Review*, October 26, 2020, https://www.thespacereview.com/article/4056/1.

439 The Bylina-MM, a ground-based mobile jammer, may be a part of this system. Hendrickx, "Russia Gears Up (Part 1);" Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-26–27.

440 Hendrickx, "Russia Gears Up (Part 1);" McDermott, *Russia's Electronic Warfare Capabilities to 2025,* 15–16; and Roger McDermott, "Russia's Armed Forces Test and Refine Electronic Warfare Capability," *Eurasia Daily Monitor* 17, no. 59, April 29, 2020, https://jamestown.org/program/russias-armed-forces-test-and-refine-electronic-warfare-capability/.

441 Hendrickx, "Russia Gears Up (Part 1);" and Weeden and Samson, *Global Counterspace Capabilities 2024*, 02-27.

442 Hendrickx, "Russia Gears Up (Part 1);" Roger McDermott, "Russia's Electronic Warfare Capability: Training and Procurement," *Eurasia Daily Monitor* 15, no. 76, May 17, 2018, https://jamestown.org/program/russias-electronic-warfare-capability-training-and-procurement/; Roger McDermott, "Russia's Military Boosts Electromagnetic Spectrum Capability," *Eurasia Daily Monitor* 18, no. 144, September 22, 2021, https://jamestown.org/program/russias-military-boosts-electromagnetic-spectrum-capability/; Reach et al., *Russia's Evolution*, 78–82; and Thomas, *Russia's Electronic Warfare Force*, 5–6.

443 McDermott, *Russia's Electronic Warfare Capabilities to 2025*, especially pp. 23–28; and C4ADS, *Above Us Only Stars: Exposing GPS Spoofing in Russia and Syria* (Washington, D.C.: C4ADS, 2019).

invasion of Ukraine demonstrated the limitations of EW.[444] However, Russian jamming has improved and adapted over the course of the war and created additional challenges for the Ukrainian armed forces.[445] A European Space Agency SAR satellite experienced interference over Rostov, Russia, in July 2021 and over Sevastopol, Ukraine, in November 2023, with some attributing the interference to Russian EW attempts to disrupt drones rather than an intentional counterspace attack.[446] Russia has also been blamed for GPS interference across the Baltic Sea region, including interference activity in spring 2024 that forced Finnair to divert and then suspend flights to Estonia.[447]

Russian actors also have cyber capabilities that could threaten satellites. For example, Turla, a group of hackers with links to the Russian Federal Security Service, has previously hacked satellites to retrieve sensitive data.[448] In 1998, hackers based in Russia allegedly fried the optics of a satellite by hacking into its control system and rotating it toward the sun.[449] In

444 Although the Russian military did have some success in its EW attempts, other attempts failed. Overinflated expectations of how Russian EW capabilities would impact Russian performance are also likely related to expectations that the Russian military would rapidly defeat the Ukrainian military. See Clark, "Fall and Rise."

On early attempts, see "Why Isn't Russia Blocking GPS in Ukraine?," *The Economist*, August 8, 2022; Dana Goward, "Why Isn't Russia Doing More to Jam GPS in Ukraine?," C4ISRNet, July 26, 2022, https://www.c4isrnet.com/opinion/2022/07/22/why-isnt-russia-jamming-gps-harder-in-ukraine/; Valerie Insinna, "SpaceX Beating Russian Jamming Attack Was 'Eyewatering': DoD Official," *Breaking Defense*, April 20, 2022, https://breakingdefense.sites.breakingmedia.com/2022/04/spacex-beating-russian-jamming-attack-was-eyewatering-dod-official/; Corin Faife, "Russian Military Reportedly Hacked Into European Satellites at Start of Ukraine War," The Verge, March 25, 2022, https://www.theverge.com/2022/3/25/22996187/russian-military-hack-viasat-internet-satellite-ukraine; Theresa Hitchens, "'Local' Russian GPS Jamming in Ukraine Hasn't Affected U.S. Support Ops, So Far," *Breaking Defense*, March 1, 2022, https://breakingdefense.com/2022/03/local-russian-gps-jamming-in-ukraine-hasnt-affected-us-support-ops-so-far/; and Elizabeth Howell, "Russia Is Jamming GPS Satellite Signals in Ukraine, U.S. Space Force Says," Space.com, April 12, 2022, https://www.space.com/russia-jamming-gps-signals-ukraine.

445 Of course, Ukrainian EW has also challenged Russian forces. On EW in the war in Ukraine, see, for example: Stavros Atlamazoglou, "Russia's Electronic Warriors Are Switching to 'Much More Subtle' Operations around the Frontlines in Ukraine," *Business Insider*, October 8, 2023, https://www.businessinsider.com/russian-electronic-warfare-tactics-changing-on-frontlines-in-ukraine-2023-10; Shashank Joshi, "The Latest in the Battle of Jamming with Electronic Beams," *The Economist*, July 8, 2023, https://www.economist.com/special-report/2023-07-08; Justin Ling, "The Invisible Russia-Ukraine Battlefield," *Wired*, December 23, 2024, https://www.wired.com/story/electronic-warfare-russia-ukraine/; Oleksandr Stashevskyi and Frank Bajak, "Deadly Secret: Electronic Warfare Shapes Russia-Ukraine War," *Associated Press*, June 3, 2022; Oleksandr Tartachnyi, "The Invisible War: Inside the electronic warfare arms race that could shape course of war in Ukraine," *Kyiv Independent*, March 12, 2014; Jack Watling and Nick Reynolds, *Meatgrinder: Russian Tactics in the Second Year of Its Invasion of Ukraine* (London: RUSI, May 19, 2023); and Jack Watling and Nick Reynolds, *Stormbreak: Fighting through Russian Defences in Ukraine's 2023 Offensive* (London: Royal United Services Institute, September 2023).

446 Swope et al., *Space Threat Assessment 2024*, 15.

447 Vitaly Shevchenko, "Russia Accused of Jamming GPS Navigation," *BBC*, May 2, 2024.

448 Andy Greenberg, "The Underground History of Russia's Most Ingenious Hacker Group," *Wired*, May 20, 2023, https://www.wired.com/story/turla-history-russia-fsb-hackers/; and Ellen Nakashima, "Russian Hacker Group Exploits Satellites to Steal Data, Hide Tracks," *Washington Post*, September 9, 2015.

449 Luke Shadbolt, *Satellite Cyberattacks and Security* (HDI Global Specialty, July 2021), 12; Brian Weeden and Victoria Samson, *Global Counterspace Capabilities: An Open Source Assessment* (Washington, DC: Secure World Foundation, 2021), 9-9; and Mark Wess, "ASAT Goes Cyber," *Proceedings* 147, no. 2, February 2021, https://www.usni.org/magazines/proceedings/2021/february/asat-goes-cyber.

February 24, 2022, a cyberattack against a commercial satellite network belonging to U.S. company Viasat impacted the Ukrainian military's command and control communications, in addition to other European civilian customers, although the effect of the attack on Ukrainian military operations is unclear.[450] The next month, Roscosmos head Rogozin said hacking any of Russia's satellites would be a justification for war.[451]

Other Developing ASAT Capabilities

In February 2024, U.S. Representative Mike Turner, at the time chair of the House Select Permanent Committee on Intelligence, shared an announcement hinting at a "serious national security threat."[452] Shortly thereafter, the U.S. government confirmed that Russia is developing a new ASAT capability.[453] A U.S. White House spokesperson alleged that though the capability poses no immediate threat, it would violate the 1967 Outer Space Treaty, which—among other provisions—bans nuclear weapons in space.[454] Little is publicly known about the program, but comments from U.S. government officials have suggested the program seeks to develop an "anti-satellite capability related to a new satellite carrying a nuclear device."[455] Whereas other ASAT capabilities can target single satellites or small groups of satellites, detonating a nuclear weapon in space has the potential to destroy large-scale satellite constellations.[456] Doing so would also affect Russian satellites, but Russia may see itself as less reliant on space and thus more willing to use it. Even without use, however, Moscow might view it as what one expert called "a sword of Damocles it could dangle over

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450 Christian Vasquez and Elias Groll, "Satellite Hack on Eve of Ukraine War Was a Coordinated, Multi-Pronged Assault," *CyberScoop*, August 10, 2023, https://cyberscoop.com/viasat-ka-sat-hack-black-hat/; "Case Study: Viasat Attack," Cyber Peace Institute, June 2022, https://cyberconflicts.cyberpeaceinstitute.org/law-and-policy/cases/viasat; and Andrew Radin, Khrystyna Holynska, Cheyenne Tretter, and Thomas Van Bibber, *Lessons from the War in Ukraine for Space: Challenges and Opportunities for Future Conflicts* (RAND, 2025), 8.

451 Reuters, "Russia Space Agency Head Says Satellite Hacking Would Justify War," *Reuters*, March 2, 2022.

452 House Intelligence Committee (@HouseIntel), "Statement from Chairman @RepMikeTurner," *X*, February 14, 2024, https://x.com/HouseIntel/status/1757805804885823775.

453 W. J. Hennigan, "The Warning," *New York Times*, December 5, 2024.

454 White House, "Press Briefing by Press Secretary Karine Jean-Pierre and White House National Security Communications Advisor John Kirby," White House, February 15, 2024, https://www.presidency.ucsb.edu/documents/press-briefing-press-secretary-karine-jean-pierre-and-white-house-national-security-1.

455 John F. Plumb, "Statement of Dr. John F. Plumb, Assistant Secretary of Defense for Space Policy, Before the House Armed Services Committee Subcommittee on Strategic Forces on Fiscal Year 2025 National Security Space Programs," U.S. House of Representatives, May 1, 2024, https://docs.house.gov/meetings/AS/AS29/20240501/117236/HHRG-118-AS29-Wstate-PlumbJ-20240501.pdf. See also John Hamre, Mallory Stewart, and Clayton Swope, "The Nuclear Option: Deciphering Russia's New Space Threat" CSIS (Washington, D.C.), May 3, 2024, https://www.csis.org/analysis/nuclear-option-deciphering-russias-new-space-threat; and Jake Sullivan, "Statement from National Security Advisor Jake Sullivan on Russia's Veto of the UN Security Council Resolution on the Outer Space Treaty," White House, April 24, 2024, https://www.whitehouse.gov/briefing-room/statements-releases/2024/04/24/statement-from-national-security-advisor-jake-sullivan-on-russias-veto-of-the-un-security-council-resolution-on-the-outer-space-treaty/.

456 Aaron Bateman, "Why Russia Might Put a Nuclear Weapon in Space," *Foreign Affairs*, March 7, 2024, https://www.foreignaffairs.com/russian-federation/why-russia-might-put-nuclear-weapon-space.

every other state's space systems," using coercion and threat to try to control escalation on earth and in space.[457]

Assessment of Capabilities

The Russian space program is formidable, even if it has less capacity than the Chinese one. With highly advanced individual capabilities and a legacy of space knowledge, the Russian military is working to regain its overall space capability and recapitalize key capabilities like PNT, ISR, and communications.

Russia's recent military activities provide an opportunity to assess how well space capabilities are integrated into their military operations. The 2008 war in Georgia highlighted the limits of Russian space-based capabilities, especially in the failure of space-based command and control, space-based intelligence, and SATCOM.[458] Russian forces in Georgia were largely unable to use satellites for navigation, reconnaissance, and targeting, hindered by (among other factors) a combination of a lack of satellite navigation and positioning equipment and the fact that GLONASS was not fully operational.[459] Russia's operations in Syria and Ukraine demonstrated mixed levels of improvement in these areas. In Syria, Russia used spacecraft, including Russian civilian remote sensing satellites, to bolster situational awareness and targeting.[460] However, reporting has suggested Russia's use of satellites in the war in Ukraine since February 2022 has been strained.[461] Although the war is ongoing and it is difficult to fully adjudicate the performance of Russian space-based assets from publicly available information, Russian challenges with command and control and errors from precision munitions that are likely GLONASS guided suggest Russia's use of space-based assets has been less effective than expected.[462]

Looking forward, Russia is likely to continue to place the bulk of its space efforts on military missions rather than civilian endeavors.[463] Although the Russian space sector has stag-

457 Bateman, "Why Russia Might Put a Nuclear Weapon in Space."

458 Ariel Cohen and Robert E. Hamilton, *The Russian Military and the Georgia War: Lessons and Implications* (Carlisle, PA: Strategic Studies Institute, U.S. Army War College, 2011); Roger McDermott, "Tracing Russia's Path to Network-Centric Military Capability," The Jamestown Foundation, December 4, 2020, https://jamestown.org/program/tracing-russias-path-to-network-centric-military-capability/; and Carolina Vendil Pallin and Fredrik Westerlund, "Russia's War in Georgia: Lessons and Consequences," *Small Wars & Insurgencies* 20, no. 2, June 2009, 400–24, https://doi.org/10.1080/09592310902975539.

459 Vendil Pallin and Westerlund, "Russia's War in Georgia," 411.

460 Vidal, *Russia's Space Policy*, 15–16; Zak, *Russian Military and Dual-Purpose Spacecraft,* 22; and DIA, *Challenges to Security in Space 2022*, 23.

461 Connell, *Role of Space*; and Krutov and Dobrynin, "In Russia's War On Ukraine."

462 David T. Burbach, "Early Lessons from the Russia-Ukraine War as a Space Conflict," Atlantic Council, August 30, 2022, https://www.atlanticcouncil.org/content-series/airpower-after-ukraine/early-lessons-from-the-russia-ukraine-war-as-a-space-conflict/.

463 Bodner, "60 Years after Sputnik;" and Luzin, *Russia's Space Program after 2024*.

nated overall, the military's and the Kremlin's emphasis on national security applications of space has continued to grow.[464] Thus, although Russian military space capabilities may increase (or be perceived as increasing), this may be at the cost of investments and progress in civil and commercial efforts. As one analyst put it, "On the one hand, [the] military component [of Russia's space activities] is strengthening its influence as a geopolitical power. On the other hand, the country is losing its longtime and prominent position in international [scientific] cooperation."[465] Although defense needs can drive innovation with civil and commercial implications, the civil industry in Russia is not built to take full commercial advantage of these new capabilities, further hobbling the space sector's contributions to Russian economic growth.

As part of its efforts to increase its military might, Russia will likely continue to invest heavily in counterspace weapons (see Figure 15). Although China is also developing capabilities, the Russians appear more brazen in demonstrating their counterspace weapons. This could signal that its development programs are further ahead, that it has more systems, and/or that it is trying to use its counterspace weapons program to signal to the United States that it can target U.S. systems. The last option would suggest Russia is already using its ASAT programs to signal its great power status, deter the United States from what Russia would see as early aggression, and to coerce the United States to behave in ways the Kremlin would prefer.

Notably, Russian risk acceptance in space may be greater than that of either the United States or China. Although one could see its more limited space program as a weakness, its lack of dependence on space could encourage Russian policymakers to believe that they have less to lose in space than their adversaries. Thus, Russia may be more willing than other actors to create debris in space, making it more unpredictable and potentially dangerous.

464 France 24, "60 Years after Gagarin, Russia Lags in the Space Race;" McClintock, "Russia's National Security Space Strategy."

465 Vidal, *Russia's Space Policy*, 14.

FIGURE 15: ASSESSED STATUS OF RUSSIAN COUNTERSPACE CAPABILITIES BY THE SECURE WORLD FOUNDATION'S 2025 *GLOBAL COUNTERSPACE CAPABILITIES* REPORT

	R&D	Testing	Operational	*Overall Status*
DA-ASAT				
LEO	*Significant*	*Significant*	*Uncertain*	*Significant*
MEO/GEO	*(No data)*	*(No data)*	*(No data)*	*Some*
Co-Orbital Weapons				
LEO	*Significant*	*Significant*	*Uncertain*	*Significant*
MEO/GEO	*Some*	*(No data)*	*(No data)*	*Some*
Other Capabilities				
Directed Energy	*Significant*	*Some*	*Uncertain*	*Some*
Electronic Warfare	*Significant*	*Significant*	*Significant*	*Significant*
Space Situational Awareness	*Significant*	*Significant*	*Significant*	*Significant*

Image derived from assessments and figures by Samson and Cesari, *Global Counterspace Capabilities 2025*, xviii and xxi.

Russia, perceiving an asymmetry in U.S. reliance on space, may continue to use its counterspace programs to shape the behavior of the United States and its allies. However, policymakers and analysts should not become complacent and see the programs as just empty threats. In part because Russia is less dependent on space than other actors, its leadership may be more willing than others, including the United States and China, to destabilize the space environment, generate debris, and break norms. Thus, if the Russian government believes conducting destabilizing behavior in space will lead to significant advantages, it may be willing to put its own assets in harm's way.

CHAPTER 4

A Two-Rival Threat Environment

Considered individually, Chinese and Russian space and counterspace capabilities, reinforced by doctrine seeking to deny the United States access to space, could represent significant threats to U.S. forces in space and on Earth. The United States thus requires the ability to both deter and respond to aggressive Chinese or Russian behavior and, if necessary, limit their freedom of action during wartime. Considered together, Chinese and Russian space and counterspace capabilities create an even more complicated threat picture, particularly given evidence of increasing collaboration between Beijing and Moscow. The United States thus faces a two-rival threat environment in space, requiring it to prepare to shape and deter China and Russia simultaneously.[466]

Assessing the Sum of Rivals' Capabilities

China and Russia are increasing their capabilities in each category of ASAT weaponry. Figure 16 uses Samson and Cesari's assessments of the progress of U.S., Russian, and Chinese counterspace programs to compare the capability level of each program type. The United States faces rising challenges from each type of ASAT program. Both China and Russia have pursued significant R&D and testing of LEO DA-ASATs, and China, according to research from the Secure World Foundation, has tested a potential DA-ASAT that may seek the capability of reaching higher orbits.[467] Both countries have invested heavily in co-orbital ASAT programs and have tested several systems and capabilities. Both countries have also invested in directed energy, and both have demonstrated operational EW and SSA. According to Samson and Cesari's analysis, there are two primary asymmetries in counterspace programs between China, Russia, and the United States, assessing that the overall

466 Although this analysis focuses on China and Russia, updated assessments should be undertaken as new actors enter space.

467 Weeden, *Chinese Direct Ascent Anti-Satellite Testing*; Samson and Cesari, *Global Counterspace Capabilities 2025*, 03-15-16.

status of China and Russia's LEO DA-ASAT and co-orbital LEO programs (a combination of assessments of the program's levels of R&D, testing, operational status, and any use in conflict) was "significant" while the United States' was "some."[468]

FIGURE 16: COMPARING ASSESSMENTS OF U.S., RUSSIAN, AND CHINESE COUNTERSPACE PROGRAMS

Assessment levels derived and image adapted from Samson and Cesari, *Global Counterspace Capabilities 2025*, xviii.

It is difficult to assess how many ASATs China and Russia may possess, but the trendlines suggest their capabilities are growing stronger. Perhaps especially concerning, both China and Russia have demonstrated significant interest and investments in co-orbital ASAT programs. Although DA-ASATs have the potential to be destructive, attacks that use them are easier to attribute than attacks using other weapons. Furthermore, given concerns about debris creation, DA-ASATs might be less likely to be used, even if threatened. However, co-orbital ASAT testing appears to be becoming more frequent. Given attribution difficulties, dual-use applications, and the challenges in defending satellites, China and Russia may increase the demonstration, testing, and signaling of co-orbital ASAT threats to coerce the United States and signal strength.

Furthermore, the individual challenges from Russia and China are compounded by the fact that cooperation in space, as in other domains, is growing between Moscow and Beijing.[469]

468 Samson and Cesari, *Global Counterspace Capabilities 2025*.

469 On the Sino-Russian relationship more broadly, see, for example, Jo Inge Bekkevold and Bobo Lo, *Sino-Russian Relations in the 21st Century* (Palgrave Macmillan, 2018); Andrea Kendall-Taylor and David O. Shullman, *Best and Bosom Friends: Why China–Russia Ties Will Deepen after Russia's War on Ukraine* (Washington, DC: CSIS, June 22, 2022), https://www.csis.org/analysis/best-and-bosom-friends-why-china-russia-ties-will-deepen-after-russias-war-ukraine; Alexander Korolev, "On the Verge of an Alliance: Contemporary China-Russia Military Cooperation," *Asian Security* 15, no. 3, April 30, 2018, 233–52, https://doi.org/10.1080/14799855.2018.1463991; and Andrew Radin et al., *China–Russia Cooperation: Determining Factors, Future Trajectories, Implications for the United States* (RAND Corporation, 2021), https://www.rand.org/pubs/research_reports/RR3067.html.

Sino-Russian space cooperation is not new (see Figure 17).[470] The Soviet Union provided support to China's early space program, including technical advisors and an R-2 ballistic missile that China reverse engineered to make what would become the base of the Long March rocket.[471] After the Cold War, Russian expertise and support continued to aid the Chinese space program.[472] For example, Russian expertise supported China's first spaceflight mission in 2003, with technology ranging from the capsule to the spacesuits based on Russian designs.[473]

Since 2014, cooperation between Russia and China has grown closer, marking a new phase in their space relationship characterized by more reciprocal contributions.[474] Sino-Russian space cooperation has spanned capabilities and industrial needs and is anticipated to continue to increase.[475] For example, Chinese companies have helped Russia weather sanctions and export controls. After the United States and others placed sanctions on Russia in response to its 2014 annexation of Crimea, Chinese companies recognized a business opportunity and began serious efforts to sell microelectronics to the Russian space industry.[476] Days after Russia's full-scale invasion of Ukraine in February 2022, Rogozin said Russia would make up for the renewed microelectronics shortfall caused by sanctions and export controls by purchasing them from China.[477] Russia seems to be planning to rely heavily on China for long-term import substitution, but it is unclear to what extent Chinese companies and the Chinese government are ready to play that role.[478]

Sino-Russian space cooperation takes place across a variety of fields. For example in 2019, Putin announced that Russia was helping China build a missile attack early warning

470 For good overviews of the history of Sino-Russian military-technical cooperation overall and of cooperation in space, see Hull and Markov, *Sino-Russian Defense Cooperation's Impact*; Charlotte Mathieu, *Assessing Russia's Space Cooperation with China and India* (Vienna: European Space Policy Institute, 2008); and Kevin Pollpeter et al., *China-Russia Space Cooperation: The Strategic, Military, Diplomatic, and Economic Implications of a Growing Relationship* (Montgomery, AL: China Aerospace Studies Institute, 2023), 8–10.

471 R. Lincoln Hines, "Houston, We Might Have a Problem: Russia's ASAT Test and the Limits of China–Russia Space Cooperation," Modern War Institute, December 15, 2021, https://mwi.usma.edu/houston-we-might-have-a-problem-russias-asat-test-and-the-limits-of-china-russia-space-cooperation/.

472 On military-technical cooperation, for example, see Hull and Markov, *Sino-Russian Defense Cooperation's Impact*, 9-14. Also see, Pollpeter et al., *China-Russia Space Cooperation*, 8-9.

473 Hines, "Houston, We Might Have a Problem."

474 For one overview, see Richard Weitz, "Sino-Russian Cooperation in Outer Space: Taking Off?," *China Brief* 20, no. 21, December 6, 2020, https://jamestown.org/program/sino-russian-cooperation-in-outer-space-taking-off/.

475 Kramer and Myers, "Russia, Once a Space Superpower;" and Pollpeter et al., *China–Russia Space Cooperation*.

476 Hull and Markov, *Sino-Russian Defense Cooperation's Impact*, 18.

477 Interfax, "'Роскосмос' закупит у Китая микроэлектронику, поставки которой попали под санкции ["Roscosmos" Will Buy Microelectronics from China, Which Have Been Blocked by Sanctions]," *Interfax*, February 27, 2022, https://www.interfax.ru/world/824864.

478 Andrew Jones, "Russia Looks to China for Collaboration in Space but Faces Isolation over Ukraine Invasion," *SpaceNews*, March 1, 2022, https://spacenews.com/russia-looks-to-china-for-collaboration-in-space-but-faces-isolation-over-ukraine-invasion/.

system.[479] In September 2022, China and Russia signed contracts to host ground stations for each other's GNSS, aiming to improve the performance of both systems.[480] The two have also agreed to coordinate on a series of lunar missions, with the goal of building a permanent research base on the Moon by 2035.[481] Diplomatically, they have coordinated to promote a proposed Treaty on the Prevention of the Placement of Weapons in Outer Space.[482]

FIGURE 17: EVOLUTION OF SINO-RUSSIAN SPACE COOPERATION

Although Sino-Russian space cooperation is not new, the dynamics between the two states are changing, with China becoming an increasingly strong and capable partner in the relationship.

Whereas in the past the Chinese space program gained more from Russian help than vice versa, the reverse is increasingly true today: the Russian space program is likely to rely to an increasing extent on China.[483] Given current trendlines, the Russian space program, particularly its civil program, may struggle in the coming decades and, as a result, lean on China to remain competitive. This potential shift in power dynamics mimics the Sino-Russian relationship more broadly. Facing severe sanctions and isolation from the West, Russia is likely to try to lean on China for collaboration across several dimensions. That is not to say that Russian expertise and support does not also support the Chinese program; it does. For example, Roscosmos has much more technical experience than CNSA in crewed missions,

479 Vasily Kashin, "Chinese–Russian Ballistic Missile Cooperation Signals Deepening Trust," East Asia Forum, February 19, 2021, https://www.eastasiaforum.org/2021/02/20/chinese-russian-ballistic-missile-cooperation-signals-deepening-trust/; Daria Litvinova, "Russia is helping China build a new missile attack warning system, Putin says," *CBS News*, October 4, 2019, https://www.cbsnews.com/news/russia-to-help-china-build-new-missile-attack-warning-system-vladimir-putin-says-today-2019-10-04/; and Pollpeter et al, *China-Russia Space Cooperation*, 22-23.

480 John Hardie, "China, Russia Deepen Partnership on Satellite Navigation," Foundation for Defense of Democracies, October 20, 2022, https://www.fdd.org/analysis/2022/10/20/china-russia-satellite-navigation/.f

481 Pollpeter et al., *China-Russia Space Cooperation*, 13–14.

482 Bowman and Thompson, "Russia and China Seek to Tie America's Hands."

483 Bernat, "Russia's Strategic Shift;" and Jones, "Russia Looks to China for Collaboration in Space but Faces Isolation over Ukraine Invasion."

space stations, and extended stays in orbit.[484] As one author has suggested, "money cannot make up for experience."[485]

There are likely limits to the relationship. The Russian space industry is still well guarded, and full trust in China, though seemingly growing, has not yet materialized. In 2016, the head of a Roscosmos research facility was jailed for treason for allegedly selling China a top-secret algorithm to calculate hypersonic flights.[486] In 2019, an official from Rostec, one of Russia's largest defense conglomerates, singled out China when discussing Russian weapons and military equipment that had been illegally copied abroad.[487] As Russia began importing more components from China after 2014, some Russian analysts complained the imports were not the same quality as Western components and could, at times, be more expensive.[488] Given the lack of options available to Russia, these imports may have to suffice. China may also, however, seek to signal distance from the Russian space program to protect its own interests as much of the West turns away from Russia.[489] For example, at a September 2022 meeting of the International Astronautical Congress in Paris, the Chinese delegation did not mention its partnership with Russia when it announced China was looking for partners for its Moon and solar system exploitation missions.[490]

Their cooperation does not mean that China and Russia represent the exact same challenge in space. Indeed, important differences between the two should inform U.S. strategy. One major difference is apparent in their space architectures and use of space to support terrestrial military operations. The PRC is building a comprehensive space architecture encompassing a wide range of capabilities to support its military and economy, as described in Chapter 2. As these capabilities grow, China is likely to become more reliant

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484 Bernat, "Russia's Strategic Shift."

Chinese aerospace expert Pan Zhihao, for example, has said: "Russia still has a lot of outstanding technological accumulation and experience in the field of manned space flight, and even the United States need[s] to take in Russia's knowledge. As a rising star, China can learn a lot from Russia." Una Aleksandra Bērziņa-Čerenkova, *Perfect Imbalance: China and Russia* (London: World Scientific Publishing Europe, 2022), 93, https://doi.org/10.1142/q0343.

485 Bērziņa-Čerenkova, *Perfect Imbalance*, 94.

486 The man asserts the claims were fabricated. Mirovalev, "Soyuz Launch Failure."

487 Tass, "В Ростехе Рассказали, Как Российское Оружие Нелегально Копируют За Рубежом [Rostec Talked about How Russian Weapons Are Illegally Copied Abroad]," *TASS*, December 13, 2019, https://tass.ru/armiya-i-opk/7344701?utm_source=icds.ee&utm_medium=referral&utm_campaign=icds.ee&utm_referrer=icds.ee.

488 Hull and Markov, *Sino-Russian Defense Cooperation's Impact*, 19.

489 On China working to balance broad support for Russia with other interests, see, for example: Patrik Andersson, Hugo von Essen, and Viking Bohman, *China's and Russia's Narratives on the War against Ukraine*, Report 3, 2023 (Stockholm: Swedish National China Centre and Stockholm Centre for Eastern European Studies, 2023); Bonny Lin, "Can China Thread the Needle on Ukraine?," *Foreign Affairs*, May 17, 2023, https://www.foreignaffairs.com/china/can-china-thread-needle-ukraine; and Yu Jie, "China's Alignment with Putin is Uneasy. But its Rivalry with the US Makes Him Too Useful to Abandon," Chatham House, May 17, 2024, https://www.chathamhouse.org/2024/05/chinas-alignment-putin-uneasy-its-rivalry-us-makes-him-too-useful-abandon.

490 Andrew Jones, "China Seeks New Partners for Lunar and Deep Space Exploration," *SpaceNews*, September 28, 2022, https://spacenews.com/china-seeks-new-partners-for-lunar-and-deep-space-exploration/.

on its space architecture, particularly for military activities outside its immediate region. Its space industry, which appears to largely be on a positive trajectory, is likely to be able to support its space endeavors. As a result, China may be less likely to use destructive counterspace weapons except in severe crisis because debris creation would also threaten Chinese satellites in orbit. Given the growth in Chinese space capabilities to support its terrestrial operations, the U.S. Joint Force may also seek ways to ensure that Chinese space capabilities do not inflict harm on U.S. operations and personnel.

In contrast, Russia has far fewer satellites in orbit than China, and its space industry faces serious challenges that will be difficult to overcome. It is unclear how Russia's relatively small number of space assets affects its approach to its reliance on what the country already has. On the one hand, the fact that it has fewer satellites could make the Russian military more reliant on the capabilities those satellites provide, making it more hesitant to use disruptive weapons in space that could impact its own capabilities. On the other hand, if the Russian military assesses it is less reliant on space than its adversaries, then it may be more willing to take risks in the domain. The DIA, for example, has assessed that the Russian government is keen to avoid becoming overreliant on space and is thus building terrestrial alternatives to space-based capabilities.[491] Furthermore, because the Russian space industry is on a more negative trajectory, it may want to act before the gap between its capabilities and those of others grows larger.

Given the trajectory of its space industry and the asymmetries that Russia faces vis-à-vis NATO and the United States across domains, it is likely that Russia will continue to use asymmetric investments and coercion to attempt to shape U.S. behavior. In other words, rather than trying to emulate U.S. use of space and build itself up (as China appears to be doing), Russia may try to pull others down. Given the mismatch between high ambitions and relatively low resources, the Russian government will likely try to get the best bang for its buck by seeking high-visibility military capabilities that grab the attention of the United States and work to disrupt others' ambitions rather than building on its own.[492] To reduce cost burdens and to attempt to maintain at least the minimum amount of positive space capabilities and scientific endeavors, it is likely to develop new international partnerships and deepen existing ones, including with China. Recognizing that it will probably not be in a position of military superiority, Russia's military space strategy will likely continue to emphasize asymmetric counterspace capabilities.

Thus, Russia is more likely than China to demonstrate and test counterspace weapons and to be more publicly brazen in its threats. Because Russia can be perceived as having less to lose in space than its adversaries, it could be more unpredictable and potentially dangerous.

491 DIA, *Challenges to Security in Space 2022*, 21.

492 Sankaran describes Russia's military space strategy as a mix of hedging and offsetting. Jaganath Sankaran, "Russia's Anti-Satellite Weapons: A Hedging and Offsetting Strategy to Deter Western Aerospace Forces," *Contemporary Security Policy* 43, no. 3, July 3, 2022, 436–63, https://doi.org/10.1080/13523260.2022.2090070.

The Chinese and Russian approaches to space have similarities, particularly a shared belief that threatening U.S. capabilities in space can shape U.S. behavior to their advantage. They share the perception that the United States is asymmetrically reliant on space for the conduct of military operations and believe holding space capabilities at risk can coerce the United States. For example, a textbook published by China's National Defense University described space deterrence as "strategically prominent and [having] a great deterrent effect on the enemy."[493] Both also have proactive approaches that emphasize not just signaling for deterrence but also demonstrating capabilities and taking early action to force the United States and other targets to react or back down. Given this shared perception and approach to deterrence, the United States will face threats from both Chinese and Russian counterspace forces, especially in the run-up to crises.

Simultaneous Threats

Even as challenges from both China and Russia grow, it could be possible to plan to manage the threats as separate. However, at least three plausible scenarios would require the United States to contend with counterspace threats from China and Russia simultaneously, suggesting that the United States should adopt a two-rival force planning construct in space.

First, the United States already faces ongoing challenges in space from both China and Russia. In 2021, General Thompson, the USSF vice chief of space operations, told a journalist that China and Russia were conducting "reversible attacks" on U.S. government satellites "every single day."[494] Both have active counterspace programs and regularly demonstrate their capabilities, leading to what one analysis called the "normalization of deviance."[495] Unlike in the ground, air, and sea domains, U.S. rivals do not operate or lay special claim to unique geographies within the space domain. As opposed to units assigned to different terrestrial geographical areas that can anticipate which adversary it might face and thus specialize, in space every operator and unit must be aware of the strategies toward and context of each adversary because they could face aggression from either or both.

493 China Aerospace Studies Institute, *Science of Military Strategy 2020*, 130.

494 Rogin, "Shadow War in Space."

495 Swope et al., *Space Threat Assessment 2024*.

The phrase originates in Diane Vaughan's analysis of the Space Shuttle *Challenger* disaster. Diane Vaughan, *The* Challenger *Launch Decision: Risky Technology, Culture, and Deviance at NASA*, enlarged ed. (Chicago: University of Chicago Press, 2016).

Second, the United States may face China and Russia simultaneously on Earth, which would have implications for U.S. strategy in space.[496] Because both emphasize early activity in space in their military doctrines, if the United States were involved in fights with both countries on Earth it is likely that the United States would have to contend with attacks from both in space as well. The United States may also, in case of war with either or both countries, seek to deny an adversary the advantages of the use of space for monitoring, tracking, communications, and targeting.[497] If the United States were fighting both countries simultaneously on Earth, it would need to not only defend U.S. space capabilities from both adversaries but also have the ability to deny both of them access to their own space capabilities.

Third, even if the United States were fighting a terrestrial war with just one of these countries, it would still likely need to account for counterspace threats from both. For example, while the United States was actively fighting one country, the other country might continue its previous counterspace activities. There is no indication that either China or Russia would cease its ongoing daily counterspace activities if there were great power conflict on Earth. Thus, the United States may need to defend against the warring country's counterspace attacks and possibly deny the warring country advantages from space while simultaneously defending against and responding to the other country's day-to-day counterspace activities. The second country, however, could also choose to escalate its counterspace activities against the United Space to attempt to take advantage of a distracted U.S. joint force. This could be done out of a desire to reshape the status quo while the United States was absorbed elsewhere or out of a desire to help the second country. If the second country sought this kind of escalation, the United States would need to be prepared to deter the behavior and to act if deterrence failed. Finally, given their growing cooperation, Chinese and Russian space capabilities could become entangled, generating complex horizontal escalation dynamics for the United States.

If either China or Russia were at war with the United States terrestrially, it is possible that one may ask the other for support, which could include actively targeting U.S. space assets or conducting activity to attempt to occupy or distract the United States in space. Russia and China have already demonstrated willingness to help each other during conflict outside the conflict zone, with Chinese entities providing material support to Russia during its war in

496 On the possibility and implications of fighting two terrestrial wars simultaneously, see Hal Brands and Evan Braden Montgomery, "Opportunistic Aggression in the Twenty-First Century," *Survival* 62, no. 4, July 3, 2020, 157–82, https://doi.org/10.1080/00396338.2020.1792129. See also Madelyn R. Creedon et al., *America's Strategic Posture: The Final Report of the Congressional Commission on the Strategic Posture of the United States* (IDA, 2023); Jane Harman et al., *Commission on the National Defense Strategy* (RAND Corporation, 2024); Matthew Kroenig, "Washington Must Prepare for War with Both Russia and China," *Foreign Policy*, February 18, 2022, https://foreignpolicy.com/2022/02/18/us-russia-china-war-nato-quadrilateral-security-dialogue/; and Thomas G. Mahnken, "A Three-Theater Defense Strategy," *Foreign Affairs*, June 5, 2024, https://www.foreignaffairs.com/united-states/theater-defense-war-asia-europe-middle-east.

497 Kendall, *Comprehensive Strategy for the Space Force*; DoD, *Space Policy Review*; USSF, *White Paper on Competitive Endurance*.

Ukraine.[498] One Chinese company has been sanctioned by the United States for providing SAR imagery to the Wagner Group.[499] In the future, China could, for example, use its growing leverage against Russia to ask Moscow to conduct counterspace operations against the United States during an Indo-Pacific contingency. Given the Kremlin's risk tolerance and its increasing reliance on China, it seems plausible that Moscow might agree to target or hold at risk U.S. assets should Beijing ask.

The Sino-Russian space relationship appears to be an effort to balance against U.S. space dominance, and the costs of acting together or simultaneously in space would appear lower than doing so in a terrestrial war.[500] Thus far, the United States has been careful to not escalate in the space domain, perhaps leaving adversaries with the impression that it may not respond forcefully. They perceive the United States to be more reliant on space assets. In a scenario in which the United States is already engaged in conflict with one of these powers terrestrially, the other may assess that the United States would not want to become engaged in another conflict or may be reluctant to create instability in space; thus, it may believe it has more room to maneuver without fear of a serious U.S. response.[501]

The Challenge of Managing Simultaneity

The United States is likely to have to contend with China and Russia simultaneously in space. The problem of simultaneity, of course, is not new. The 2018 and 2022 *National Defense Strategies* both emphasize a one-war force planning construct, asserting that the Joint Force should be able to fight a major war while deterring others.[502] A main danger of adopting a one-war construct is that the United States could end up in a situation in which it has to fight both China and Russia simultaneously but lacks the capability and capacity to

498 See, for example, Henry Foy et al., "U.S. Accuses China of Directly Supporting Russia's 'War Machine,'" *Financial Times*, September 10, 2024; Taras Kuzio, "China Enables Russia's War of Aggression against Ukraine," *Eurasia Daily Monitor* 21, no. 128, September 10, 2024, https://jamestown.org/program/china-enables-russias-war-of-aggression-against-ukraine/; Kelly Ng and Yi Ma, "How Is China Supporting Russia after It Was Sanctioned for Ukraine War?," *BBC*, March 4, 2022; and U.S.–China Economic and Security Review Commission, "China's Position on Russia's Invasion of Ukraine," U.S.–China Economic and Security Review Commission, December 31, 2024, https://www.uscc.gov/research/chinas-position-russias-invasion-ukraine.

499 Jones, "U.S. Sanctions Chinese Satellite Firm."

500 Pollpeter et al., *China–Russia Space Cooperation*.

501 Brands and Montgomery, "Opportunistic Aggression."

502 DoD, *Summary of the 2018 National Defense Strategy* (Washington, DC: DoD, 2018); and DoD, *2022 National Defense Strategy*. See also Harman et al., *Commission on the National Defense Strategy*.

do so. Others have analyzed these challenges as they apply to broader U.S. force planning.[503] However, suggestions for mitigating the problem of simultaneity terrestrially do not work as well in the space domain, heightening the risk of having to contend with two actors at once.

Proposals to reduce the risk of having to fight more than one conflict are ill-suited to the realities of the space domain. Hal Brands and Evan Montgomery, in a piece assessing the risks of a one-war planning construct, outlined three strategies that proponents of a one-war planning construct might use in response to threats from multiple countries: demonstration, delay, and discipline.[504] First, one could reduce the chances of a second war by *demonstrating* strength in the first war. If the United States performed well in the first war, the logic goes, the second adversary should reassess its own likelihood of victory and refrain from engaging the United States in a conflict. Demonstration, however, also allows the adversary to learn about its target's fighting methods and can inadvertently reveal weakness.[505] This may be especially true in space. A conflict in space has not yet occurred, so it is very difficult to assess how a demonstration might unfold. A conflict in space may play out differently than anticipated, perhaps revealing that an actor is not fully prepared for space conflict. Active conflict in the space domain could also demonstrate vulnerabilities rather than strengths. If during or after the first war the Joint Force struggles to recover from degraded or destroyed space capabilities, the opponent in the potential second war could think the United States is weaker rather than stronger and be incentivized to take aggressive action sooner rather than later. Finally, because many space assets would likely play a role against multiple adversaries, any destroyed assets from the first war would be unavailable in the second war unless they were rapidly reconstituted or repaired. The second adversary would also learn lessons about how the United States fought the first war and adjust its own strategy.

A second way to mitigate the danger of simultaneity would be to *delay* a response to a second war and fight it after the first has concluded or once conditions are favorable. However, the United States does not alone control when a war starts, and an adversary could choose to launch an attack at a time when the United States was not prepared. The losses from any active targeting of space capabilities from a first conflict are also likely to impact the ability to fight a second space conflict. Furthermore, kinetic activity in space by one adversary

503 See, for example, Hal Brands and Evan Braden Montgomery, "One War Is Not Enough: Strategy and Force Planning for Great-Power Competition," *Texas National Security Review* 3, no. 2, Spring 2020; Brands and Montgomery, "Opportunistic Aggression;" Raphael S. Cohen, "Ukraine and the New Two War Construct," War on the Rocks, January 5, 2023, https://warontherocks.com/2023/01/ukraine-and-the-new-two-war-construct/; Mark Gunzinger and Lukas Autenried, *Building a Force That Wins* (Arlington, VA: Mitchell Institute for Aerospace Studies, 2021); Mahnken, "A Three-Theater Defense Strategy;" Thomas G. Mahnken, "Could America Win a New World War?," *Foreign Affairs*, October 27, 2022; David Ochmanek et al., *U.S. Military Capabilities and Forces for a Dangerous World: Rethinking the U.S. Approach to Force Planning* (RAND Corporation, November 28, 2018). See also Harman et al., *Commission on the National Defense Strategy*.

504 Brands and Montgomery, "One War Is Not Enough."

505 Evan Braden Montgomery, "Signals of Strength: Capability Demonstrations and Perceptions of Military Power," *Journal of Strategic Studies* 43, no. 2, February 23, 2020, https://doi.org/10.1080/01402390.2019.1626724.

could be ongoing during terrestrial war with that adversary or another. The simultaneity problem in space arises not just from two adversaries but from the possibility that the domain is active while fighting other wars.

Third, one could exercise *discipline* by choosing to intervene selectively. Being able to select which counterspace activities to counter seems unlikely, however, particularly if adversaries target space capabilities that impact larger swaths of the military, population, or economy. Choosing not to respond strongly to counterspace attacks also risks normalizing and, thus, encouraging them.

Alternatively, one could work to deter rivals from launching simultaneous conflicts through escalation, mobilization, and outsourcing deterrence to allies.[506] Yet again, however, each of these strategies is complicated in space. First, one could threaten to escalate the conflict. With regard to the space domain, one could either threaten to escalate the conflict in space (becoming more aggressive and/or, if necessary, threatening kinetic effects), horizontally escalate the conflict so it also occurs on Earth, or vertically escalate the conflict by threatening nuclear use. Convincingly threatening to escalate the conflict in space requires convincing other actors of one's willingness to take losses in a certain orbit segment or capability category. Both China and Russia, however, view the United States as being more reliant on space than they are—and thus more sensitive to risk. They may not believe the United States is willing to put more space assets at risk. Furthermore, horizontal escalation in space may require capabilities that can target a larger number of satellites. Some capabilities, such as targeted cyberattacks or attacks on ground stations, could accomplish this. An EMP burst would also destroy or disable a large quantity of space assets in the area, but it would be nondiscriminatory, damaging both adversarial and allied assets, and would likely violate the Outer Space Treaty.[507] Escalation in space could also have to carefully calibrate how not to trigger nuclear concerns because many nuclear early warning and nuclear command, control, and communications (NC3) systems and other nuclear infrastructure

506 Brands and Montgomery, "One War Is Not Enough."

507 For example, see Victoria Samson and Seth Walton, "FAQ: What We Know about Russia's Alleged Nuclear Anti-Satellite Weapon," Secure World Foundation, June 11, 2024, https://www.swfound.org/publications-and-reports/insight----faq-what-we-know-about-russias-alleged-nuclear-anti-satellite-weapon.

components are connected to space assets.[508] Threatening nuclear use would certainly escalate the conflict but requires a higher threshold and may be seen as lacking credibility.

Second, one could mobilize resources to increase the capacity of the force as threats materialize. In the space domain, one could utilize quick launch facilities and capacity, but doing so would require already having in place the capability and capacity for launch; satellites in storage ready to launch or able to be quickly built; and the ability to defend launchpads, storage facilities, supply chains, and any factories from any attack. One could also have satellites in orbit with multiple functions that could begin to undertake counterspace or space defense roles, though if they were serving other functions presumably switching them into more active roles would reduce their ability to deliver those other functions.

Third, one could rely on allies to respond to rising threats. U.S. allies, however, currently do not have the capabilities that the United States does. Even if they were to invest in these capabilities, they may not be fully willing to defend U.S. assets in space because doing so could risk disrupting their own space services or escalating into conflict on Earth.

With each of these options suboptimal in space, managing simultaneity in space by treating each threat as separate is dangerous. Instead, the United States needs to develop the capabilities to shape Chinese and Russian space behavior simultaneously.

Taking Stock of the Two-Rival Threat Environment

The United States faces growing space and counterspace threats from Russia and China. Both have doctrines that emphasize early use, and both have focused their investments and strategies on taking advantage of a perceived U.S. asymmetric reliance on space. Not only do these countries have assets and concepts that could directly threaten the United States, but they are also working together and may force the United States to have to contend with each threat vector simultaneously.

Growing Sino-Russian cooperation threatens the United States in several ways. First, their support of each other's programs reinforces their own national capabilities, not only by strengthening each other's capabilities but also by sharing lessons learned. Second, if they

508 Nivedita Raju and Tytti Erästö, *The Role of Space Systems in Nuclear Deterrence* (Stockholm: Stockholm International Peace Research Institute, September 2023); and Nivedita Raju and Wilfred Wan, *Escalation Risks at the Space–Nuclear Nexus* (Stockholm: Stockholm International Peace Research Institute, February 2024). On the conversation about nuclear entanglement, see James M. Acton, "Escalation through Entanglement: How the Vulnerability of Command-and-Control Systems Raises the Risks of an Inadvertent Nuclear War," *International Security* 43, no. 1, August 1, 2018, https://doi.org/10.1162/isec_a_00320; James M. Acton and Thomas D. MacDonald, "Nuclear Command-and-Control Satellites Should Be Off Limits," Defense One, December 10, 2021, https://www.defenseone.com/ideas/2021/12/nuclear-command-and-control-satellites-should-be-limits/187472/; Matthew Kroenig and Mark J. Massa, *Are Dual-Capable Weapon Systems Destabilizing?: Questioning Nuclear-Conventional Entanglement and Inadvertent Escalation* (Washington, DC: Atlantic Council, June 2021); Don Snyder and Alexis A. Blanc, *Unraveling Entanglement: Policy Implications of Using Non-Dedicated Systems for Nuclear Command and Control* (RAND Corporation, 2023); and Robert Samuel Wilson and Russell Rumbaugh, "Reversal of Nuclear-Conventional Entanglement in Outer Space," *Journal of Strategic Studies* 47, no. 1, 2023.

were to coordinate actions, one could distract or threaten U.S. space forces as the other undertook actions in space or on Earth. For example, given growing Russian dependence on China and Russian willingness to take risks in space, Russia could support China during a military operation to seize Taiwan by threatening U.S. space capabilities, forcing the United States to respond to or defend against Russian actions or consider escalation. Third, any growing interlinkages between Chinese and Russian space assets could create scenarios in which the United States would have to be careful not to inadvertently bring one country into an ongoing crisis or conflict with the other.

There are, of course, differences between Russian and Chinese approaches to space that should be reflected in policy. Russia has fewer space assets and is limited in its ability to build out a robust space architecture. Whether as a reflection of these realities or a different approach, Russia appears to be careful not to build too much reliance on space. China, on the other hand, is building a much more expansive space architecture. Russia may thus be more risk acceptant than China and may try to use space to bring others down instead of to build itself up.

There is no way for the United States to fully separate these challenges, and as the United States builds out strategies for space, it will need to contend with both. The United States, in other words, should adopt a two-rival force planning construct for space. Developing strategies, concepts, and corresponding investments to manage both threats will be a key challenge moving forward.

CHAPTER 5

Approaches to Deterrence in Space

Given the two-rival space environment, the United States faces new questions about how to best prevent adversaries from attacking U.S. and allied space capabilities. This chapter examines U.S. approaches to deterrence in space, analyzes the limits of deterrence by denial and resilience, and suggests an additional way of thinking about the value of resilience.

There are two primary costs that Russian and Chinese counterspace capabilities could try to impose on the United States. The first is the denial, degradation, disruption, or destruction of U.S. space capabilities. Given the military advantages the United States gains from its space-based capabilities and the critical services space capabilities provide the U.S. government, commercial companies, and society, space-based capabilities could be a tempting target for adversaries.

The second cost is more nuanced. Instead of damaging U.S. space capabilities to gain a direct military advantage, adversaries could use threats to U.S. space assets and capabilities to try to gain political advantage. Both Chinese and Russian thinking stipulate that because the United States has an asymmetric reliance on space, threatening or disrupting U.S. space capabilities can have a dampening effect on U.S. behavior not just by making the United States less effective but also by coercing the United States to change its intended behavior out of fear of the effects of space disruption. In other words, other actors may try to use space to shape U.S. decision-making and limit U.S. freedom of action.

The space domain is not isolated; rather, it should be placed in the broader context of political and military goals and terrestrial warfare. The United States should think of its deterrence goals in space as twofold. First, it should work to maintain full access to its space capabilities to enable terrestrial warfare, society, and economics. Second, it should work to ensure adversaries ensure adversaries are not able to use space to limit U.S. freedom of action on Earth and in space. This implies convincing China and Russia not to threaten or conduct counterspace attacks in the first place and building U.S. resilience to such threats so its freedom of action is not limited by Chinese and Russian threats.

The Characteristics of Deterrence in Space

Space has several qualities that affect approaches to deterrence (see Table 1). First, space is a domain through which all other operational domains and national instruments of power flow: U.S. capabilities operate both through and in space.[509] U.S. armed forces rely on space capabilities to enable and strengthen their terrestrial fighting power. Capabilities that travel through or orbit in space affect all other domains by providing PNT services, communications, ISR, and targeting capabilities. Space does not just support or enable other domains, however. Other domains also support and enable space. For example, SATCOM flow through cyber networks, and ground infrastructure supports launch and communications capabilities and capacity. Thus, though it can be easy to think of space as removed from Earth, it is virtually impossible to absolutely separate the space domain from others. Given the importance of space in terrestrial military operations, if major-power war were to occur on Earth, it is likely that militaries with the capability to do so will try to threaten and potentially damage adversaries' space capabilities. Indeed, China and Russia already exhibit threatening behavior that could degrade U.S. space capabilities. Furthermore, if conflict were to start in space, it is unclear whether it would remain there or whether the conflict, given space's importance in other domains and to national economies, would become cross-domain and spread to actions on Earth.

Second, there is broad agreement within the U.S. policy community that kinetic war in space should be avoided for at least two reasons. The first is that physically destroying a satellite yields debris that becomes a long-term feature of the space environment, creating hazards to space navigation.[510] Debris created by launches, kinetic tests, and collisions affects

509 The space domain shares this aspect, and others, with the cyber domain. On the point of operating through and in cyberspace, see Michael P. Fischerkeller and Richard J. Harknett, "Deterrence Is Not a Credible Strategy for Cyberspace," *Orbis* 61, no. 3, 2017, 381–93, https://doi.org/10.1016/j.orbis.2017.05.003.

510 Some debris in LEO will de-orbit itself over time, and states can undertake operations in ways that can minimize debris creation and debris retention. For example, the 1985 U.S. ASAT test took place at a relatively low altitude, so atmospheric drag caused most of the larger debris to decay within a decade. The 2007 Chinese ASAT test was conducted at a higher altitude, and the debris is likely to remain in orbit for decades. For more, see UCS, *Space Debris from Anti-Satellite Weapons* (Union of Concerned Scientists, April 2008).

The creation of debris can also contribute to a possibility known as the Kessler Syndrome, a scenario in which there are so many objects in LEO that a cascade of collisions between them could occur. On Kessler Syndrome, see Donald J. Kessler and Burton G. Cour-Palais, "Collision Frequency of Artificial Satellites: The Creation of a Debris Belt," *Journal of Geophysical Research: Space Physics* 83, no. A6, 1978, 2637–46, https://doi.org/10.1029/JA083iA06p02637; and Mike Wall, "Kessler Syndrome and the Space Debris Problem," Space.com, November 15, 2021, https://www.space.com/kessler-syndrome-space-debris.

every actor in space, creating indiscriminate danger for all space objects.[511] Chief of Space Operations General Saltzman has asserted that relying on irreversible kinetic effects "end[s] up causing ourselves as many problems as we do for the adversary."[512] Although some actors may still choose to pursue debris-creating events, there is a built-in cost of kinetic attack because that debris may harm friendly forces and contribute to a less safe operating environment. The second consideration is that, although there has not yet been a war in space, such a conflict could be extremely dangerous.[513] The question for the U.S. military is how to ensure its own freedom of maneuver in space and to have the ability to diminish adversary advantages in space while simultaneously minimizing debris creation and managing unintentional escalation. Deterrence in space will thus need to be carefully calibrated.

Third, space has a unique geography. Space is generally understood to begin at either 100 kilometers or 100 miles above the Earth's surface, with the most militarily relevant area between the Earth and the Moon. For most of space, competition will not aim to control physical locations in the conventional sense but rather to contest satellites' ability to perform their missions. [514] Thus, deterrence in space should focus on behaviors that would directly affect U.S. capabilities rather than on, for example, defending territory.

Fourth, the space domain is unique for its size. Space is extremely large: the volume of space between LEO and GEO is about 200 trillion cubic km (50 trillion cubic miles), or roughly 190 times larger than the volume of Earth.[515] The size of space has at least two important effects on deterrence. First, it is not easy to move in space.[516] Although individual satellites move quickly relative to objects on Earth, maneuvering between altitudes, planes, and phases (locations along an orbit) can take hours to weeks, depending on the orbit and the "delta-v" (the change in velocity, or the force applied to a vehicle needed to perform a maneuver) expended. This means any satellites that a government wants to use offensively

511 Unlike in terrestrial domains, any destroyed objects will stay in space unless actively removed or until they de-orbit over time at lower altitudes. They will also not be stationary, instead left to the physics of gravitational fields. Ben Zweibelson, *Reconceptualizing the Space Domain Beyond Historic Perspectives of Warfare*, Schriever Paper 1 (Maxwell AFB, AL: Air University Press, 2023).

512 Patrick Tucker, "China's New Satellites Extend Its Military Reach, U.S. Says," Defense One, September 12, 2023, https://www.defenseone.com/threats/2023/09/chinas-new-satellites-extend-its-militarys-reach-us-says/390223/.

513 Fully adjudicating what conflict in space would look like is beyond the scope of this study. For further reading, see, for example, Anelí Bongers and José L. Torres, "Star Wars: Anti-Satellite Weapons and Orbital Debris," *Defence and Peace Economics* 35, no. 7, 2024, https://doi.org/10.1080/10242694.2023.2208020; Rebecca Reesman and James R. Wilson, *The Physics of Space War: How Orbital Dynamics Constrain Space-to-Space Engagements* (Aerospace Corporation, October 2020); Paul Szymanski, "Techniques for Great Power Space War," *Strategic Studies Quarterly* 13, no. 4, Winter 2019; John C. Wright, *Deep Space Warfare: Military Strategy beyond Orbit* (McFarland & Company, 2020), https://mcfarlandbooks.com/product/deep-space-warfare/; and Zweibelson, *Reconceptualizing the Space Domain*.

514 As one report explains, "to 'control space' is not necessarily to physically conquer sectors of space but rather to reduce or eliminate adversary satellite capabilities while ensuring one retains the ability to freely operate their own space capabilities." Reesman and Wilson, *Physics of Space War*, 2.

515 Reesman and Wilson, *Physics of Space War,* 4.

516 For an accessible primer, see Reesman and Wilson, *Physics of Space War*.

or defensively may need to be placed in convenient locations far in advance, making prepositioning central for waging co-orbital warfare. Second, the size of space makes space surveillance and situational awareness challenging.[517] Although the United States has the world's best SDA capabilities, one former USSPACECOM commander compared the country's SDA efforts to "searching for our keys under a streetlight."[518] Maintaining custody of a space object involves not only knowing where it is in space at a given moment but also tracking and monitoring that object with a high degree of accuracy over time. This requires a significant sensor network and data processing capability, which can be technically difficult.

Diagnosis and attribution of some counterspace attacks can therefore be difficult. At least three steps are required to diagnose and attribute an attack. First, one must determine what affected a satellite's operations. Disruption of a satellite's operations may not be the result of hostile action: Naturally occurring phenomena including radiation and debris can also affect satellites. Second, one must determine who conducted the attack. The ease of this task will vary with the type of attack. For example, it should be relatively easy to determine the source of DA-ASAT attacks launched from Earth because such missiles will have traceable flight paths. On-orbit physical attacks, if fully observed, should be moderately easy to attribute because the ownership of most satellites is known. The source of cyberattacks, on the other hand, may be more difficult to attribute. Third, one must determine intent, as accidents may occur. Determining that the source of a disruption of a U.S. satellite was an adversary and that the damage was intentional can thus take significant time and resources, depending on the form of attack.

Fourth, actions in space may also feel distant, affecting deterrence dynamics. For the foreseeable future, military activity in space will be driven by machines in space controlled by a human sitting far away.[519] This has at least two ramifications for deterrence, which work in opposite directions. First, the fact that there is a smaller chance of immediate loss of human life in a space conflict may reduce the credibility of a deterrence-by-punishment threat. As some policymakers have said, "Satellites don't have mothers."[520] Absent the loss of human life, will a leader be committed to escalation? Second, because actions in space are distant and may not be immediately attributable to hostile actors, there may be more room for private signaling. In other words, because the public may not realize its country's space

517 See, for example, Megan Traviss, "Challenges of Space-Based Space Situational Awareness," *Innovation News Network*, October 3, 2023, https://www.innovationnewsnetwork.com/challenges-of-space-based-space-situational-awareness/34979/.

518 Sandra Erwin, "U.S. Military Space Domain Awareness Lags behind Expectations," *SpaceNews*, August 26, 2024, https://spacenews.com/u-s-military-space-domain-awareness-lags-behind-expectations/.

519 Zweibelson, *Reconceptualizing the Space Domain*.

520 See, for example, John E. Hyten, "Mitchell Institute Breakfast Series," U.S. Strategic Command, June 20, 2017, https://www.stratcom.mil/Media/Speeches/Article/1226883/mitchell-institute-breakfast-series/; Charles Pope, "Raymond and Space Force Enter New, Ambitious Phase as U.S. Space Command Changes Leaders," USSF, August 24, 2020, https://www.spaceforce.mil/News/Article/2322445/raymond-and-space-force-enter-new-ambitious-phase-as-us-space-command-changes-l/; and "Never Assume Space Is Safe, Hyten Cautions," *Air & Space Forces Magazine*, August 4, 2016, https://www.airandspaceforces.com/never-assume-space-is-safe-hyten-cautions/.

systems were attacked by another country, the country's leader may have more room to negotiate a deal privately and back down gracefully rather than feel obliged to retaliate.

That being said, not all space attacks will feel distant. In some instances, space attacks could spur demand for a strong response. For example, attacks on more sensitive military targets could generate significant concern. Any attacks that disrupt the GPS constellation would affect everything from electronic payments to PNT, interrupting not just military uses but also civilian ones, likely raising calls for a response. These capabilities need not be the direct target. As in the cyber domain, there is a risk of cascading, compounding, and collateral effects.[521] An operation meant to target a specific capability of one satellite could have knock-on effects on other capabilities or affect unintended satellites. For example, disrupting a satellite that supports multiple capabilities could impact not just the intended capability but other capabilities housed on it. Alternatively, if capabilities are linked across different satellites, disrupting one could disrupt the entire chain. Kinetic attacks could also cause debris that could harm other surrounding satellites. If these secondary effects were to affect either civilian uses of space or have larger effects on the military, the attack could generate unintentional escalation because there may be greater calls for action.

Fifth, policymakers in the United States, China, and Russia seem to assess that there is currently an offensive advantage in space that may encourage militaries to act early in the case of approaching conflict.[522] In 2023, Chief of Space Operation General Saltzman asserted the "visibility, predictability, and reconstitution timelines associated with current military space architectures favor the actor that goes on the offensive first."[523] Many analysts agree with Saltzman's assessment and see space as a domain in which the offense has the advantage, as do the Russian and Chinese governments.[524] Even if these conclusions are incorrect, the perception that offense holds the advantage will drive policies.

521 U.S. Joint Staff, *Cyberspace Operations*, Joint Publication 3-12 (Washington, DC: U.S. Joint Chiefs of Staff, 2018), IV-3.

522 Alexandra T. Evans et al., *Space Strategic Stability Assessing U.S. Concepts and Approaches* (Santa Monica, CA: RAND, 2024), 4–8.

523 Hitchens, "Space Force Chief Outlines.'"

524 Brian Goodman, "Offensive Dominance in Space," *Æther* 3, no. 1, Spring 2024; Forrest E. Morgan, *Deterrence and First-Strike Stability in Space: A Preliminary Assessment* (RAND Corporation, April 2, 2010); Paul Scharre, "The U.S. Military Should Not Be Doubling Down on Space," Defense One, August 1, 2018, https://www.defenseone.com/ideas/2018/08/us-military-should-not-be-doubling-down-space/150194/; and Brad Townsend, "Strategic Choice and the Orbital Security Dilemma," *Strategic Studies Quarterly* 14, no. 1, Spring 2020, https://www.jstor.org/stable/26891884.

On Chinese and Russian beliefs, see: Hou, "Offensive Defense." Evidence of Russia's perception of an offensive advantage includes the emphasis on early action in space (see Chapter 3).

A line of argument concerned about the weaponization of space suggests the United States should push for norms regarding the peaceful use of space.[525] Indeed, the United States has repeatedly pledged to seek global recognition of shared space norms.[526] Despite such pledges, however, relatively little progress has been made on achieving agreement on norms. Furthermore, as this report has demonstrated, China and Russia are already developing and deploying offensive counterspace capabilities. Leaders in Beijing and Moscow are inclined to view U.S. space activity as inherently threatening and may interpret efforts to create norms as part of a U.S. strategy to create advantages for the United States at the expense of China and Russia.[527] Although it is an admirable goal, it seems the United States is unlikely to get China and Russia to adhere to space norms in a way that guarantees the pacification of the domain. It has already been weaponized. Absent a universal acceptance of and adherence to norms, other options for reducing the risk of aggressive behavior in space rely on the United States developing and applying deterrence models in the domain.[528]

525 See, for example, Bruce M. DeBlois, “Space Sanctuary: A Viable National Strategy,” *Airpower Journal* 12, no. 4, Winter 1998; Steven Freeland, “The Peaceful Use of Outer Space: Protecting Life on Earth,” *Digital War* 5, no. 1, January 1, 2024, https://doi.org/10.1057/s42984-023-00065-w; Wendy N. Whitman Cobb, “Making a Moral Case for Nonconflict in Space: Expanding Strategic Norm to Taboo;” Air University, March 16, 2020, https://www.airuniversity.af.edu/Wild-Blue-Yonder/Articles/Article-Display/Article/2106715/making-a-moral-case-for-nonconflict-in-space-expanding-strategic-norm-to-taboo/; and David D. Ziegler, “Safe Heavens: Military Strategy and Space Sanctuary,” in Bruce M DeBlois, ed., *Beyond the Paths of Heaven: The Emergence of Space Power Thought* (Maxwell AFB, AL: Air University Press, 1999).

526 See, for example, Theresa Hitchens, “Exclusive: In a First, SecDef Pledges DoD to Space Norms,” *Breaking Defense*, July 19, 2021, https://breakingdefense.sites.breakingmedia.com/2021/07/exclusive-in-a-first-secdef-pledges-dod-to-space-norms/; Philip Potter, George W. Foresman, and Michael Horowitz, “Space Norms and U.S. National Security: Leading on Space Debris,” War on the Rocks, August 2, 2021, https://warontherocks.com/2021/08/space-norms-and-u-s-national-security-leading-on-space-debris/; DoD and Office of the Director of National Intelligence, “National Security Space Strategy;” “A Strategic Framework for Space Diplomacy” (U.S. Department of State, 2023); and United Nations, “United States of America National Submission to the United Nations Secretary General Pursuant to UN General Assembly Resolution 75/36 Reducing Space Threats through Norms, Rules and Principles of Responsible Behaviors,” 2021, https://documents.unoda.org/wp-content/uploads/2022/05/04292021-US-National-Submission-for-UNGA-Resolution-75.36.pdf. See also Evans et al., *Space Strategic Stability*, 18–23.

527 Blanc et al., *Chinese and Russian Perceptions*.

528 This is not to suggest norms should not be pursued. Among other benefits, norms can contribute to the identification of behaviors that require deterrence and responses. See, for example, Robin Dickey, “Why Norms Matter More Than Ever for Space Deterrence and Defense,” War on the Rocks, June 13, 2023, https://warontherocks.com/2023/06/why-norms-matter-more-than-ever-for-space-deterrence-and-defense/; Audrey M Schaffer, “The Role of Space Norms in Protection and Defense,” *Joint Force Quarterly* 87, 2017.

TABLE 1: SELECT UNIQUE CHARACTERISTICS OF SPACE AND HOW THEY AFFECT DETERRENCE

Select characteristics of space	Example effects on deterrence considerations
Space is deeply intertwined with other military domains.	· Adversaries may use counterspace threats or behavior to try to deter the United States from undertaking activities on Earth. · Space capabilities are likely to be a target during times of crisis and conflict on Earth.
There are more reasons to avoid kinetic war in space.	· Escalation management will be of particular concern. · The credibility of threats of kinetic weapons may be questioned. · The United States will likely seek to minimize debris creation in most circumstances.
Space is vast and has no terrain in the conventional sense.	· On-orbit capabilities, rather than the seizure of terrain, will usually be the target of aggression. · On-orbit ASATs may need to be prepositioned far in advance of a planned attack. · Attribution can be difficult.
Aggressive actions in space may feel distant—but this is not guaranteed.	· Due to a lower chance of immediate loss of human life, the perceived commitment of a deterring state to threats in response to aggression may be reduced. · There may be more room for private signaling in crisis periods. · Unintended consequences that impact civilian and military use of space could create unintentional escalation.
There is a perceived offensive advantage in space.	· Adversaries may perceive a first-mover advantage and utilize preemptive attacks.

Two basic deterrence models could apply to space. First, a deterrence-by-denial approach—largely focused on defense—could make adversaries' objectives harder to achieve, theoretically changing the target's decision-making calculus. Resilience, which can be understood as the ability to "bounce back" from an attack or crisis with minimal interruption, can be a part of a deterrence-by-denial approach because a target could signal that if an adversary launched an attack, its effects would be short lived.[529] Second, a deterrence-by-punishment approach with an emphasis on offensive weapons would work to dissuade an

529 Although there is often a distinction applied, deterrence by denial and resilience are closely related. Deterrence by denial can be understood as changing a deterrence target's decision-making calculus by convincing the adversaries that achieving their objectives will be extremely costly or impossible to achieve. Often, deterrence-by-denial approaches focus on increased defenses. However, resilience can also serve deterrence-by-denial purposes by reducing the effect of an attack or reducing the amount of time during which the effect of an attack holds.

adversary from an action by creating an unacceptable cost for the adversary should it take the action.[530]

Current U.S. Focus on Denial and Resilience

The U.S. Department of Defense has, thus far, publicly emphasized a deterrence-by-denial approach that is based on resilience to protect U.S. space assets and capabilities.[531] For example, a 2023 Department of Defense document explaining its strategy to protect satellites outlined three means of defending space-based services: (1) assuring critical missions, primarily through resilience; (2) strengthening the ability to detect and attribute hostile acts; and (3) protecting the Joint Force from adversarial attacks from and through space.[532] The document identifies resilience as "the primary means of denying adversaries the benefits of space."[533]

Resilience in space can take several forms, including disaggregation, distribution, diversification, reconstitution, proliferation, and deception (see Table 2).[534] Other measures to enhance a deterrence-by-denial approach could include increasing defenses against ASATs. There are several ways of doing this, depending on which threats are of greatest concern.[535] For example, terrestrially based defenses could target DA-ASATs before launch or prepare cyber measures to disrupt adversary communications with counterspace systems.[536]

530 Of course, one can also adopt both approaches or a mix thereof. See, for example, Stephen J. Flanagan et al., *A Framework of Deterrence in Space Operations* (RAND Corporation, 2023).

531 Courtney Albon, "U.S. Space Force Aims for More Resilient Architecture by 2026," C4ISRNet, February 18, 2022, https://www.c4isrnet.com/battlefield-tech/space/2022/02/17/us-space-force-aims-for-more-resilient-architecture-by-2026/; Space Systems Command, "Race to Resilience," Space Systems Command, accessed on September 30, 2024, https://www.ssc.spaceforce.mil/About-Us/Race-To-Resilience.

532 DoD, *Space Policy Review*.

533 DoD, *Space Policy Review,* 8.

534 Office of the Assistant Secretary of Defense for Homeland Defense & Global Security, *Space Domain Mission Assurance: A Resilience Taxonomy* (Washington, DC: Office of the Assistant Secretary of Defense for Homeland Defense & Global Security, September 2015). See also, for example, Chris Bassler and Tate Nurkin, "A Comprehensive Triad for Space Resilience—More than Just Numbers," *SpaceNews*, May 9, 2022, https://spacenews.com/op-ed-a-comprehensive-triad-for-space-resilience-more-than-just-numbers/; Boeing, "Resilient Space Order of Battle: Flexible, Adaptable & Affordable," *SpaceNews*, February 13, 2024, https://spacenews.com/resilient-space-order-of-battle-flexible-adaptable-affordable/; Tory Bruno, "Resilient Space: A Defense in Depth," *Medium* (blog), April 25, 2023, https://medium.com/@ToryBrunoULA/resilient-space-a-defense-in-depth-9b419f0b61d8; Greg Hadley, "Keys to Space Resilience: It's More Than Orbits, Says DOD's Plumb," *Air & Space Forces Magazine*, February 15, 2023, https://www.airandspaceforces.com/keys-to-space-resilience-its-more-than-orbits-says-dods-plumb/; Theresa Hitchens, "DoD Space Protection Strategy: Resilience, Defense, and Offense by Another Name," *Breaking Defense*, September 14, 2023, https://breakingdefense.sites.breakingmedia.com/2023/09/dod-space-protection-strategy-resilience-defense-and-offense-by-another-name/; and Dax Linville and Robert A. Bettinger, "An Argument against Satellite Resiliency: Simplicity in the Face of Modern Satellite Design," *Air & Space Power Journal* 34, no. 1, Spring 2020.

535 For an overview, see Harrison, Johnson, and Young, *Defense against the Dark Arts*.

536 Eugene C. Richter, "Achieving Alliance Space Deterrence: A Proposal for NATO 'Space Defense'" (master's thesis, Air War College, Air University, 2024), 16.

On-orbit defenses could be pursued, including passive defenses such as electromagnetic shielding, radio frequency filters, and shuttered optics and active defenses such as maneuver and DEW capabilities either on the targeted satellite or on an escort or neighboring satellite. To buttress against attacks on the communications systems of satellites, cyber defenses, local air defense covering ground stations, and counter-jamming equipment could be adopted.

TABLE 2: MEANS OF IMPROVING RESILIENCE OF SPACE ARCHITECTURES

Means	Definition
Disaggregation	Separating dissimilar capabilities onto different platforms or payloads
Distribution	Spreading the nodes for a function or mission across several nodes, rather than one, ensuring no individual node is a single point of failure for the mission
Diversification	Using a variety of means across platforms, orbits, systems, or operators to contribute to the same mission in multiple ways
Protection	Active and passive defensive measures, including nuclear hardening, maneuverability, and decoys
Proliferation	Fielding large numbers of the same platforms, payloads, or systems to perform a single mission (or the same missions)
Deception	Adopting measures to confuse or mislead

Categories and their definitinos adapted from “Space Domain Mission Assurance: A Resilience Taxonomy” and “Space Policy Review and Strategy on Protection of Satellites.”

The United States could seek resilience and denial through a combination of these approaches. However, pursuing all of them at once for every capability would be prohibitively expensive. Even applying just one of these approaches to every satellite could prove prohibitively expensive: for example, installing defenses on every single satellite on orbit would be extremely costly. The value and success of approaches may also vary across time. For example, an approach based on reconstitution could be disrupted by brittle supply chains, attacks on production or assembly facilities, or strikes on launch sites. Even in the context of an uninterrupted reconstitution strategy, the United States still may want to delay launching replacement satellites until after the counterspace threat that caused the original disruption has been neutralized. Putting all of one’s eggs into a single basket also seems dangerous. For example, for some time at least, the United States likely will be unable to put all its capabilities in a disaggregated or proliferated architecture, so it will continue to rely on some number of exquisite satellites for some time to come. The capabilities derived from these satellites will need to be protected through other means. A mixed approach to resilience, using different means or sets of means for different capability sets, would be wise.

Although the United States has been pursuing multiple routes to improving resilience, the Space Development Agency has been strongly emphasizing proliferation in public discussions. The agency’s proliferated LEO (PLEO) strategy seeks to distribute capabilities across multiple satellites so that the disruption or destruction of a single satellite would not fully interrupt access to a given capability and so that any disruption would occur gracefully.[537] The resulting constellation, the Proliferated Warfighter Space Architecture (PWSA), aims to include hundreds of satellites launched in "tranches" every two years with seven layers to fulfill a range of mission sets.[538] PLEO is part of broader efforts to improve resilience across orbits. For example, the USSF Space Systems Command is looking to build resilience through a similar approach to proliferation in MEO for missile warning and missile tracking.[539]

U.S. policymakers are hopeful that the approach has changed the cost equation for adversaries that may consider attacking satellites, particularly in LEO. For example, former Space Development Agency Director Derek M. Tournear has said the United States plans to have "hundreds and hundreds of these [small] satellites up there [as part of the PWSA]. It will cost more to shoot down a single satellite than it will cost to build that single satellite. We just completely changed that value equation."[540] Chief of Space Operations General Saltzman has said, "if we proliferate [a mission] out to hundreds of satellites performing that [mission], it changes the attack calculus substantially."[541] As a result of this perceived shift in the cost equation, Tournear has also said he is "not worried about any physical threats to the satellites themselves. I'm just not."[542] Indeed, by distributing capabilities across smaller, cheaper satellites, a PLEO approach does appear to make disrupting these LEO capabilities on orbit more difficult and costly, particularly using DA-ASAT.

A resilient space architecture also offers additional benefits should deterrence fail. At a fundamental level, effective resilience reduces the degree to which any attack degrades U.S. capabilities. Importantly, by enabling the graceful degradation of capabilities rather than a

537 Sandra Erwin, "Space Force Preparing for the Age of Proliferated Low Earth Orbit Satellite Networks," *SpaceNews*, July 8, 2024, https://spacenews.com/space-force-preparing-for-the-age-of-proliferated-low-earth-orbit-satellite-networks/; Josh Luckenbaugh, "Proliferation Provides Space Force Resilience, New Challenges," *National Defense*, May 16, 2024, https://www.nationaldefensemagazine.org/articles/2024/5/16/proliferation-provides-space-force-resilience-new-challenges; and Vivienne Machi, "U.S. Military Places a Bet on LEO for Space Security," *Via Satellite*, May 25, 2021, http://interactive.satellitetoday.com/via/june-2021/us-military-places-a-bet-on-leo-for-space-security/.

538 Todd Lopez, "Space Development Agency to Launch 10 Satellites," DoD, March 29, 2023, https://www.defense.gov/News/News-Stories/Article/Article/3345559/space-development-agency-to-launch-10-satellites/.

539 Space Systems Command, *The First Medium Earth Orbit Resilient Missile Warning Missile Tracking Program Successfully Completes Its Critical Design Review and Goes Into Production* (Space Systems Command, November 27, 2023); Sandra Erwin, "Space Force to Expand Missile-Defense Satellite Network in Medium Earth Orbit," *SpaceNews*, August 9, 2024, https://spacenews.com/space-force-to-expand-missile-defense-satellite-network-in-medium-earth-orbit/; Theresa Hitchens, "Space Force Targets 2027 for Resilient On-Orbit Posture Initial Capability," *Breaking Defense*, May 17, 2022, https://breakingdefense.com/2022/05/space-force-targets-2027-for-resilient-on-orbit-posture-initial-capability/; and Luckenbaugh, "Proliferation Provides Space Force Resilience."

540 Greg Hadley, "SDA's Tournear 'Just Not' Afraid of Satellite Shootdowns. Supply Chain Is the Greater Worry," *Air & Space Forces Magazine*, April 5, 2023, https://www.airandspaceforces.com/sda-tournear-kinetic-attacks-satellites/.

541 Luckenbaugh, "Proliferation Provides Space Force Resilience."

542 Hadley, "SDA's Tournear 'Just Not' Afraid."

sudden disruption or destruction of them, a resilient space architecture can buy U.S. policymakers and military planners time to respond to any attack.

The Limits of Deterrence by Denial and Resilience in Space

Increasing the resilience of U.S. space capabilities offers several benefits, including reducing the effects of any counterspace attacks on U.S. military capabilities, but the approach still has significant limits when utilized alone. A resilience-based approach, for example, may not be sufficient to protect against nonkinetic attacks or to protect existing constellations of high-performance, exquisite satellites upon which the United States will likely rely for many years. The Department of Defense will also be unable to fully set the resilience levels of commercial and allied space assets it may be called to defend. At a broader level, signaling about resilience and denial could fail to accurately transmit messages to adversaries, impacting the degree to which adversaries' decision calculi are changed.

First, although measures to increase resilience can mitigate some threats, they may be of little help or be prohibitively expensive against others. PLEO, for example, may discourage adversaries from using DA-ASATs against LEO targets, but EW, cyber, directed energy, and orbital weapons could continue to target satellites in LEO and higher orbits. Indeed, making DA-ASAT attacks harder might actually drive adversaries to invest in other counterspace capabilities with potentially wider areas of threat effects, such as high-energy weapons. Although proliferation could help against some of these threats, adversaries could selectively target key satellites to create gaps and "militarily useful blind spots" in U.S. capabilities and buy themselves time while the United States reconstituted.[543] Cyberattacks targeting communication with a single satellite or a constellation of satellites also pose a significant threat.[544] A resilience-based approach is also unlikely to fully deter and protect against potential threats of nuclear use. The EMP burst from a nuclear weapon detonated in space, for example, would likely disable and degrade a wide swath of satellites, and former Assistant Secretary of Defense for Space Policy John Plumb has suggested that a nuclear detonation in space could potentially render LEO unusable for up to a year.[545] A disaggregated or proliferated satellite architecture alone, even one with expensive electromagnetic shielding, is unlikely to deny enough of the attack's desired effect to deter a would-be aggressor.

543 Bruno, "Resilient Space."

544 Hadley, "SDA's Tournear 'Just Not' Afraid."

545 Audrey Decker, "Russian Space Nuke Could Render Low-Earth Orbit Unusable for a Year, U.S. Official Says," *Defense One*, May 1, 2024, https://www.defenseone.com/threats/2024/05/russian-space-nuke-could-render-low-earth-orbit-unusable-year-us-official-says/396245/; and Warren P. Strobel et al., "Russia Launched Research Spacecraft for Antisatellite Nuclear Weapon Two Years Ago, U.S. Officials Say," *Wall Street Journal*, May 16, 2024, https://www.wsj.com/politics/national-security/russia-space-nuke-launched-ukraine-invasion-c4aad62e. See also Victoria Samson, "FAQ: What We Know about Russia's Alleged Nuclear Anti-Satellite Weapon," Secure World Foundation, April 14, 2024, https://www.swfound.org/publications-and-reports/faq-what-we-know-about-russias-alleged-nuclear-anti-satellite-weapon.

Furthermore, the United States will likely continue to rely on exquisite satellites for some key missions for the foreseeable future. Deterring attacks against and defending these satellites and capabilities may be especially important during this transition period to a more resilient architecture, yet a resilience-based or deterrence-by-denial approach offers limited protection to them. Terrestrially based defenses would require exquisite intelligence, early warning, and quick reaction times to be able to respond effectively. Timelines for any counterspace attacks, however, are likely to be compressed, depending on the nature of the attack.[546] On-orbit defenses are also technically challenging. Expensive on-satellite defenses add weight to a given payload and thus would force tradeoffs with components that contribute to the performance and capability of the satellite. Satellites prioritizing counterspace roles, meanwhile, can dedicate much of their onboard resources to attack. Satellites built specifically to defend could be deployed alongside assigned satellites, but costs could add up quickly. Conducting defensive maneuvers to evade attacks may seem an attractive alternative, but satellites generally have predictable orbits and maneuvering out of them can require significant time and energy.[547] Moreover, each satellite has only so much fuel onboard, so it is limited in its ability to maneuver away from threats. There are methods to refuel and service spacecraft, but they would have to be used selectively.[548] Thus, though on-satellite defenses are likely worth pursuing for a subset of satellites with key and irreplaceable capabilities, the United States would have to be selective about which satellites it places heavy defenses on, and which defensive mechanisms are most appropriate for them. Such decisions should be informed by matching defenses to likely threats rather than by aiming to protect against everything.[549]

Second, a resilience-based approach benefits U.S. government satellites more than commercial and allied ones. The Department of Defense does not control every satellite that contributes to U.S. national security. Although the U.S. government can control the defenses and resilience of its own satellites, it is limited in what it can do for satellites it does not own or operate. Working with the commercial sector and integrating commercial technology into the U.S. military's operations has several advantages.[550] Yet commercial

546 Marc Berkowitz, *Redesigning Space Forces for Deterrence and Warfighting* (Arlington, VA: National Security Space Association, February 22, 2023), 4.

547 There are certainly benefits to maneuver, though it would likely need to be used selectively. See, for example, Chris Williams, *Dynamic Space Operations: An Overview and Assessment* (Arlington, VA: National Security Space Association, April 2, 2024).

548 Courtney Albon, "Space Force Mulls Refueling as Industry Calls For Funding, Standards," C4ISRNet, March 12, 2024, https://www.c4isrnet.com/battlefield-tech/space/2024/03/12/space-force-mulls-refueling-as-industry-calls-for-funding-standards/; Sandra Erwin, "Space Force Plans Deep-Dive Study on Pros and Cons of Orbital Refueling," *SpaceNews*, May 20, 2024, https://spacenews.com/space-force-plans-deep-dive-study-on-pros-and-cons-of-orbital-refueling/; and Sandra Erwin, "Satellite Servicing Industry Faces Uncertain Military Demand," *SpaceNews*, October 28, 2024, https://spacenews.com/satellite-servicing-industry-faces-uncertain-military-demand/.

549 Harrison, Johnson, and Young, *Defense against the Dark Arts*.

550 DoD, *DOD Commercial Space Integration Strategy* (Washington, DC: DoD, 2024); National Security Space Association, *Leveraging Commercial Space Capabilities for U.S. National Security* (Arlington, VA: National Security Space Association, February 22, 2022); and USSF, *U.S. Space Force Commercial Space Strategy*.

assets—those directly supporting military missions and those that do not—could be targeted by U.S. adversaries, potentially with negative impacts on U.S. national security.[551] The Russian government has already asserted commercial satellites could be considered viable targets, particularly when they support military efforts.[552] Nathan Beauchamp-Mustafaga has suggested Chinese thinkers may see the dependence of Western societies (not just of the U.S. military) on space as an asymmetry that could be exploited.[553] If major commercial capabilities were targeted—even those not tied into military missions—it is possible that the Department of Defense would be asked to develop response options. Indeed, the 2020 *Defense Space Strategy* called on the department to "deter adversary aggression against the space capabilities of the United States and its allies, partners, and commercial interests."[554] The Department of Defense can impose contracting requirements for resilience and defenses in mission-critical services, but it is limited in the degree to which it can enforce resilience and defensive measures in nonmilitary commercial satellites.[555] Although the U.S. government can encourage resilience and defense of commercial capabilities, it has limited ability to control whether commercial companies accept the costs of developing resilience or how strong their resilience may be. Furthermore, adversaries could decide to target allies' space infrastructure. In 2019, NATO declared space an operational domain, with statements in 2021 suggesting Article 5 of the North Atlantic Treaty, the common defense pledge, could apply to attacks in space against an ally.[556] In case of attacks against commercial or allied capabilities, a U.S. military focus on denial would be insufficient to defend against threats or ensure consequences for the attacks.

551 Robin Dickey, "Commercial Normentum: Space Security Challenges, Commercial Actors, and Norms of Behavior," Aerospace Corporation, August 2022, https://csps.aerospace.org/papers/commercial-normentum-space-security-challenges-commercial-actors-and-norms-behavior; Theresa Hitchens and Colin Clark, "Commercial Satellites: Will They Be Military Targets?," *Breaking Defense*, July 16, 2019, https://breakingdefense.com/2019/07/commercial-satellites-will-they-be-military-targets/.

During his confirmation process as secretary of defense, Mark Esper argued, "We anticipate that adversary nations are unlikely to discriminate between U.S. military satellites and commercial satellites providing services to the U.S. Government, in the event of a conflict." Leaders at commercial companies have also raised the possibility that commercial communications satellites could be among the first targets in a space conflict. Hitchens and Clark, "Commercial Satellites;" and Sandra Erwin, "U.S. Generals Planning for a Space War They See as All but Inevitable," *SpaceNews*, September 17, 2021, https://spacenews.com/u-s-generals-planning-for-a-space-war-they-see-as-all-but-inevitable/.

552 Guy Faulconbridge, "Russia Warns West: We Can Target Your Commercial Satellites," *Reuters*, October 27, 2022, https://www.reuters.com/world/russia-says-wests-commercial-satellites-could-be-targets-2022-10-27/.

553 Beauchamp-Mustafaga, "Exploring Chinese Thinking," 115.

554 DoD, *Defense Space Strategy Summary*, 8.

555 A panel of acquisition experts has been working to set resilience measures for capabilities the Space Force buys. Courtney Albon, "How the Space Force Is Making Its Systems More Resilient," *Defense News*, April 18, 2024, https://www.defensenews.com/battlefield-tech/2024/04/18/how-the-space-force-is-making-its-systems-more-resilient/.

556 NATO, "NATO's Overarching Space Policy;" and Lorne Cook, "NATO Says Attack in Space Could Trigger Mutual Defense Clause," *Defense News*, June 14, 2021, https://www.defensenews.com/smr/nato-priorities/2021/06/14/nato-says-attack-in-space-could-trigger-mutual-defense-clause/.

Third, more fundamental challenges might cause a deterrence-by-denial or deterrence-by-resilience approach to fail. For example, deterrence signals may fail to reach their intended audience or convince them. The heart of deterrence is affecting the decision-making calculus of the adversary. The adversary's culture, worldview, bureaucratic processes, and interests will shape how signals are read and received and how they impact perceptions and decision-making calculations. For example, in 2014, the United States revealed its Geosynchronous Space Situational Awareness Program (GSSAP), describing its purpose as tracking man-made objects in orbit.[557] "GSSAP," the commander of Air Force Space Command at the time said, "will bolster our ability to discern when adversaries attempt to avoid detection and to discover capabilities they may have which might be harmful to our critical assets at these higher altitudes."[558] Rather than seeing the program as a monitoring system to increase defensive measures, however, China and Russia both viewed the announcement as part of a trend of U.S. militarization of space, with Russian analysts believing GSSAP created a threatening capability.[559] Even if defenses would be perceived as intended, passive defenses are not always observable or impactful in ways that may affect adversaries' decision-making. For example, a RAND analyst suggested that it is unclear whether passive defenses like shuttered optics are visible in the data collected by space surveillance systems.[560]

Competitors could also misread the balance of forces, have objectives that are not necessarily tied to the efficacy of U.S. satellites, decide suboptimal damage is better than no damage, or simply be determined to disrupt. Furthermore, as long as adversaries believe the United States has more to lose than they do, they may decide a preemptive attack or escalation—even if it is not as effective as it might have been without U.S. defensive efforts—would still be advantageous.[561]

Approaches to deterrence should also consider the adversaries' goals. A natural objective for the United States is to deter Russia and China from targeting U.S. satellites. Here, a range of paths toward resilience, including a combination of proliferation in LEO and hardening in other orbits, may work. Those adversaries, however, may have other goals beyond attacking a capability. In particular, China and Russia may seek to use space threats to deter the United States from taking certain behaviors on Earth, including intervening in conflict. The threat, in other words, may not be just the disruption to space-based or space-enabled capabilities, but the limit on U.S. decision-making.

557 Zachary Vucic, "Shelton Announces New Space Situational Awareness Satellite Program," A*ir Force News Service*, February 24, 2014, https://www.af.mil/News/Article-Display/Article/473403/shelton-announces-new-space-situational-awareness-satellite-program/.

558 Stephen Clark, "Air Force General Reveals New Space Surveillance Program," Space.com, March 3, 2014, https://www.space.com/24897-air-force-space-surveillance-program.html.

559 Blanc et al., *Chinese and Russian Perceptions*, 36–38.

560 Morgan, *Deterrence and First-Strike Stability in Space*, 31.

561 Bonnie L. Triezenberg, *Deterring Space War: An Exploratory Analysis Incorporating Prospect Theory into a Game Theoretic Model of Space Warfare* (RAND Corporation, December 21, 2017), https://www.rand.org/pubs/rgs_dissertations/RGSD400.html.

An adversary that aims to interfere with U.S. decision-making may not be deterred by a resilience-based approach alone. When U.S. officials discuss deterrence by resilience, they often refer to the idea that attempting to disrupt U.S. space-based capabilities would be foolish because it would cost more money and effort to damage the satellite than it would be to replace the capability or satellite. Importantly, Russian and Chinese policymakers may not focus on the material force and cost ratios, however. They may think more about the psychological and political impacts their threats might create. Deterrence aims to manipulate the target's decision-making process, not necessarily the force ratio. For example, Russian analysts' belief that the United States is asymmetrically dependent on space could lead Moscow to believe that Washington is particularly vulnerable to threats to space security. Thus, Russian policymakers could conclude that signaling or demonstrating counterspace capabilities could potentially coerce Washington to change its behavior and/or impose significant costs on the United States. A similar logic seems to apply with regard to Chinese thinking about using space for deterrence: PLA analysts have been assessed as thinking that threatening aggression in space will deter the United States from intervening in a regional conflict.[562] The logic, however, does not appear to be just that the PLA will seek to make it more costly or more difficult for the United States to intervene (a more traditional deterrence-by-denial approach); it also appears that the PLA seeks to make the United States fear the costs of intervention or be too slow to intervene due to decision-making processes. The PLA's 2013 *Science of Military Strategy*, for example, argued, "The means and activity which potentially can cause jamming and sabotage of the normal operation of space systems, *even if they do not cause actual sabotage*, still can create psychological fear to a certain extent, and have an influence on national decision makers and the associated strategic decision-making activity."[563]

Rethinking the Value of Resilience

One approach to the threat of counterspace attacks in the face of failed deterrence signals could be to increase resilience so that any attacks will not succeed—but Chinese and Russian deterrence attempts to change U.S. behavior may still work if U.S. officials are not confident in their own resilience and thus hesitate to act. Furthermore, U.S. adversaries may still continue with their threat if they assess that U.S. officials or the U.S. public are not confident in the resilience of the system. If U.S. leaders' confidence in the country's space systems is at the heart of this deterrence challenge, then the U.S. approach should focus not only on convincing adversaries that they will not be successful in disabling a certain capability or

562 DoD, *Military and Security Developments Involving the People's Republic of China 2023*, ix, 98; and DoD, *Space Policy Review*, 2. Montgomery and Yoshihara argued a similar logic could be at play with nuclear deterrence, with the PLA perhaps viewing its nuclear deterrent as a way to keep the United States out of crises in the region. Evan Braden Montgomery and Toshi Yoshihara, "The Real Challenge of China's Nuclear Modernization," *Washington Quarterly* 45, no. 4, October 2, 2022, 45–60, https://doi.org/10.1080/0163660X.2022.2148508.

563 Emphasis added by author. China Aerospace Studies Institute, *Science of Military Strategy 2013: In Their Own Words—Foreign Military Thought* (Montgomery, AL: China Aerospace Studies Institute, 2021), 229.

in destroying some percentage of satellites but also on demonstrating that the United States will not be deterred by their threats and that their actions will not restrict the United States' freedom to act. This, in turn, suggests convincing U.S. policymakers that U.S. capabilities are safe and then communicating that sense of security.

U.S. policy may thus be missing an important benefit of resilience. Resilience has value not only in demonstrating to adversaries that its threats will not succeed but also in building U.S. confidence in its own ability to operate in the face of counterspace attacks and in the case of deterrence failure by providing greater likelihood of minimized disruption. Resilience, however, is not enough to ensure deterrence from all types of attacks; furthermore, it is largely latent and reactive. As the United States looks to the future, it may want to more proactively shape the behavior of U.S. adversaries. Here, resilience and deterrence by denial have limited value.

Resilience and deterrence by denial cannot do everything, particularly against two adversaries with growing capabilities. For example, although a resilient PLEO approach may be an effective deterrent against Chinese DA-ASAT capabilities, Russia has shown more progress in its on-orbit capabilities, which may be less affected by deterrence by denial (especially if the goal is to force a U.S. reaction). Furthermore, China and Russia are developing other capabilities, including on-orbit capabilities and cyber capabilities, that could threaten U.S. capabilities even if they are proliferated, disaggregated, or hardened. If resilience attempts are successful, adversaries are still likely to try to find another avenue of attack—perhaps each in their own ways or in coordination with each other. Thus, resilience can help change the equation, but it does not change the game.

Deterrence by denial and resilience provide considerable benefits, not least of which is contributing to the deterrence of physical attacks that could damage more than the specific target through debris creation. It also hardens U.S. capabilities in case of deterrence failure. A more comprehensive approach to space, however, requires additional methods.

CHAPTER 6

Using Counterspace Capabilities to Buttress U.S. Space Freedom of Action

In addition to adopting a resilient architecture, the United States should embrace a more coercive, proactive approach centered on nonkinetic, reversible counterspace capabilities. These capabilities could contribute to a deterrence-by-punishment approach and to cost imposition during peacetime and wartime.

The U.S. space policy community has traditionally hesitated to discuss the development of counterspace capabilities and of warfighting in space more broadly, particularly since the end of the Cold War. For example, General Saltzman has said that as recently as 2015, the Pentagon debated whether a top U.S. Air Force general "would be allowed to say 'space' and 'warfighting' in the same sentence."[564]

Over the last few years—and certainly since the creation of the Space Force—the approach to space's relationship to warfighting has changed. For example, the 2020 *Defense Space Strategy* asserted that "space is now a distinct warfighting domain."[565] In March 2025, the Space Force released a public framework for "space warfighting."[566] Debate about strategies in and for space appears to be growing, with more discussion about the role of the space domain during conflict.[567]

564 David Ignatius, "The Space Force Needs to Get Bigger," *Washington Post*, August 22, 2023.

565 DoD, *Defense Space Strategy Summary*, 1.

566 USSF, "Space Warfighting: A Framework for Planners" (Washington, DC: USSF, March 2025).

567 Swope et al., *Space Threat Assessment 2025*, 31.

As conversation about warfighting in space develops, so too is the conversation about how to accomplish warfighting goals. Multiple recently published documents have recognized that the Space Force should be prepared to counter any adversaries' efforts to deny the United States advantages deriving from space and, if necessary, to deny adversaries the ability to use space capabilities to target the United States.[568] In the forward to the Space Force's space warfighting framework, Gen. B. Chance Saltzman wrote, "[W]e must defend U.S. space capabilities, and we must protect our forces from space-enabled attack. … We must be prepared to employ capabilities for offensive and defensive purposes to deter and, if necessary, defeat aggressors that threaten our vital national interests."[569]

Counterspace capabilities should be a part of this conversation. In August 2024, General Stephen Whiting, the commander of USSPACECOM, said a top USSPACECOM priority for FY27 was "space fires to enable us to establish space superiority."[570] The Space Force's public FY 2025 budget request included funding for research, development, test, and evaluation of at least two counterspace systems: the Counter Communications System, a mobile EW system to block adversary communications, and Bounty Hunter, a defensive EW system.[571] Developing counterspace options would support not only warfighting, but also add in importance deterrence tools for the United States.

The Benefits of Counterspace Options

An approach to space based on denial and resilience is valuable and perhaps necessary. However, relying on denial alone still leaves several vulnerabilities and, importantly, misses several opportunities to pursue a more proactive space strategy. Adding counterspace options to the U.S. space toolkit provides flexibility that an approach based primarily on resilience and denial does not.[572] In addition to providing a stronger deterrence-by-punishment mechanism, counterspace options create opportunities for cost imposition

568 See, for example, Kendall, *Comprehensive Strategy for the Space Force*; DoD, *Space Policy Review*, esp. 11; and USSF, *White Paper on Competitive Endurance*.

569 USSF, "Space Warfighting," 2.

570 Theresa Hitchens, "'Space Fires' to Enable 'Space Superiority' Are Top SPACECOM Priorities for FY27," *Breaking Defense*, August 6, 2024, https://breakingdefense.com/2024/08/space-fires-to-enable-space-superiority-are-top-spacecom-priorities-for-fy27/.

571 Jennifer DiMascio, *U.S. Counterspace Capabilities* (Washington, DC: Congressional Research Service, September 11, 2024), 2; Department of the Air Force, *Justification Book: Research, Development, Test & Evaluation, Space Force: Department of Defense Fiscal Year (FY) 2025 Budget Estimates* (Department of the Air Force, 2024), 333–45.

For more on the United States, see DiMascio, *U.S. Counterspace Capabilities*;" Theresa Hitchens, "Space Force EW Unit Working to Integrate New Weapon Systems, Intel Personnel," *Breaking Defense*, April 24, 2024, https://breakingdefense.com/2024/04/space-force-ew-unit-working-to-integrate-new-weapon-systems-intel-personnel/; Samson and Cesari, *Global Counterspace Capabilities 2025*, chap. 1; and Clayton Swope et al., *Space Threat Assessment 2025* (Washington, DC: CSIS, 2025), 31.

572 Galbreath argued developing counterspace capabilities is an "imperative" for U.S. defense. Charles S. Galbreath, *Building U.S. Space Force Counterspace Capabilities: An Imperative for America's Defense* (Arlington, VA: Mitchell Institute for Aerospace Studies, June 2023).

during peacetime, crisis, and conflict. Selectively adopting and signaling these weapons will augment resilience-based approaches in several ways and afford the United States more flexibility in space and on Earth.

Deterrence by Punishment

Counterspace weapons could provide the United States with a deterrence-by-punishment option that it does not now have. Such an approach would signal to adversaries that if they took an undesired action, they would face a severe penalty. Without applicable counterspace options, a U.S. deterrence-by-punishment approach would rely on cross-domain threats including sanctions or other economic punishment, cyberattacks on adversary space or other systems, conventional strikes on Earth, or (in extreme cases) nuclear punishment.

Each of these cross-domain deterrence-by-punishment options, however, has its own challenges. For example, threatening sanctions or other economic punishment as a deterrence-by-punishment approach has mixed results across domains.[573] Although sanctions threats may work in some cases, if a target believes the deterrer is going to use sanctions, the target can take measures to mitigate their economic impact, as Putin appears to have done before the 2022 full-scale invasion of Ukraine.[574] Thus, one would only want to threaten sanctions use relatively close to the immediate action to be deterred, so it may be less effective for broader deterrence. Cyberattacks on space or other systems could be an attractive option, but capabilities are difficult to demonstrate without revealing methods and allowing defenses to be built.[575]

More broadly, cross-domain deterrence raises a number of challenges, including attribution, threat credibility and proportionality, signaling, and a shared understanding of escalation

573 See, for example, David A. Baldwin and Robert A. Pape, "Evaluating Economic Sanctions," *International Security* 23, no. 2, 1998, 189–98, https://doi.org/10.2307/2539384; Menevis Cilizoglu and Bryan R. Early, "Researching Modern Economic Sanctions," in *Oxford Research Encyclopedia of International Studies*, 2021, https://oxfordre.com/internationalstudies/display/10.1093/acrefore/9780190846626.001.0001/acrefore-9780190846626-e-599; Gary Clyde Hufbauer et al., *Economic Sanctions Reconsidered,* 3rd ed. (Washington, DC: Peterson Institute for International Economics, 2009); Elizabeth Rosenberg et al., *The New Tools of Economic Warfare* (Washington, DC: Center for a New American Security, April 2016), https://www.cnas.org/publications/reports/the-new-tools-of-economic-warfare-effects-and-effectiveness-of-contemporary-u-s-financial-sanctions; and Patrick M. Weber and Gerald Schneider, "Post-Cold War Sanctioning by the EU, the UN, and the U.S.: Introducing the EUSANCT Dataset," *Conflict Management and Peace Science* 39, no. 1, January 1, 2022, 97–114, https://doi.org/10.1177/0738894220948729.

574 Max Fisher, "Putin, Facing Sanction Threats, Has Been Saving for This Day," *New York Times*, February 3, 2022.

575 Manuel Fischer, "The Concept of Deterrence and Its Applicability in the Cyber Domain," *Connections* 18, no. 1/2, 2019, 69–92; Martin C. Libicki, *Cyberdeterrence and Cyberwar* (Santa Monica, CA: RAND, 2009); Jacquelyn G. Schneider, "Deterrence in and through Cyberspace," in Eric Gartzke and Jon R. Lindsay, eds., *Cross-Domain Deterrence: Strategy in an Era of Complexity* (Oxford: Oxford University Press, 2019), https://doi.org/10.1093/oso/9780190908645.003.0005.

management.[576] A cross-domain deterrence-by-punishment approach could suggest that if an adversary attacked a space asset, the United States would respond by striking a target on Earth.[577] However, credibly signaling a willingness to extend the conflict into another domain may be difficult, particularly if there is a perception that the United States wanted to minimize risk and/or avoid conflict. This problem would be especially potent if the United States were already engaged in a war with one actor and were trying to deter a second actor: How could the United States credibly signal it was willing to launch an attack against another actor on Earth, thereby opening up a second war, for an action taken in space?

In extreme cases, the United States may be able to threaten nuclear use. This threat would have to be applied carefully. The behavior to be deterred would need to be proportional to nuclear use or be so valuable that threatening nuclear use would be credible (and justifiable). There has been a discussion about whether attacks against dual-use NC3 systems—including assets in space—would warrant a nuclear response.[578] However, declaratory policies may be especially dangerous, tying U.S. hands even if adversaries do not believe the threats.[579] For most space capabilities that could be targeted, it seems very unlikely that the United States should threaten nuclear use or that adversaries would believe any such U.S. threats.

Threatening to disrupt adversaries' own space capabilities if they disrupt those of the United States is a more realistic and credible deterrence-by-punishment option, allowing the United States to threaten proportionate punishment in the same domain as the behavior to be deterred. For example, the United States could signal that if an adversary disrupted a U.S. government communications satellite, the United States could disrupt or deny that adversary access to its own space-based communications capabilities. The United States could also adopt such a strategy in cases in which defenses are unlikely to succeed, threatening to impose costs on an adversary's space assets and capabilities if it took an undesired action. Alternatively, counterspace options could theoretically be used in specific cases to preemptively neutralize a space-based threat, adding another policy option for the United States.

Some may argue that adversaries may not be deterred by threats to their own space systems because they perceive the United States as being more reliant on space than they are and thus they may not feel vulnerable to such threats. This is not necessarily true. First, as U.S. challengers become more reliant on their own space capabilities, they may increasingly value their space assets. Second, U.S. adversaries may have less redundancy than the United

576 Tim Sweijs and Samuel Zilincik, "The Essence of Cross-Domain Deterrence," in Frans Osinga and Tim Sweijs, eds., *NL ARMS Netherlands Annual Review of Military Studies 2020: Deterrence in the 21st Century—Insights from Theory and Practice* (The Hague: T.M.C. Asser Press, 2021), 129–58, https://doi.org/10.1007/978-94-6265-419-8_8.

577 Nicole Pettruci, "Building 'Space' into Multi-Domain Deterrence Strategy," Air Power Strategy, December 1, 2018, https://www.airpowerstrategy.com/2018/12/01/space-deterrence/.

578 For example, see Acton, "Escalation through Entanglement;" Evan Braden Montgomery, "Posturing for Great Power Competition: Identifying Coercion Problems in U.S. Nuclear Policy," *Journal of Strategic Studies* 45, no. 6–7, November 10, 2022, 1021–43, https://doi.org/10.1080/01402390.2021.1886932.

579 Montgomery, "Posturing for Great Power Competition."

States, meaning the loss of one satellite or a small group of satellites may significantly impact an adversary's conventional terrestrial operations, hindering its objectives on Earth. Thus, a credible U.S. threat against some set of adversarial space capability could have deterrent effect. Signaling that the United States is willing to risk escalation in space could send a message about how serious the United States is about its deterrent threats precisely because of its dependence on space capabilities. Furthermore, pairing a deterrence-by-punishment approach with greater resilience could increase the perceived credibility of a U.S. punishment threat because it would be less likely to significantly suffer from any counterresponse.

Most countries do not pursue just one approach to deterrence; instead, they apply a mix of strategies either simultaneously or tailored to specific situations. Indeed, adding a deterrence-by-in-domain-punishment option to the United States' toolbox could enhance its deterrence posture in a two-rival threat environment. A mixed deterrence approach relying on both deterrence by denial and deterrence by punishment (both cross- and in-domain) would enable the greatest protection of U.S. assets and afford the United States the most flexibility.[580] Indeed, the United States could have deterrent options tailored to each rival, capability, and situation. For example, it is plausible that China could be deterred from launching DA-ASATs because a resilient PLEO architecture increases the costs of achieving a significant effect and because the debris caused by a kinetic attack would harm its own satellites; but Russia, if it wished to use space threats in LEO to coerce the United States, may be more effectively deterred by threats to its exquisite satellites in other orbits. Alternatively, Russia's quantitative disadvantage in space could lead Russian leaders to perceive themselves as less vulnerable to space attacks. If that were true, deterrence-by-punishment options that were cross-domain may be more effective. Having the ability to pursue both options would allow the United States more flexibility to respond to individualized threats, and the ability to credibly pursue multiple deterrence approaches would afford the United States more flexibility in how it seeks to deter adversarial behavior more broadly.

Adding a deterrence-by-in-domain-punishment capability can also be thought of as an insurance policy. The United States is already investing a significant amount of money on deterrence by denial and resilience. For example, the Space Development Agency 's PWSA's Tranche 0, which launched 28 space vehicles to the transport and tracking layers of the architecture that provide data transmission and sensing, is estimated to have cost $980 million.[581] The total estimate for Tranches 1 and 2 of the PSWA's transport layer is more than $8 billion, and the total estimate for Tranches 1 and 2 of the tracking layer is almost $6.5 billion.[582] The projected FY 2020–2029 costs for RDT&E alone of the transport and

580 Flanagan et al. reach a similar conclusion. Flanagan et al., *Framework of Deterrence*.

581 Greg Hadley, "SDA to Launch First Satellites of Tranche 0 from Vandenberg," *Air & Space Forces Magazine*, March 29, 2023, https://www.airandspaceforces.com/sda-launch-satellites-tranche-0-vandenberg/.

582 Department of the Air Force, *Fiscal Year (FY) 2025 Budget Estimates, Research, Development, Test & Evaluation, Space Force*, vol. 1 (Washington, DC: Department of the Air Force, 2024), 44, 473, https://www.saffm.hq.af.mil/LinkClick.aspx?fileticket=eMkgj7wbmGM%3d&portalid=84.

tracking layers add up to more than $30 billion.[583] Protecting this investment should thus be important.[584] Developing, exercising, and signaling counterspace options would allow the United States to enforce resilience efforts. For example, the United States could signal that its resilient architecture will make an attack unlikely to succeed—but if the adversary insisted on attacking U.S. capabilities, the United States could retaliate by counterattacking. Defensive counterspace weapons could also be used to supplement resilience in deterrence-by-denial approaches. For example, given sufficient SDA capabilities, the USSF could use counterspace weapons to neutralize on-orbit threats as they approach their target.

Use in Conflict and Competition

Counterspace weapons developed by the United States could also be used in conflict if broader deterrence efforts fail. U.S. defense space officials have begun making nuanced reference to these capabilities, pointing to the need to be able to deny adversaries their own use of space capabilities that could attack the U.S. military during wartime. The *White Paper on Competitive Endurance*, for example, points to fielding capabilities such as "preventing [adversaries'] ISR satellites from finding and tracking U.S. terrestrial forces, disrupting communication satellites from passing targeting data, and denying PNT services that guide long-range precision attack."[585] Although much of the focus has been on denying the adversary capabilities that could be used terrestrially, in case of a conflict that included adversarial targeting of U.S. space capabilities, the United States could use theoretically counterspace weapons to neutralize on-orbit counterspace threats.

Coercive counterspace options could be used for both short- and long-term effects. At the beginning of a conflict, for example, counterspace weapons could be used to deny adversaries the use of space-based capabilities on which they may rely. Unless the adversary had previously developed alternatives to which it could transition seamlessly, this would at a minimum cause the adversary to be delayed as alternatives were fielded. During this time, U.S. forces could take advantage of the delay to make operational progress, such as advancing forces, setting up defenses, targeting adversarial communications or command and control, and degrading adversary forces.

Counterspace operations could also be used to impose costs throughout a protracted conflict. For example, counterspace weapons could be used to slowly degrade adversary space capabilities, forcing the adversary to reconstitute capabilities and satellites over time. During particularly important moments in a conflict, counterspace weapons could be used

583 This figure is the sum of actual (FY20-23), estimated (FY24), requested (FY25), and projected (FY26-29) total program element denominated in current year dollars of the Total Obligation Authority for the following project codes: 1206310SDA/1206310SF, 1206410SDA/1206410SF, 1206446SF, and 1206448SF. See Appendix B.

584 A Center for Strategic and Budgetary Assessments report from 2007 provided early estimates of the costs of space-based weapons. Steven M. Kosiak, *Arming the Heavens: A Preliminary Assessment of the Cost and Cost-Effectiveness of Space-Based Weapons* (Washington, DC: Center for Strategic and Budgetary Assessments, 2007).

585 USSF, *White Paper on Competitive Endurance*, 5.

for shorter term effect. Revealing new counterspace capabilities during a protracted conflict would also force the adversary to respond and invest in its own countermeasures.

Combining counterspace weapons with resilience efforts would provide the United States options for managing threats from multiple actors. For example, resilience would support U.S. signals to opportunistic aggressors that attempting to disrupt U.S. capabilities while the Joint Force was involved in another conflict would be unlikely to work. At the same time, punctuated demonstrations of counterspace capabilities could signal to potential aggressors that the United States could punish the aggressors' space capabilities and serve as a warning not to interfere.

The United States needs to not only deter aggression against its own space-based capabilities and protect its own freedom of decision-making but also manage peacetime competition in space. U.S. adversaries are already constantly engaging U.S. space capabilities and assets, with reversible counterspace attacks from both China and Russia occurring regularly.[586] Given the volume of counterspace capabilities that U.S. adversaries have and their demonstrated willingness to use them, the United States will need to adopt a posture that seeks to manage day-to-day counterspace activity. This is especially salient in a world in which multiple states pursue proliferated architectures and constantly work to degrade others' constellations. It is likely to be difficult to deter all below-threshold activities in space, highlighting the need to continuously manage the activity and shape adversaries' behavior in space.[587]

General Salzman has stated that the planned U.S. approach is to be in a state of "perpetual competition," and USSF's *White Paper on Competitive Endurance* described "responsible counterspace campaigning" as "protracted, day-to-day competition."[588] Although public Space Force documents do not outline in detail what such campaigning looks like, management of peacetime space competition likely has at least five goals: (1) minimizing disruption to U.S. space capabilities, (2) protecting information about U.S. space capabilities, (3) ensuring the development of and adherence to norms of conduct, (4) shaping adversarial investments and options, and (5) ensuring the United States has freedom of decision. Resilience contributes strongly to the first and last goal. It could also contribute to the goal

586 Rogin, "Shadow War in Space."

587 In 2023, Saltzman suggested that because military victory in space could generate debilitating debris, the "goal is perpetual competition, locked in a battle for stability in the domain, neither driving our adversaries towards disrupting the space domain nor towards desperation. That is the essence of competition. That means orienting ourselves around the idea that there is no end-state, there is no victory in space because if you do this right, you never fight." Secretary of the Air Force Public Affairs, "Saltzman Outlines 'Theory of Success' Guiding Space Force in Fulfilling Its Essential Missions," USSF, March 7, 2023, https://www.spaceforce.mil/News/Article/3322198/saltzman-outlines-theory-of-success-guiding-space-force-in-fulfilling-its-essen/.

588 Sandra Erwin, "U.S. Space Force Game Plan: Compete with China, Prevent Shooting War in Orbit," *SpaceNews*, March 8, 2023, https://spacenews.com/u-s-space-force-game-plan-compete-with-china-prevent-shooting-war-in-orbit/; and USSF, *White Paper on Competitive Endurance*, 4.

of shaping adversarial investments, though possibly toward greater offensive capabilities to try to offset defensive and resilience capabilities.

Developing counterspace weapons provides greater flexibility in continuously managing peacetime competition. Defensive counterspace weapons can help the resilience mission of minimizing disruption to U.S. space capabilities by targeting ASATs, particularly those on orbit. On-orbit counterspace weapons could also contribute to the goal of defending against rivals' intelligence collection activities by, for example, putting weapons on escort satellites near key exquisite satellites that could maneuver toward and threaten adversary inspector satellites.[589] Counterspace weapons could also be used, alongside improved SDA, to enforce norms by providing a means of punishment should norms be violated.[590]

Counterspace weapons can also impose costs on adversaries during long-term peacetime competition. In response to U.S. demonstrations and development of counterspace weapons, adversaries will be forced to devote time and resources to alternative capability sources, defenses, and/or more resilient architectures. The United States could shape adversary investment behavior into capabilities that may not ultimately benefit the adversary by highlighting select capabilities and exploiting quantitative, qualitative, cultural, cognitive, and organizational asymmetries.[591]

Developing the capability to deny, degrade, disrupt, or destroy adversaries' space capabilities exploits existing weaknesses of both China and Russia. The United States faces two primary challengers in space. One—China—is increasingly dependent on its large space network to enable its military, including for beyond-line-of-sight operations. The other—Russia—relies on relatively few assets to deliver space-based and space-enabled capabilities. Both vulnerabilities (reliance on a large network and reliance on a small network) are susceptible to coercive counterspace weapons.

The Risks of Counterspace Weapons

One may argue that developing and deploying counterspace weapons could create a space arms race that could lead to the weaponization of space. Such concerns are understandable, but they miss important developments and mitigation strategies. First, the growth of

589 This capability would have to be used judiciously. Other options include deception (such as camouflage and disguise) and on-satellite defenses.

590 For example, a more rigorous norm could be developed about how close RPOs can get to foreign satellites, similar to thresholds for spacecraft approaching the ISS. In the case of closer approaches, counterspace weapons could engage the offender. Nicholas Deschenes, "Enabling Leaders to Dominate the Space Domain," *Military Review*, June 2019, https://www.armyupress.army.mil/Journals/Military-Review/English-Edition-Archives/May-June-2019/Deschenes-Space-Domain/.

Research suggests making opponents feel like they have something to lose can support deterrence in space. Triezenberg, *Deterring Space War*.

591 Thomas G. Mahnken, ed., *Competitive Strategies for the 21st Century: Theory, History, and Practice*, 1st ed. (Stanford, CA: Stanford Security Studies, 2012).

weapons in space is already happening; Chinese and Russian counterspace investments are a reality. Although the United States developing counterspace weapons would increase the number of weapons overall, the number of ASATs fielded will likely be driven less by which and how many counterspace capabilities actors are developing and more by the number and characteristics of satellites that actors may want to be able to hold at risk.[592]

A related concern could be the risk of escalation. One avenue of this concern is that the employment of counterspace weapons could lead countries to fear that their NC3 systems may be targeted or that NC3 could be inadvertently threatened.[593] Although that concern is warranted, it may be overstated. During the early stages of space exploration, most satellites were related to the U.S. nuclear architecture. That is not the case today: There are simply more non-NC3 targets on orbit.[594] Furthermore, ASAT technologies are more precise and sophisticated than before.[595] The existence of these weapons in and of itself would not be the sole determinant of any escalation; other actions could be taken to mitigate the risks. For example, arms control measures, norms development, direct lines of communication, and unilateral measures like clear signaling all could reduce escalation risks.[596]

There are important ways that states can mitigate the risks of the weaponization of space, including developing and strengthening enforcement of norms.[597] Adding deterrence by in-domain punishment capabilities would not mean abandoning efforts to create norms of peaceful use. Agreed-upon norms would reinforce efforts to stabilize space and could strengthen deterrence effects. First, conversations about norms could provide a space for diplomacy and dialogue about intentions in space, potentially providing a stabilizing mechanism. Second, the creation of norms could raise the costs of breaking them through international uproar. Third, norms could clarify what the United States is trying to deter, which would support stability if the United States clarified that its deterrence-by-punishment weapons were only to be used if norms were broken. Relevant norms should include details about the use of space assets, for example establishing thresholds for how close a system could get to another before being considered aggressive.[598] Any norms should be

592 Benjamin W. Bahney, Jonathan Pearl, and Michael Markey, "Antisatellite Weapons and the Growing Instability of Deterrence," in Eric Gartzke and Jon R. Lindsay, eds., *Cross-Domain Deterrence: Strategy in an Era of Complexity* (Oxford: Oxford University Press, 2019), 134–35, https://doi.org/10.1093/oso/9780190908645.003.0006. On first-strike stability in space, see also Morgan, *Deterrence and First-Strike Stability in Space*.

593 See, for example, Acton, "Escalation through Entanglement." For two counters, see Kroenig and Massa, *Are Dual-Capable Weapon Systems Destabilizing?*; and Snyder and Blanc, *Unraveling Entanglement*.

594 Bahney, Pearl, and Markey, "Antisatellite Weapons."

595 Bahney, Pearl, and Markey, "Antisatellite Weapons."

596 Raju and Wan, *Escalation Risks*.

597 Douglas C. Ligor and Dan McCormick, "Opportunities for the United States to Shape International Norms, Rules, and Principles Applicable in Space," in Bruce McClintock, ed., *Select Space Concepts for the New Space Era* (RAND Corporation, 2023), https://www.rand.org/pubs/perspectives/PEA2644-1.html.

598 Brian G. Chow, "Space Arms Control: A Hybrid Approach," *Strategic Studies Quarterly* 12, no. 2, Summer 2018, 126–28; and Deschenes, "Enabling Leaders."

backed by developing real consequences for breaking them, including the possibility of targeting the norm-breaker's own space capabilities. Thus, a mixed approach in which the United States develops an array of deterrence options and continues to pursue norms for the use of outer space would be advised.

Realizing a More Proactive Space Strategy

Given the limitations of resilience and the benefits that counterspace options can bring, the United States should emphasize building a balanced space architecture that is both resilient and proactive (see Figure 18). Investing in both resilience and counterspace options would provide the United States with more flexibility to pursue its objectives in space and to deter adversaries. A balanced approach would enable both deterrence by denial and punishment and strengthen U.S. options during all stages of competition.

TABLE 3: SELECT BENEFITS PROVIDED BY A PROACTIVE, RESILIENT SPACE STRATEGY

	Deterrence approaches enabled	Phase of competition	
		Competition	Conflict
Resilience efforts	· Deterrence by denial	· Buttress U.S. capabilities · Signal to adversaries that denying or degrading U.S. space capabilities or threatening U.S. freedom of action will be costly and/or ineffective	· Buy U.S. decision-making time in case of attack · Provide defenses in case of deterrence failure · Enable graceful decay of any attacked capabilities
Counterspace weapons	· Deterrence by punishment · Deterrence by denial (if used to neutralize on-orbit threats)	· Encourage adversary to invest resources on defenses, alternatives, and resilience · Enforce norms	· Disrupt adversary systems that can be used to target U.S. forces · Enable short-term advantages · Cost imposition during protracted conflict

Currently, however, the United States appears to be at risk of underinvesting in the counterspace capabilities that would enable a proactive space strategy. To enable a strategy that balances resilience with counterspace options, the USSF and USSPACECOM need to make several changes.

First, to support deterrence efforts and provide cost-imposition tools during peacetime and conflict, the United States should invest in more counterspace capabilities that have at their core two key attributes: First, they should avoid creating debris.[599] Adhering to a policy of minimizing or not creating debris would have three effects: It works to reinforce norms

599 There may be some instances in which threatening or even creating debris may be warranted; however, the bulk of capabilities should avoid debris creation.

about debris minimization, it protects other U.S. and allied space assets from debris and collateral damage inadvertently caused by any potential U.S. weapons use, and it increases the credibility of use because such weapons would not violate existing norms and would be less likely to harm U.S. assets. Second, capabilities and strategy should seek to minimize the risk of inadvertent or unintended escalation. Thus, the capabilities should create conditions that best allow another country's leader to back off from an action. One way to enhance these conditions is to ensure the leaders' hands are not tied by public pressure to respond.[600] Thus, behaviors that do not directly impact public services or can be reversed before public attribution may be most conducive to a leader stopping an unwanted behavior by allowing time to privately negotiate. Additionally, because actions taken in space are generally less visible than those taken terrestrially, there may be room for leaders to save face.[601] Another strategy is to use measures that can be turned off, which would incentivize the cessation of any unwanted behavior by signaling that the punishment will not continue if the target cooperates.

Taken together, the need to minimize debris and optimize chances of behavior reversal suggest that a deterrence-by-punishment approach adopted by the United States should prioritize highly discriminate counterspace capabilities that minimize or do not cause debris. These could take a number of forms, including physical on-orbit weapons that do not cause debris (for example, grasps that could move satellites into other orbits and chemical obscurants), cyber tools, EW weapons, and DEW. The exact weapons mix is not the subject of this study, but it should balance desired effects. For example, the United States may want to have a number of reversible effects to reassure rivals that any punishment could be turned off if they adopted the desired behavior.

Second, to maximize the deterrent effectiveness of counterspace weapons for deterrence by punishment and cost imposition, the United States will need to not only increase investment in counterspace capabilities but also refine policies for when and how to reveal such capabilities. Credibly threatening counterspace actions will require selective demonstration of the capability to follow through on the threats. Revealing capabilities, however, risks allowing adversaries to observe the capability and develop countermeasures or copy them. Thus, policymakers would need to carefully calibrate which capabilities to reveal and when to do so.[602] Conversations critiquing classification policies related to space are relevant, but a separate strategy is required to decide when to reveal which capabilities.

600 Austin Carson, "Facing Off and Saving Face: Covert Intervention and Escalation Management in the Korean War," *International Organization* 70, no. 1, January 2016, 103–31, https://doi.org/10.1017/S0020818315000284; and James D. Fearon, "Domestic Political Audiences and the Escalation of International Disputes," *The American Political Science Review* 88, no. 3, 1994, 577–92, https://doi.org/10.2307/2944796.

601 Thomas Van Bibber, Madeline Lambert, and Kaitlyn Lenkeit, *The Role of Space in Defense Strategy: Workshop Summary* (Livermore, CA: Center for Global Security Research, Lawrence Livermore National Laboratory, October 16, 2023).

602 Thomas G. Mahnken, *Selective Disclosure: A Strategic Approach to Long-Term Competition* (Washington, DC: Center for Strategic and Budgetary Assessments, 2020); and Montgomery, "Signals of Strength."

Third, the Department of Defense should continue to invest in SDA. SDA can enable attribution, which would be key to any deterrence-by-punishment efforts. Notably, the United States would also have to demonstrate this ability to attribute.[603] There is some precedent here. For example, when the GSSAP program was declassified, General Hyten said the goal of making the program known was to "send a message to the world that says: Anything you do in the geosynchronous orbit we will know about. Anything."[604] Detection of gray zone activities can also contribute to deterrence, and SDA can help identify mobilization activities such as prepositioning satellites and deploying counterspace weapons.[605] Furthermore, SDA can enable warfighting, monitor adherence to norms, and inform the collision threat of debris.[606] Improving U.S. SDA should include not only technical capabilities but also the analytical capability and capacity—data processing, intelligence analysts, etc.—needed to make sense of and act on the data being gathered.

The U.S. armed forces should also hold more training programs and exercises to examine the dynamics of deterrence and competition management in space. These exercises could include developing and refining operational concepts for the threat and/or use of counterspace weapons for deterrence. Exercises should also train resilience, in part to increase policymakers' confidence that resilience measures would allow the United States to continue to operate even in the face of adversary threats to U.S. space assets. The Space Force alone and in conjunction with other parts of the Joint Force should thus conduct counterspace exercises, resilience exercises, and exercises that include elements of both. Exercises should also clarify authorities, develop scenarios, and practice making decisions down to the operator level.[607]

All of this will require larger budgets. Although the Space Force budget has increased since its inception, the service requested less for FY25 than in previous years.[608] Decreased funding has already reportedly had an impact: Saltzman told reporters that a Congressional defense-spending cap in 2024 would stall USSF's "counterspace effort."[609] Adopting a deterrence-by-in-domain-punishment approach alongside a resilience-based approach would require more funding for RD&E and acquisition. As Congress considers increasing the

603 Michael P. Gleason and Peter L. Hays, "Getting the Most Deterrent Value from U.S. Space Forces" (Center for Space Policy and Strategy, The Aerospace Corporation, October 2020), 3.

604 Mike Gruss, "Space Surveillance Sats Pressed into Early Service," *SpaceNews*, September 18, 2015, https://spacenews.com/space-surveillance-sats-pressed-into-early-service/.

605 Pollpeter, *Space Domain Awareness*. On deterrence by detection, see Thomas G. Mahnken, Travis Sharp, and Grace B. Kim, *Deterrence by Detection: A Key Role for Unmanned Aircraft Systems in Great Power Competition* (Washington, DC: Center for Strategic and Budgetary Assessments, 2020).

606 Pollpeter, *Space Domain Awareness*.

607 Deschenes, "Enabling Leaders."

608 Robert S. Wilson, *FY 2025 Defense Space Budget: Continued Emphasis on Proliferation under a More Constrained Top-Line* (Center for Space Policy and Strategy, The Aerospace Corportation, June 2024).

609 Audrey Decker, "The State of the Space Force 2024," *Defense One*, April 8, 2024, https://www.defenseone.com/threats/2024/04/state-space-force-2024/395563/.

budget, however, it should also consider developing reporting mechanisms to better assess and track investments in counterspace capabilities and warfighting.

The Pentagon should also continue to consider ways to bolster its own space efforts through external partnerships. For example, the Pentagon should explore ways allies can complement and support U.S. space activities and deterrence and strengthen their own deterrence efforts.[610] U.S. allies—even if they do not have significant space capabilities themselves—could support U.S. space efforts by reaffirming norms, providing access to launch pads, disclosing intelligence related to space, and sharing lessons learned. The Pentagon should also continue to seek ways to boost its cooperation with the U.S. (and, possibly, allied) space industry, particularly to improve space resilience efforts.[611] The Pentagon could, for example, leverage the commercial sector to provide cost-effective options for hardening satellites, provide additional launch capacity for quick reconstitution, and provide back-up or complementary capabilities, especially on imaging and PNT.[612] Indeed, the war in Ukraine has demonstrated the utility of commercial–military cooperation.[613] The 2024 *USSF Commercial Space Strategy* provided a framework for some of this cooperation, but work should continue.[614] The U.S. government could also consider cross-cutting ways to capitalize on and continue to improve the U.S. space sector.[615] At the same time, there should be serious conversation about the role the U.S. military will play in protecting commercial

610 Alice Hancock, "U.S. Space Force Warns of 'Mind-Boggling' Build-up of Chinese Capabilities," *Financial Times*, November 1, 2024, sec. Aerospace & Defence, https://www.ft.com/content/509b39e0-b40c-41b3-9c6a-9005859c6fea; and Bruce McClintock et al., *Charting a Path to Thoughtful Allied Space Power: Allied by Design* (RAND Corporation, January 30, 2024), https://www.rand.org/pubs/research_briefs/RBA1739-1.html.

611 J. Olson et al., "State of the Space Industrial Base 2022: Winning the New Space Race for Sustainability, Prosperity and the Planet," August 2022. For more on the path to operationalizing commercial space, see Clayton Swope, "Bringing the Private Sector to Space: Operationalizing Commercial Space for U.S. National Security" (Washington, D.C: Center for Strategic and International Studies, January 2025), https://www.csis.org/analysis/bringing-private-sector-space.

612 Some of this work is ongoing. For example, in the in run-up to the Russian full-scale invasion of Ukraine, the intelligence community "doubled its procurement of commercial satellite imagery to help prepare and provide intel to our Ukrainian allies," according to Senator Tim Kaine. Theresa Hitchens, "Space Force Should Heed Ukraine Lessons as It Revamps Structure: CSO Nominee Saltzman," *Breaking Defense*, September 13, 2022, https://breakingdefense.sites.breakingmedia.com/2022/09/space-force-should-heed-ukraine-lessons-as-it-revamps-structure-cso-nominee-saltzman/.

613 Courtney Albon, "How Commercial Space Systems Are Changing the Conflict in Ukraine," *C4ISRNet*, April 25, 2022, https://www.c4isrnet.com/intel-geoint/2022/04/25/how-commercial-space-systems-are-changing-the-conflict-in-ukraine/; Arda Ayan and Brian Ladd, "The Impact of Commercial Space in Times of Conflict," *Transforming Joint Air and Space Power* 35 (February 2023), https://www.japcc.org/articles/the-impact-of-commercial-space-in-times-of-conflict/; Hitchens, "Space Force Should Heed Ukraine Lessons as It Revamps Structure"; Amritha Jayanti, "Starlink and the Russia-Ukraine War: A Case of Commercial Technology and Public Purpose?," The Belfer Center for Science and International Affairs, March 9, 2023, https://www.belfercenter.org/publication/starlink-and-russia-ukraine-war-case-commercial-technology-and-public-purpose; Debra Werner, "Ukraine's Lessons for Military Space," *SpaceNews*, April 19, 2023, https://spacenews.com/ukraines-lessons-for-military-space/.

614 USSF, U.S. Space Force, *U.S. Space Force Commercial Space Strategy*.

615 Todd Harrison, "Building an Enduring Advantage in the Third Space Age" (Washington, D.C.: American Enterprise Institute, May 2024).

space entities from attack, as well as expectations for how the companies should harden themselves and their assets as targets.

Investments in defense and resilience should continue to shore up the U.S. ability to operate even in the face of disrupted space capabilities. In addition to space-based resilience, shoring up redundancy in systems like advanced surveillance unmanned aerial vehicles and ground-based communications systems could allow the United States to focus on the mission, not just the domain.[616] Demonstrating the ability to continue to be effective in the face of attacks to its space capabilities would signal that such attacks may not accomplish adversaries' political goals and increase U.S. political and military confidence that the Joint Force could perform under such conditions. This would increase the likelihood that adversarial attempts to use the threat of counterspace attacks would not deter the United States from limiting its own freedom of action on earth and beyond. The United States should also continue efforts to create norms around the use of space and ensure strategic messaging about U.S. intentions accompanies any demonstrations of counterspace capabilities.

Finally, Defense Department planners should adopt a two-rival force planning construct for space. As this report has demonstrated, the United States has two strong challengers in space. As it invests in counterspace weapons, it should balance qualitative and quantitative approaches to managing the problem of simultaneity. Such options could include developing enough offensive opportunity to target key satellites that both China and Russia operate and developing fungible counterspace weapons, such as cyber capabilities, that could feasibly be used against both powers without requiring slow orbital maneuvers.

The Way Ahead

Comprehensive threats to U.S. space capabilities are real. As this report has demonstrated, China and Russia are actively challenging U.S. space superiority and increasingly investing in, testing, and demonstrating ASAT capabilities targeted at the United States. They do so not only to deny U.S. advantage but also to try to use a perceived U.S. reliance on space to limit U.S. actions. Access to space is vital for the U.S. military operations, and the United States is unlikely to be able to field equally capable alternatives to space-based and space-enabled capabilities in full measure. The United States must work to protect U.S. space capabilities and ensure threats in space do not limit U.S. freedom of decision.

Building U.S. resilience, especially through proliferation, is a key part of any U.S. space strategy. Resilience contributes to a deterrence-by-denial approach. It also helps minimize disruption to space-based capabilities in case of deterrence failure. There is another important, potentially overlooked benefit that resilience provides: Resilience can play a role in ensuring adversaries' efforts to deter the United States from action through space threats do not succeed by increasing U.S. policymakers' confidence that the United States could still

616 Scharre, "The US Military Should Not Be Doubling Down on Space."

operate in the face of any such threats. At the same time, resilience-based approaches are limited in their ability to deter major threats, protect commercial and allied space assets, and proactively shape the space environment. Resilience also contributes minimally to cost imposition.

To support and supplement resilience efforts, the United States should also invest in counterspace weapons and concepts. Counterspace weapons that do not cause debris contribute to deterrence-by-punishment approaches and to cost imposition in peacetime and conflict.

A toolkit including resilience and counterspace weapons would enable a more proactive space strategy in which the United States could shape space rather than respond to threats as they emerge. Doing so would optimize USSF flexibility to support U.S. freedom of decision-making and U.S. space superiority. The United States is in a strong position to continue to take advantage of the benefits that space offers—but it must act wisely now to ensure that continues.

APPENDIX A: RECENT CHINESE AND RUSSIAN RPOS

CSBA gathered data on recent Chinese and Russian RPOs from the Secure World Foundation's 2025 *Global Counterspace Capabilities* report to create images representing the duration and frequency of observed RPOs that these countries have created. The base of the data was formed from tables Samson and Cesari created detailing recent RPOs. The relevant information from those tables is provided in this appendix with some modifications, as shown in Tables A.1 and A.2. More detailed information about each entry, including more exact orbital parameters, can be found in the original source.[617]

TABLE A.1: RECENT ASSESSED CHINESE RPOS

Date(s)	System(s)	Orbit	Brief description
June–Aug. 2010	SJ-06F, SJ-12	LEO	SJ-12 maneuvered to rendezvous with SJ-06. It appears the satellites may have bumped into each other, though no substantial damage was noted.
July 2013–May 2016	SY-7, CX-3, SJ-15	LEO	SY-7, which may have had a telerobotic arm, released an object with which it performed maneuvers. CX-3 conducted optical surveillance of other objects in space. SJ-15 conducted altitude and inclination changes and approached other satellites.
Nov. 2016–Feb. 2018	SJ-17, YZ-2 upper stage	GEO	The YZ-2 upper stage carrying SJ-17 into GEO failed to remove itself to the graveyard orbit and stayed near GEO. SJ-17 conducted a series of maneuvers around the GEO belt, including circumnavigating a Chinese communications satellite.
Jan.–April 2019	TJS-3, TJS-3 AKM	GEO	The TJS-3 apogee kick motor (AKM) separated from the TJS-3 in the GEO belt, and both performed a series of maneuvers to maintain relatively close position with each other. The satellites later moved away from each other.
May 2019–present	TJS-3	GEO	TJS-3 drifted around the GEO belt, periodically stopping to conduct RPO with other satellites, including a Russian Luch satellite and several U.S. national security satellites.
Jan.–Oct. 2020	SJ-17	GEO	SJ-17 made smaller changes to conduct RPOs with two Chinese satellites.
Dec. 2021–Jan. 2022	SJ-21	GEO	SJ-21 moved to dock with a defunct Chinese navigation satellite and pull it into a much higher orbit.
Jan. 2022	SY-12 01, SY-12 02	GEO[618]	A U.S. satellite maneuvered toward the two Chinese satellites, which then split up and began rotating around GEO in opposite directions.

617 Samson and Cesari, *Global Counterspace Capabilities 2025*, 02-14–15; 03–11.

618 Samson and Cesari did not list orbital parameters for this entry. The Chinese satellites, however, traveled around the GEO belt, and precise data was unnecessary for the graphic.

Nov. 2022–March 2023	PRC Test Spacecraft 2, Object J	LEO[619]	The Shenlong spaceplane released an object, Object J, and made multiple RPOs, including repeated docking, deployment, and formation flying.
Feb. 2023–Nov. 2024	SJ-17	GEO	SJ-17 made an RPO with a Venezuelan communications satellite and continued to move before entering the Western hemisphere.
March–April, Sept., and Dec. 2024[620]	SY-24C 01, SY-24C 02, SY-24 C 03, SJ-6 05A, SJ-6 05B	LEO[621]	These five satellites have conducted RPOs with each other.
June 2024	PRC Test Spacecraft 3, Object G	LEO[622]	The third Shenlong spaceplane reportedly released an object and conducted RPOs with it.

Table derived from a similar table in Samson and Cesari, *Global Counterspace Capabilities 2025*, 03-11.

619 Samson and Cesari did not list orbital parameters for this entry. The Shenlong, however, was operating in LEO, and precise data was unnecessary for the graphic. For more on the activity, see Andrew Jones, "China's Mystery Spaceplane Releases Object into Orbit," *SpaceNews*, November 2, 2022, https://spacenews.com/chinas-mystery-spaceplane-releases-object-into-orbit/.

620 Graphed as continuous activity from March to December 2024 to indicate ongoing, repeated activity rather than identify as separate incidents.

621 Samson and Cesari did not list orbital parameters for this entry. An earlier page in their report provided parameters, and Space Force officials have confirmed the maneuvers were taking place in LEO. Precise data was unnecessary for the graphic. See Samson and Cesari, *Global Counterspace Capabilities 2025*, 03-04–05; Theresa Hitchens, "5 Chinese Satellites Practiced 'dogfighting' in Space, Space Force Says," Breaking Defense, March 18, 2025, https://breakingdefense.com/2025/03/5-chinese-satellites-practiced-dogfighting-in-space-space-force-says/.

622 Samson and Cesari did not list orbital parameters for this entry. They did provide altitudes of activity, all within LEO, on a previous page. Precise data was unnecessary for the graphic. Samson and Cesari, *Global Counterspace Capabilities 2025*, 03–06.

TABLE A.2: RECENT ASSESSED RUSSIAN RPOS

Date(s)	System(s)	Orbit	Brief description
June 2014–March 2016	Cosmos 2499	LEO	Cosmos 2499 did a series of maneuvers to approach and then move away from the upper stage of its rocket.
Oct. 2014–present	Luch	GEO	Over the course of almost a decade, Luch has maneuvered toward and then parked near more than two dozen communications satellites.
April 2015–April 2017	Cosmos 2504	LEO	Cosmos 2504 approached the upper stage that launched it, possibly impacting before separating.
March–April 2017	Cosmos 2504	LEO	Cosmos 2504, after a year of inactivity, did a close approach with a piece of debris from the 2007 Chinese ASAT test.
Aug.–Oct. 2017	Cosmos 2521, Cosmos 2519, Cosmos 2523	LEO	Cosmos 2519 released Cosmos 2521, which then performed a series of maneuvers before redocking with Cosmos 2519. Cosmos 2521 later released Cosmos 2523.
March–April 2018	Cosmos 2521, Cosmos 2519	LEO[623]	Cosmos 2521 conducted a series of close approaches to Cosmos 2519.
Aug.–Dec. 2019	Cosmos 2535, Cosmos 2536	LEO	Both satellites conducted more than two dozen individual RPOs.
Dec. 2019–March 2020	Cosmos 2542, Cosmos 2543	LEO	Cosmos 2542 released Cosmos 2543. Cosmos 2543 maneuvered within 30 km of a U.S. satellite, which Cosmos 2542 also approached.
June–Oct. 2020	Cosmos 2543, Cosmos 2535, Cosmos 2536	LEO[624]	Cosmos 2543 rendezvoused with Cosmos 2535 and ejected a small object. Cosmos 2536 later repositioned with the other two and may have docked with Cosmos 2535.
Feb. 2022–May 2024(?)[625]	Cosmos 2558	LEO[626]	Cosmos 2558 has conducted repeat close approaches with USA 326, getting within 50km of the U.S. satellite regularly.
Nov. 2022	Cosmos 2562	LEO	Cosmos 2562 conducted an RPO with Resurs-P3, a formerly inactive Russian Earth observation satellite.
March 2023–present	Luch 2	GEO	Luch 2, similar to the first Luch satellite, has parked next to multiple communications satellites.

Table derived from a similar table in Samson and Cesari, *Global Counterspace Capabilities 2025*, 02-14–15.

623 Samson and Cesari did not list orbital parameters for this entry. CSBA assessed the satellites conducted RPOs in the same orbital belt as previous RPOs, and precise data was unnecessary for the graphic.

624 Samson and Cesari did not list orbital parameters for this entry. CSBA assessed the satellites conducted RPOs in the same orbital belt as previous RPOs, and precise data was unnecessary for the graphic.

625 Samson and Cesari include the question mark, possibly to denote uncertainty about whether is activity is ongoing. *Samson and Cesari, Global Counterspace Capabilities 2025*, 02-14–15.

626 Samson and Cesari did not list orbital parameters for this entry. A previous page provided more detail, including Cosmos 2558 was launched into LEO, and precise data was unnecessary for the graphic. Samson and Cesari, *Global Counterspace Capabilities 2025*, 02–11.

APPENDIX B: PWSA RDT&E COST ESTIMATE

To arrive at a figure for RDT&E sums of the Proliferated Warfighter Space Architecture, we first identified programs to include by searching for the terms "Proliferated Warfighter Space Architecture" and "PWSA" in the U.S. Air Force's FY25 budget justification book for RDT&E and the Space Development Agency's budget justification books for RDT&E for FY22-24.

Program Element Name: *Space Science and Technology Research and Development*
Program Element Code: 1206310SF, 1206310SDA (FY21)
Description: Supports the Transport Layer as part of PWSA

Program Element Name: *Space Technology Development and Prototyping*
Program Element Code: 1206410SF, 1206310SDA (FY21)
Description: Supports the Transport Layer as part of PWSA

Program Element Name: *Resilient Missile Warning Missile Tracking - Low Earth Orbit (LEO)*
Program Element Code: 1206446SF
Description: Supports the Tracking Layer Layer as part of PWSA

Program Element Name: *Resilient Missile Warning Missile Tracking – Integrated Ground Segment*
Program Element Code: 1206448SF
Description: Supports the SDA Tracking Layer as part of PWSA
Notes: This project code was only used for FY24, as in FY2025 and beyond, the program element was transferred to PE 1206446SF (Resilient Missile Warning Missile Tracking - Low Earth Orbit (LEO)), Project 657LEO (Resilient MW/MT - LEO) and to PE 1206447SF (Resilient Missile Warning Missile Tracking - Medium Earth Orbit (MEO)), Project 657MEO (Resilient MW/MT - MEO). For FY24, we only included the funding in this code for LEO ("Missile Warning (MW)/ Missile Tracking (MT) Ground Low Earth Orbit (LEO)"), *not* the funding broken down for MEO.

There was an additional Program Element, 0605502SDA/Small Business Innovation Research, which we did not include in the analysis. It included funds for small business R&D in support of PWSA. It appeared in the SDA's budget documents for FY24, but it does not appear in FY25's Air Force document nor in early SDA budget documents under the same name.

TABLE B.1: COST OF PWSA RDT&E, MILLIONS OF USD

Program Element Code	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	Total
	Actual				*Estimated*	*Requested*	*Projected*				
1206310SF[627]	20.001	69.914	166.615	431.411	472.493	425.166	477.878	428.174	281.289	428.318	3181.258
1206410SF[628]	75.216	187.953	1160.23	979.36	2081.307	1701.685	1799.72	1824.708	1900.937	1938.374	13574.28
1206448SF[629]					252.785						252.785
1206446SF[630]				786.34	1266.437	1730.821	1887.813	2553.739	2066.041	2788.691	13079.88
										TOTAL	30,088.2

The resulting figure is the sum of actual (FY20-23), estimated (FY24), requested (FY25), and projected (FY26-29) total program element denominated in current year dollars of the Total Obligation Authority.

627 For the figures for FY20-22, this PE Code used to find the PE was 1206310SDA.

FY20 figures from: DoD, *Fiscal Year (FY) 2022 Budget Estimates, Research, Development, Test & Evaluation, Defense-Wide (Space Development Agency)*, vol. 5 (Washington, DC: DoD, 2021) https://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2022/budget_justification/pdfs/03_RDT_and_E/SDA_PB2022_v2.pdf, 1. FY21 figures from: DoD, *Fiscal Year (FY) 2023 Budget Estimates, Research, Development, Test & Evaluation, Defense-Wide (Space Development Agency)*, vol. 5, (Washington, DC: DoD, 2022), https://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2023/budget_justification/pdfs/03_RDT_and_E/SDA_PB2023.pdf, 1. FY22 figures from: and DoD, *Fiscal Year (FY) 2024 Budget Estimates, Research, Development, Test & Evaluation, Defense-Wide (Space Development Agency)*, vol. 5, (Washington, DC: DoD, 2023), https://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2024/budget_justification/pdfs/03_RDT_and_E/RDTE_SDA_PB_2024.pdf, 1. FY23-29 figures from: Department of the Air Force, *Fiscal Year (FY) 2025 Budget Estimates, Research, Development, Test & Evaluation, Space Force*, vol. 1 (Washington, DC: Department of the Air Force, 2024), 44, 473, https://www.saffm.hq.af.mil/LinkClick.aspx?fileticket=eMkgj7wbmGM%3d&portalid=84, 43.

628 For the figures for FY20-22, this PE Code used to find the PE was 1206410SDA.

FY20 figures from: DoD, *Fiscal Year (FY) 2022 Budget Estimates, RDT&E,* 11. FY21 figures from: DoD, *Fiscal Year (FY) 2023 Budget Estimates, RDT&E*, 5. FY22 figures from: DoD, *Fiscal Year (FY) 2024 Budget Estimates, RDT&E*, 5. FY23-29 figures from: Department of the Air Force, *Fiscal Year (FY) 2025 Budget Estimates, RDT&E, Space Force,* 133.

629 FY23-29 figures from: Department of the Air Force, *Fiscal Year (FY) 2025 Budget Estimates, RDT&E, Space Force,* 499.

630 FY23-29 figures from: Department of the Air Force, *Fiscal Year (FY) 2025 Budget Estimates, RDT&E, Space Force,* 473.

LIST OF ACRONYMS

APOSOS	Asia-Pacific Ground-Based Optical Space Object Observation System
APSCO	Asia-Pacific Space Cooperation Organization
ASAT	anti-satellite weapon
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
CASC	Chinese Aerospace Science and Technology Corporation
CCP	Chinese Communist Party
CMF	civil–military fusion
CNSA	China National Space Administration
DA-ASAT	direct-ascent anti-satellite weapon
DEW	directed-energy weapons
DIA	U.S. Defense Intelligence Agency
ESSS	Integrated Satellite Communication System
EO	electro-optical
EW	electronic warfare
FOBS	Fractional Orbital Bombardment System
GEO	geostationary orbit
GLONASS	Globalnaya Navigatsionnaya Sputnikovaya Sistema
GNSS	global navigation satellite system
GSSAP	Geosynchronous Space Situational Awareness Program
HEO	highly elliptical orbit
HGV	hypersonic glide vehicle
ISR	Intelligence, Surveillance, and Reconnaissance
ISS	International Space Station
LEO	low Earth orbit
KV	Russian Space Forces
MEO	medium Earth orbit
NC3	Nuclear Command, Control, and Communications
NDS	National Defense Strategy
PLA	People’s Liberation Army
PLASSF	People’s Liberation Army Strategic Support Force
PLEO	proliferated low Earth orbit
PNT	position, navigation, and timing
PRC	People’s Republic of China
PWSA	Proliferated Warfighter Space Architecture

RPO	rendezvous and proximity operations
SAR	synthetic aperture radar
SASTIND	State Administration for Science, Technology, and Industry for National Defense
SATCOM	satellite communications
SDA	space domain awareness
SIGINT	signals intelligence
SLV	space launch vehicle
SOE	state-owned enterprise
SSA	space situational awareness
USSF	U.S. Space Force
USSPACECOM	U.S. Space Command
VKS	Russian Aerospace Forces

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