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ANALYSIS

A Comprehensive Triad for Space Resilience – More than Just Numbers

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By: Chris Bassler and Tate Nurkin

Related Experts: Chris Bassler, Tate Nurkin

Defense Department and Space Force leaders have increasingly emphasized space resilience as the key to space superiority. Previous efforts developed taxonomies for space resilience and considered differences between mission resiliency and system resiliency. In 2016, then deputy assistant secretary of defense for space policy, Douglas Loverro, specified six major investment areas to enhance space resilience: disaggregation, diversity, distribution, deception, protection, and proliferation and urged that "we need to exercise all six of those different kinds of resilience…[to] get the true resilience we want."

Taken together, these ideas offer three approaches to resilience: proliferation, reconstitution, and retaliation. To date, DoD's approach to resilience has been overly focused on resilience through proliferation. To meet the threat to U.S. space systems, DoD needs to broaden its approach to resilience to fully embrace reconstitution. DoD also should think further about deterrence through the threat of retaliation, especially non-kinetic-based deterrence by punishment approaches that are already feasible and mutually reinforcing to reconstitution and retaliation. Although DoD and Space Force leaders have begun talking about the need for rapid replenishment of space constellations, the department needs to accelerate investment and acquire the needed capabilities for reconstitution and retaliation to shore up the space resiliency triad.

Threats to Space Capabilities

In November 2021, Space Force's Vice Chief of Operations, Lt. Gen. David Thompson, revealed that U.S. satellites face cyber attacks, jamming, and laser dazzling from states including China and Russia "every single day." The comments came only days after Russia tested a ground-launched anti-satellite (ASAT) weapon against a live satellite target, joining China (2007) and India (2019) in the list of countries that have tested direct-ascent ASAT weapons against a satellite in orbit. In addition, Russian and Chinese satellites have been observed shadowing other space assets, likely to practice and prepare for disabling operations.

Collectively, Lt. Gen.Thompson's comments and DoD's overall threat assessments for space and the Russian test demonstrate the increasing diversity and sophistication of the counter-space challenge as well as the growing intensity of military competition in space. As Air Force Secretary Frank Kendall observed in March 2022, "our general posture has been to assume essentially impunity in space…that era is over."

This rapidly emerging era of a more contested, congested, and competitive space domain holds significant risk for the United States and its allies and partners. The space architecture used by the U.S. and its allies is an artifact of a past era and was built under assumptions of security that no longer apply. Adversaries have developed the ability to hold at risk the small quantities of exquisite satellites that make up the current architecture. If the United States remains on its current course, its ability to find, collect, communicate, and track threats – including fast-moving and difficult targets, such as hypersonic or space weapons – could be diminished.

Resilience Through Proliferated Constellations

To help retain U.S. advantage and protect American military and commercial interests in space, DoD's space architecture must have increased resilience as one of its key design parameters. Achieving resilience will require developing new capabilities and implementing new approaches in space, on Earth, and with industry. Chief of Space Operations, Gen. Jay Raymond, has characterized the shift in DoD's space architecture as moving from exquisite, few, and vulnerable to diverse, proliferated, and resilient. Most of DoD's recent and ongoing efforts have pursued the shift to proliferated and distributed constellations, along with increased use of commercial space assets to complement national security space assets.

The discussion of space resilience naturally begins with measures to increase the quantity, diversity, and redundancy of DoD's space architecture. Through the Space Development Agency, DoD has already started the process of building a proliferated architecture of hundreds of small satellites in low Earth orbit that will track advanced mobile missile launches and transport data around the architecture at the speed of light. The idea is that creating redundancy lowers the possibility that a single attack could disrupt the whole system. The initial Tranche 0 tracking satellites are now expected to be launched in 2023, and Tranche 1 will be launched in 2025. Space Force's FY23 budget request dedicates $1 billion to the continued development of the seven-layer National Defense Space Architecture, which overwhelmingly emphasizes proliferated constellation approaches.

Although necessary, greatly expanding the number of satellites in LEO alone will be insufficient to increase resilience for American and allied space activities. Needed efforts to increase resilience should include placing satellites in other orbits and hardening satellites against cyber and electronic warfare attacks. It should include measures to increase the maneuverability of space assets to avoid physical threats, either from adversary co-orbital satellites or from space debris. It should also include the use of commercial space-based resources, as well as increased collaboration with allies and partners. Collaboration with America's closest allies, Australia and Britain, in the context of the trilateral AUKUS security pact makes sense. Japan is also accelerating its commercial and military space efforts. In addition, Norway, Japan, and the United Kingdom have all agreed to host U.S. military payloads on their satellites, and additional partners are likely to offer new opportunities.

Such efforts do not come without risk. Expanding satellite constellations will complicate the already daunting task of space situational awareness (SSA). In August 2021, Lt. Gen. Stephen Witting, the head of Space Operations Command, said that U.S. Space Command is tracking 35,000 objects in LEO, a 22% increase from just two years ago. This increase is largely due to commercial "megaconstellations" such as Starlink, which also affect the quality of radio and optical astronomical observations. Moreover, greater government use of commercial satellites could lead adversaries to target them, holding at risk constellations that provide important services, not to governments but to societies.

Although attractive because of ubiquity and cost, commercial space assets have their own resilience challenges. Space weather and solar storms can disable insufficiently shielded systems. Adversaries can carry out jamming and cyberattacks. DoD can advise on basic hardening approaches to keep these assets low cost while decreasing their vulnerability. But widespread and multi-mode data link compatibility and laser communications can also help to increase the resilience of commercial space assets further.

Space traffic management and multi-orbit SSA capabilities to track and detect threats are thus intrinsic to space resilience and must be priorities for DoD and the U.S. government. In addition, investment in satellite maneuverability and space debris remediation capabilities will also help ensure that a more proliferated and resilient U.S. space-based architecture remains sustainable.

Space resilience also has an important terrestrial component. Hardening ground stations against cyber and electronic warfare attacks will be necessary. So, too, will be developing and proliferating terrestrial alternatives to space-based communications. Re-routing and adding additional undersea cables, along with fielding decentralized mesh networks enabled by 6G technologies, are key diversification efforts.

The Second Leg of the Space Resilience Triad: Reconstitution

The United States needs to broaden its approach to space resilience to include rapid reconstitution. Although DoD and Space Force leaders have increasingly acknowledged the need for rapid replenishment of space constellations, and the need to move faster to acquire the capabilities necessary to make that happen, that has yet to be reflected fully in the DoD budget. DoD should urgently work with commercial industry and other government agencies to develop the capacity to reconstitute satellites rapidly and affordably to hedge against the possibility that existing ones will be degraded, destroyed, or become inoperable. As Boeing executive Stu Eberhardt noted during March's Air Warfare Symposium, "We used to play those war games where you looked at reconstitution. And it would take you two years to reconstitute a satellite. That's totally unacceptable." Indeed, for decades DoD has played many days (or weeks) without space wargames that have revealed U.S. vulnerabilities and the potentially dire consequences of losing access to space. But what if the U.S. developed rapid reconstitution capabilities that would reduce this period from months or weeks to mere hours – effectively an early afternoon without space?

The current national security space industrial base and supply chain are not aligned with the need for rapid reconstitution. The preponderance of production lines remain labor-intensive and have low-quantity outputs. Exquisite systems are designed and manufactured under the most stressing parameters and tolerances. Stocks of ready-now spares are woefully inadequate, and it takes far too long to get space-qualified microelectronics. Some efforts have already shown the possibilities for new paths, using advanced manufacturing and automation techniques that are already enabling order of magnitude jumps in production output. Still, DoD must do more to incentivize these scale and surge capacities.

SpaceX's reusable rockets have proven a more efficient and cost-effective means of getting satellites into space, offering more numerous and frequent windows for national security space to leverage ridesharing opportunities. However, the time is now for DoD to invest in the readiness of launch facilities and move away from dependence on Vandenberg, Cape Canaveral, and Wallops Island. This can be achieved by certifying America's other spaceports for national security use and adding allied international spaceports to the inventory of options. It will be worthwhile to develop the capacity to launch satellites from other platforms, such as using naval surface combatant vertical launching system cells, submarine missile tubes, and shipping containers. Additionally, orbital refueling, in-space servicing, and on-orbit manufacturing can help build resiliency through reconstitution. Previous DARPA efforts, such as the Launch Challenge, airborne launch assist, disposable satellites, and robotic servicing have demonstrated technological approaches that Space Force should adapt and field.

Achieving this will require resources, leadership focus, and ultimately organizational and cultural change. The Defense Department faces competing modernization priorities, while America's space industry faces attractive commercial and venture investment opportunities and must contend with a supply chain strained by geopolitical competition and COVID-19. However, DoD can help create the processes and incentives needed to speed up acquisition, increase flexibility, and effectively engage with the defense industry and the growing commercial space sector.

DoD can, for example, catalyze rapid manufacturing approaches for the production and fielding of space assets at previously unimaginable scales. Investments in automated production, digitalization, and the minimization of human touch labor will facilitate the production of satellites and other space assets at the scale required to achieve lower cost, field more rapidly, and prepare for mass production and reconstitution in the event of warfare in space. Space Force and the Department of the Air Force are already at the forefront of incorporating digital engineering and agile software development, but continued and focused work is necessary to fully leverage the benefits of shared digital design and simulation environments to achieve mass production, to have the ability to deliver bespoke space assets at scale. Once launched, additional on-orbit servicing, assembly and repair capabilities and space debris clean-up can help reconstitution efforts, even without a supporting launch.

The Third Leg of the Space Resilience Triad: Retaliation

Perhaps the least considered of the three legs, the U.S. may increasingly have more options available for retaliation. Recent approaches and technologies enable multiple options, even without resorting to a kinetic counter-attack against an adversary. Adoption of key technologies and approaches can specifically enable non-kinetic capabilities. These provide additional flexibility for the U.S to disrupt, degrade, and disable an adversary, especially considering adversary space architectures also share many of the existing vulnerabilities that the U.S. faces. These non-kinetic approaches can be levied against adversary space capabilities in orbit, terrestrially, and via other means, including limiting access to key enabling technologies. These additional options for retaliation may help increase the deterrence of an attack, all while not having to resort to kinetic anti-satellite capabilities and their damaging and chaotic effects, creating space debris and orbital collisions.

A Connected Triad of Resilience

Although leaders have increasingly been willing to talk about space resilience in the form of proliferated constellations, what is needed is a balanced, mutually reinforcing triad based on proliferation, reconstitution, and retaliation. However, implementing such a vision will require bureaucratic and cultural change and a shift in budgetary priorities.

Secretary Kendall has asked what scares America's competitors and adversaries. The answer should be the pursuit of a comprehensive and connected triad of resilience that can ensure U.S. advantage even after an attack. Space capabilities that can persist in the crucial but increasingly contested space domain will be the decisive advantage even in the face of expanding and more sophisticated threats. Adversaries will soon come to realize that even if they attempt to knock down U.S. space capabilities, America will be able to get them right back up again, and the consequences will be severe.

Chris Bassler is a senior fellow and Tate Nurkin is a non-resident senior fellow with the Center for Strategic and Budgetary Assessments.

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