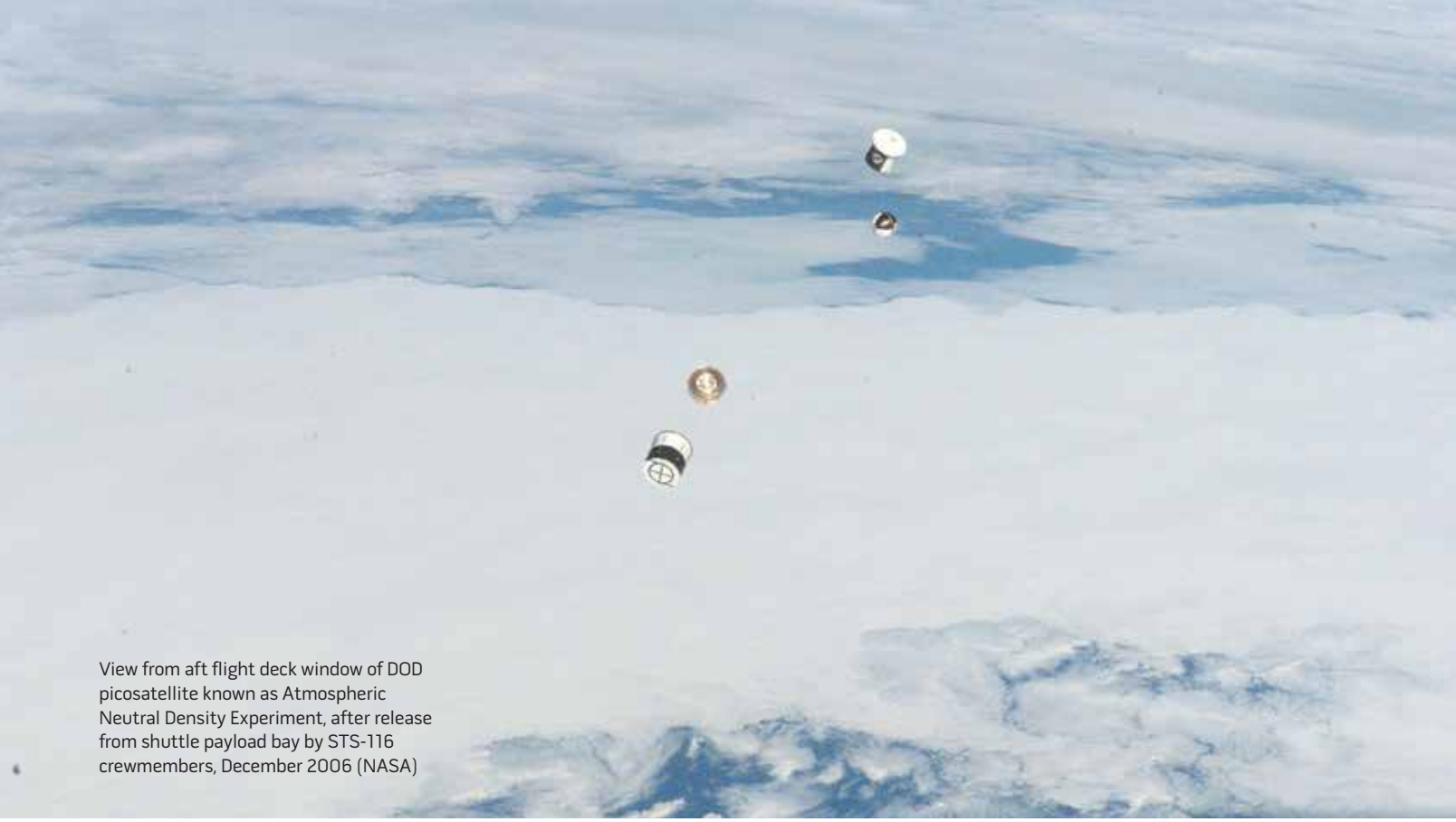

View from aft flight deck window of DOD picosatellite known as Atmospheric Neutral Density Experiment, after release from shuttle payload bay by STS-116 crewmembers, December 2006 (NASA)

568 Balls in the Air

Planning for the Loss of Space Capabilities

By Chadwick D. Igl, Candy S. Smith, Daniel R. Fowler, and William L. Angermann

An event of considerable technical and scientific importance . . . [its] *importance should not be exaggerated . . . the value of the satellite to mankind will for a long time be highly problematical.*

—Secretary of State John Foster Dulles, 1957

On October 4, 1957, while the United States focused on domestic issues, the Soviet Union successfully launched the world's first satellite, Sputnik. This event, which President Dwight Eisenhower quipped was simply "one small ball in the air," ushered in the Space Era and—following President John F. Kennedy's challenge to land an American on the moon by the end of the 1960s—ignited the Space Race.[1]

The Space Race encompassed the National Aeronautics and Space Administration's (NASA's) Manned Space Lunar program, which drove America to the moon and inspired groundbreaking American satellite programs. From 1958 to 1960, U.S. space firsts included Corona, the first reconnaissance satellite; Vanguard II, the first weather satellite and the first to take a photo from space; and TRANSIT IB, the first navigation satellite program.[2] These programs laid the framework for the U.S. military's dependence

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on the National Reconnaissance Office's imagery and signals intelligence capabilities, real-time weather capabilities provided by the Defense Meteorological Support Program, and the ubiquitous Positioning, Navigation, and Timing (PNT) system, which provides, at no charge to over 2 billion people, access to the Global Positioning System (GPS) constellation. Today, nearly 60 years after Sputnik, the space capabilities and effects provided by 568 U.S. satellites are deeply integrated into all aspects of society, especially the U.S. military, and that dependence upon them is simultaneously unrecognized and irreplaceable.[3] Specifically, the U.S. military is heavily dependent on space capabilities to provide navigation accuracy for weapons employment, bandwidth for telecommunications, signals and imagery for indications and warning, and missile warning for theater operations and nuclear strategic attack. These dependencies create unquantified risk to the United States, and an adversary attack could compromise the effects provided by U.S space systems.

Essentially, space capabilities became a center of gravity (COG) for the United States because the U.S. military depends on these capabilities and effects across all aspects of military operations.[4] Space effects influence planning and execution at strategic, operational, and tactical levels of war. At the strategic level, space capabilities influence national economic and defense policy including investment banking and combatant command theater strategies. Campaigns and major operations depend on space assets at the operational level. Tactically, battles and engagements utilize space assets to gain and maintain advantage over the enemy. In fact, the Department of Defense (DOD) integrates and embeds these capabilities so deeply that warfighters rely heavily on the benefits of space assets without a corresponding understanding of how much the U.S. military depends on them. By examining the assumed and unique risk of space assets, we posit that systemic integration requires commanders and planning staffs to reduce this liability by coherently identifying, comprehending, planning, and mitigating the potential loss of capabilities.

The Importance of Space to the U.S. Military

The uniqueness of the space domain requires combatant commands to acknowledge and protect this COG through the operational art of planning and mitigating risk. The failure to understand and plan for the probability and severity of loss may well lead to the culmination of the United States during war. Unfortunately, many U.S. adversaries already understand the American reliance on space as a COG and an operational military paradigm. Chinese military officers, strategists, and academics demonstrate a clear-eyed view of the space role by pointing out that the opening action of any future war will likely take place in space, due to its nature as a COG.[5] Russia, notable and singular among U.S. near-peers, recently combined its air and space capabilities under one command, not only to ensure a prompt response to an attack on its capabilities but also to ensure it engages adversaries in the first stage of any conflict.[6] Combatant command staffs must plan to mitigate the potential loss of space capabilities if the United States is to counter near-peer adversaries' understanding of space and their attempts to leverage space as a COG during or prior to conflict.

Assessing the Absence of Space Capabilities

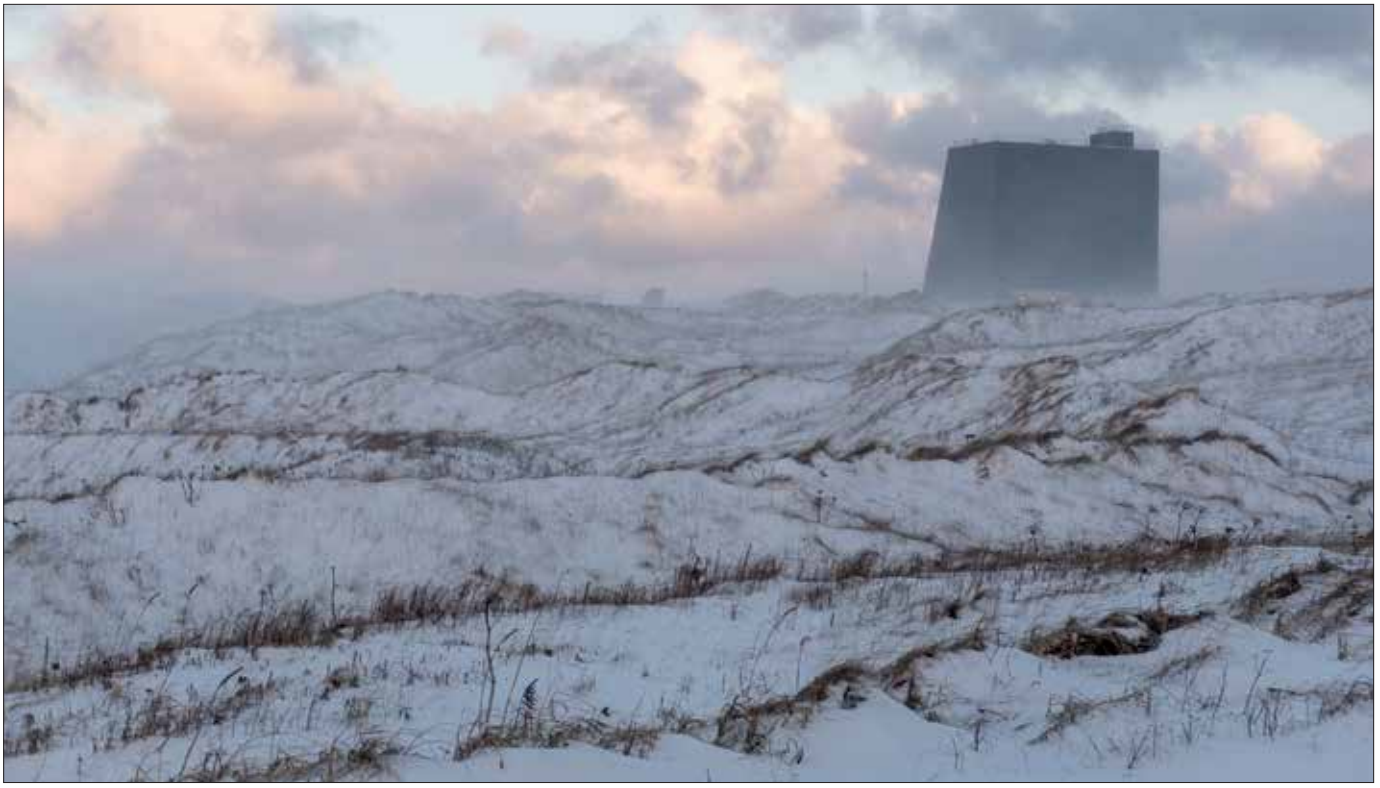
Because the Services fully integrate space capabilities into warfighting systems, the space capabilities themselves have become integral to mission execution and, ultimately, mission success. To assume that space capabilities, including ground systems, will be available and dependable in a conflict is inherently dangerous and could lead to U.S. military failure. Given how the U.S. military conducts its simulations of denied or degraded space capabilities in exercises, such failure is possible. In recent exercises, white cell teams quickly restored denied space services and capabilities to allow progress in order to meet training objectives.[7] While the purpose of a joint military exercise is to create an artificial environment that provides warfighters the opportunity to execute wartime operational plans, competing objectives result in an unwillingness to play out the scenarios in a denied or degraded environment that warfighters can expect to experience during actual conflict. This is a clear indicator of the critical dependence U.S. forces have on space. Yet the U.S. military operates daily with the expectation that it will not experience long-term denial of space effects. As with the rest of the exercise training objectives, U.S. military commanders and staffs must assess, plan, and routinely train for the risk of operating without integrated space effects at every level of war. This conflict of interest does not allow the warfighter to understand the true impact of near-peer adversaries' abilities to counter U.S. capabilities on the battlefield.

Identifying risk at the strategic level should begin by addressing the military assumption that long-term GPS denial is unlikely to occur. The common misperception by military commanders in the field is that GPS denial would be localized, temporary, and compensated by alternate options. In October 2008, Dr. Peter Hays, a senior space policy analyst with Falcon Research, stated,

One of the greatest distinctions today is that most commanders in the field don't put a lot of time and energy into thinking about how to get the effect they are calling for. They simply call for an effect and they have great confidence that it will be delivered from a wide variety of long-range precision strike capabilities and platforms.[8]

Highly reliable satellites and their corresponding space effects contribute to this misperception. However, more important, the commander's confidence in space effects results in a lack of plans for operating in a protracted, contested space environment and an implied assumed risk rather than an explicit assumption of risk.

A lack of detailed, articulate plans at the strategic level leads to unacknowledged and unquantified risks at the operational level. A primary consequence of overconfidence in the provision of



AN/FPS-108 Cobra Dane radar, located at Eareckson Air Station, on Shemya, Aleutian Islands, Alaska, collects radar metric and signature data on foreign ballistic missile events and space surveillance data on new foreign launches and satellites in low-Earth orbit (U.S. Air Force/Brandon Rail)

space effects is the risk of having ineffective mitigation and restoration plans. Warfighters must understand what the consequences of a loss of space effects would be, and they should be able to quickly make informed decisions on direct action to restore a capability or operate without it. At U.S. Strategic Command (USSTRATCOM), warfighters who directly control space assets and have mitigation plans to address losses or gaps do not actively utilize the space capabilities allocated in their area of responsibility. In most situations, a warfighter downrange must inform the functional combatant command warfighters who control space assets that a denial or degradation exists. Often, warfighters downrange perceive a denial as fleeting and likely to be resolved without taking action. This usually delays switching to a contingency plan—if one exists. A comprehensive plan must promptly direct operators to identify lost and degraded space effects, quickly notify all users of the outage situation, inform the correct agencies and units that can restore services, and transparently implement immediate mitigation actions.

At the operational level, a long-term GPS or satellite communications denial would cripple all joint functions and result in incalculable risk. Operational commanders' complete isolation from the battlefield would detrimentally affect distributed command and control of forces until mitigation actions resolve the outage. A common operating picture could be unreliable for situational awareness because chat and voice communications dependent on GPS timing signals would be unavailable. The ability to give and receive orders would be restricted to hardline telephones; these could be easily compromised and the adversary could deny line-of-sight radio transmissions. While intelligence, surveillance, and reconnaissance capabilities may be available through classified systems, war-planning rooms dependent on satellite communications would have blank displays instead of routine news feeds. Additional data sources might display a "404–Page Not Found!" error, signaling a failed Internet connection. Accordingly, operational plans need to be in place to ensure mission accomplishment, and those plans need to be exercised extensively in anticipated real-world conditions to retrograde to alternative means or equipment.

The tactical level would also suffer severe limitations for providing an accurate application of lethal force and effective self-defense resulting in the unnecessary risk of collateral damage to people and equipment. Many sensors, munitions, guidance, navigation, and weapons systems have a critical dependence on GPS or other space effects. For example, an unmanned aircraft tasked to conduct a mission in a degraded environment would struggle to proceed to the target and be unable to reliably deliver ordnance or find the way back for a safe recovery. The United States predicates many of its systems designed for the purpose of indication and warning on the availability of space-provided connectivity. Peter W. Singer, a 21st-century warfare expert from the New America Foundation, summarized the military consequences of losing satellites:

As one U.S. military officer put it, [it would] *take us back to the "pre-digital*

age." Our drones, our missiles, even our ground units wouldn't be able to operate the way we plan. It would force a rewrite of all our assumptions of 21st-century high-tech war. We might have a new generation of stealthy battleships . . . but the loss of space would mean naval battles would in many ways be like the game of Battleship, where the two sides would struggle to even find each other.[9]

Near-peer adversaries publicly admitted to challenging continued U.S. reliance on strategic advantages in space, thereby making the expectation of complete control over the U.S. operating environment a risk-laden assumption.[10]

While many of the systems the U.S. military utilizes today can operate in degraded conditions, warfighters lack sufficient proficiency due to limited experience operating the systems in that fashion. The reliability and seamless integration of satellites and their corresponding space effects in military operations cause most warfighters to take space capabilities and effects for granted, which instills a false sense of confidence that will be shattered and paralyzing if or when that capability is unavailable. Confidence in a capability that may not exist—but upon which the warfighter is also completely dependent—quickly becomes a major liability. As Michael Peck, a contributing writer for the *National Interest*, noted, "No doubt the Pentagon will find alternative technologies, perhaps something that will replace GPS. But the larger question is technological dependence. If the [U.S. military] is that helpless when GPS is down, then perhaps the problem is with the user as well as the technology."[11] For this simple reason, the U.S. military must place greater emphasis on education, training, and planning, to include the identification or development of alternate technology to address appropriately operating without space-related capabilities.

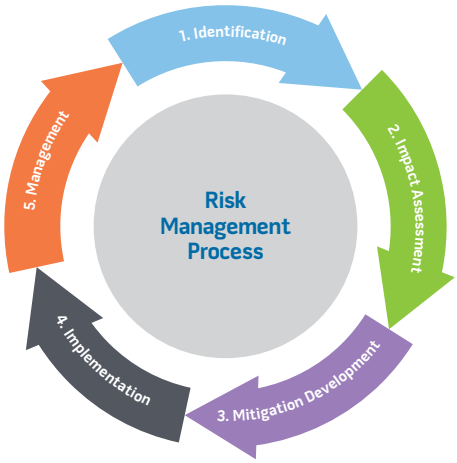
The 2012 Capstone Concept for Joint Operations (CCJO) recognizes the shortfall in education, planning, and training. Specifically, it addresses operating in a degraded environment by underscoring the *dramatic increases in the ability of adversaries to disrupt, degrade, or destroy cyberspace and space systems, it is essential that Joint Forces be able to operate effectively despite degradation to those systems. Greater resilience must be built into technical architectures, and the force must regularly train to operate in worst case degraded environments.*[12]

While the CCJO states mission command must be integral to training at the tactical level, the concepts of shared understanding and executing commander's intent will only be amplified and severely affected if the tactical warfighters become cut off from operational commanders due to the unplanned and unmitigated loss of space capabilities. This is more than a technical limitation. Education, planning, and training for the loss of space capabilities must be reinforced with routine exercises to firmly incorporate a decision-making paradigm where deployed forces are empowered to make all necessary decisions affecting their force deployment and engagement.

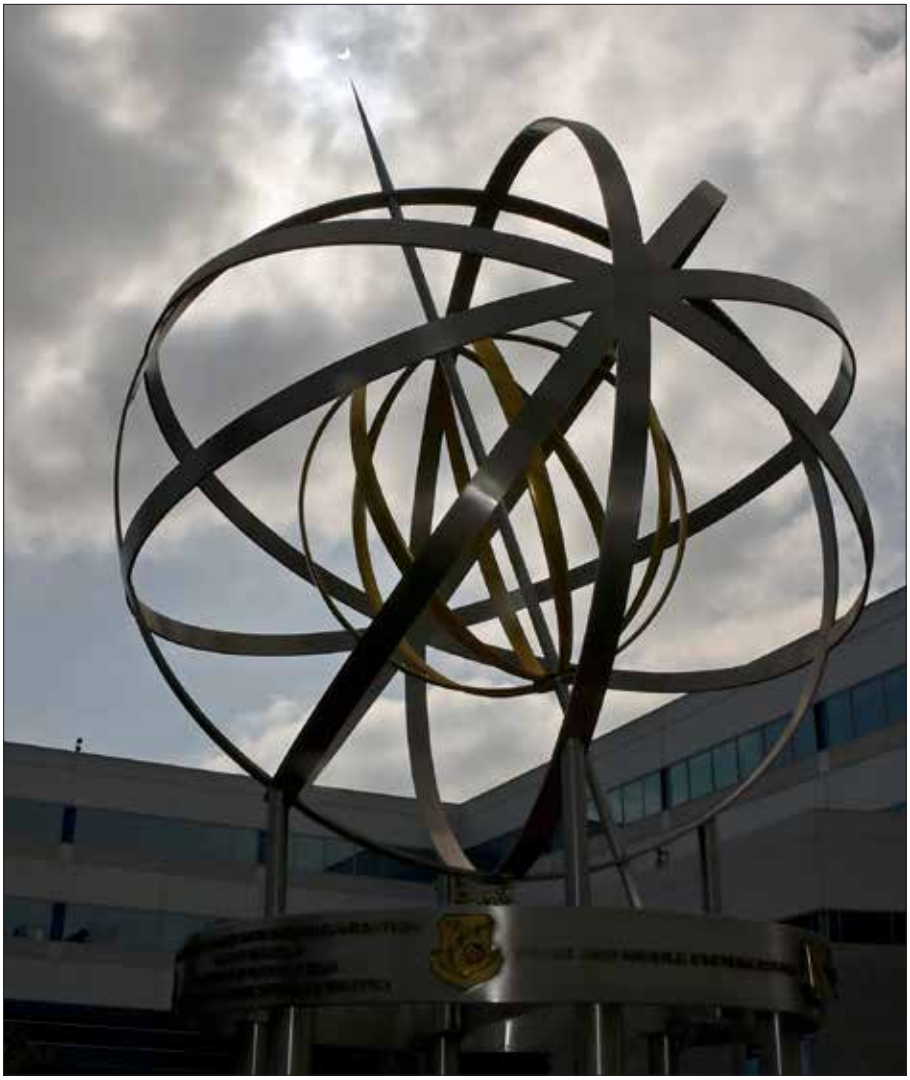
Ensuring Access to Capabilities

A common risk management process, as illustrated in the figure, represents a simplified, structured approach for commanders and combatant command staffs to plan for the loss of space capabilities at all three levels of war. Through a process of continual assessment, U.S. forces must identify problems, assess impacts, develop and implement mitigation plans, and train to manage risk to and dependence on exploitable space systems in a conflict.[13] Any technological advantage U.S. forces have over an adversary could be severely and devastatingly reduced and result in the culmination of the U.S. military through mission failure or unacceptably high attrition. This risk could manifest itself in lost aircraft, ships, Soldiers, and Marines at levels not experienced since the Vietnam War. Under the Trump administration, DOD must include requirements in U.S. grand strategy and national policy to pursue alternative technologies that reduce this exploitable dependency. For GPS, an initiative termed "Assured PNT (APNT)" advocates for an open architecture that has the ability to incorporate multiple PNT-like sensors that improve resilience.[14] Dee Ann Divis, a contributing editor to *Inside GNSS*, highlights how APNT systems under development, including pseudolites and chip-scale atomic clocks,[15] present viable alternatives that provide resiliency and immediate backup capability to on-orbit GPS satellites.[16] Operationally, combatant command staffs must enforce denial or degradation reporting. Prompt reporting enables warfighters to implement mitigation plans and restore capabilities as quickly as possible. These comprehensive plans must also focus on how to maintain command and control through backup and legacy systems as well as direct tactical forces to work independently utilizing tactics and procedures that do not rely on space.

Figure. Risk Management Process



Currently, planning fails to account for the sustained loss of space effects. Commanders rely on staff planners to engage this problem, which they are accustomed to, but space capabilities and effects are not an asset that geographic combatant commands directly control. Due to the global nature of the space domain, space effects extend across all theaters. As specified in the Unified Command Plan, USSTRATCOM is responsible for delivering the requested space effects to meet combatant command requirements. Joint Functional



Armillary Sphere, adopted symbol of Space and Missile Systems Center at Los Angeles Air Force Base, points to partial solar eclipse at approximately 61 percent obscuration of sun at 10:20 A.M. local time, El Segundo, California, August 21, 2017 (U.S. Air Force/Sarah Corrice)

Component Command for Space (JFCC SPACE) accomplishes this through Joint Space Tasking Orders, focusing on effects, not tangible asset allocation.[17] Geographic combatant commanders are not allocated space assets. USSTRATCOM provides other space capabilities, such as satellite communications, as an effect rather than an asset, through a priority-based architecture. In most cases, combatant command staffs do not explicitly plan for space effects because USSTRATCOM provides space capabilities. The personnel responsible for maintaining the technological advantage at the combatant commands are space operations subject matter experts (SMEs). The "U.S. Strategic Command effects" and the corresponding U.S. military advantage in space are assumed asymmetric advantages. However, assumed technological advantages are decreasing rapidly.

The April 2012 Chairman of the Joint Chiefs of Staff White Paper discussing mission command emphasizes the need to empower field commanders to make decisions in the field.[18] This mentality permeates geographic combatant command staffs and joint force headquarters where the joint force commanders (JFCs) rely on SMEs to use their knowledge pertaining to highly complex systems to influence decisionmaking.

From a mission command perspective, the SMEs have the unique responsibility requiring them to consider all possible scenarios and then incorporate the effects into corresponding plans. Within USSTRATCOM, a small number of space SMEs are assigned to the headquarters staff, while a larger number of SMEs are assigned to JFCC SPACE. At the geographic combatant commands, just a few billets are allocated to space SMEs with a predominant number of those billets allocated to the Air Force. The Services must fill these billets with competent, knowledgeable space personnel capable of complete integration into any type of planning process, whether deliberate or crisis action. At the combatant commands, the J3 and J5 staffs must prioritize their space SME billets through the assignment process to ensure a gap in personnel does not result in a loss of military capability because a space SME was not positioned to articulate the importance of space capabilities to routine military operations. Building a robust space SME core is thus a joint effort where both the Services and combatant commands must work together to fill these critical space SME billets.

Operating Without Space

With the onset of combat operations in 2003, DOD focused on reacting to the changing nature of military operations in Iraq and Afghanistan, contributing to a decreased emphasis on maintaining the U.S. technological supremacy over near-peer adversaries. This change in focus allowed adversaries to close the technology gap significantly. The Chinese launch in 2007 of a direct ascent antisatellite weapon to destroy an old satellite in low-Earth orbit caused concern.[19] However, it was the 2013 revelation that China had the capability to launch a direct ascent antisatellite weapon to destroy a satellite in a 22,000-mile geosynchronous orbit that proved China had closed the technology gap.[20] The discovery that China could attack U.S. systems in space quickly sparked the realization that the U.S. military's dependence on space technology may also be its greatest risk. This idea has yet to fully sink in. More concerning to experts is that both China and Russia are developing weapons that threaten U.S. space capabilities on the ground as well as in space.

The discussion of the importance of space capabilities and effects highlights the crucial need to understand space as a center of gravity. The impact of a loss of space effects is clear, especially as near-peer adversaries actively develop capabilities to deny, degrade, and disrupt U.S. access. As the functional combatant command tasked with providing space capabilities, USSTRATCOM has the responsibility to plan for and provide these space effects. However, advanced planning at geographic combatant commands cannot stand by and wait when space effects are lost or disrupted. From a warfighter's perspective, the JFC executes mission command over the assets assigned to accomplish the mission. Planning staffs must recognize the misperception that space effects will always be available and begin educating, planning, and training to operate in a degraded environment to prevent the loss of Servicemembers and materiel, as well as to avoid incurring collateral damage. The fact that geographic combatant commands do not own space assets does not prevent them from continually assessing risk and developing robust plans that mitigate the risk to ensure U.S. forces have the capability to fight a near-peer adversary when space capabilities are lost or degraded. Today's warfighter, from the JFC to the Soldier or Marine with boots on the ground, depends on space capabilities and effects just like the greatest generation depended on "beans and bullets" to win World War II.

Simply recognizing the importance of space effects integration is not enough. Comprehending the assumed risk and developing and exercising active mitigation plans is essential. Failure to do so quickly could lead to a culminating point and a corresponding severe degradation of U.S. military capability with potentially disastrous effects for U.S. national security. Such a failure, measured in lives lost, would be on a scale reminiscent of wars fought in the pre-digital age. A loss on this scale is simply unacceptable to the American public, especially when this risk can be mitigated by proactive planning at the geographic combatant commands.

The goal of this article, however, is not to prescribe specific types of risk mitigation and plans geographic combatant commands should pursue. It is to stress the importance that combatant commands must first *acknowledge* space as a center of gravity and, as such, *accept* that protecting the domain and its capabilities requires planning and risk mitigation. The combatant commands must also allow exercises to play out in order to understand requirement gaps and then clearly articulate those gaps to inform the Services' ability to develop and field systems to meet validated warfighter requirements. This is just the beginning of what should be a long, routine conversation to ensure that the U.S. military maintains the asymmetric advantage provided by space capabilities and effects. Ultimately, warfighters in every corner of the globe must understand and protect the critical capabilities that the 568 balls in the air provide. **JFQ**

Notes

[1] *One Small Ball in the Air: October 4, 1957–November 3, 1957*, Monographs in Aerospace History 10, NASA's Origins and the Dawn of the Space Age, available at <https://history.nasa.gov/monograph10/onesmlbl.html>.

[2] Yanek Mieczkowski, *Eisenhower's Sputnik Moment: The Race for Space and World Prestige* (Ithaca, NY: Cornell University Press, 2013), 368.

[3] Union of Concerned Scientists, "UCS Satellite Database," February 25, 2016, available at <www.ucsusa.org/nuclear-weapons/space-weapons/satellite-database#.Vzomc_krKUk>.

[4] Joint Publication 1-02, *Department of Defense Dictionary of Military and Associated Terms* (Washington, DC: The Joint Staff, November 8, 2010, as amended through February 15, 2016), defines *centers of gravity* as "those characteristics, capabilities, or localities from which a military force derives its freedom of action, physical strength, or will to fight."

[5] John Costello, *Chinese Views on the Information "Center of Gravity": Space, Cyber and Electronic Warfare*, China Brief 15, no. 8 (April 16, 2015), available at <https://jamestown.org/program/chinese-views-on-the-information-center-of-gravity-space-cyber-and-electronic-warfare/#.VyYxUKMrIb0>.

[6] Matthew Bodner, "Russian Military Merges Air Force and Space Command," *The Moscow Times*, August 3, 2015, available at <www.themoscowtimes.com/business/article/russian-military-merges-air-force-and-space-command/526672.html>.

[7] Chadwick D. Igl has witnessed this during multiple Tier 1 exercises since 2011.

[8] Ed Morris et al., "A Day Without Space: Economic and National Security Ramifications," Washington Roundtable on Science and Public Policy, Washington, DC, October 16, 2008.

[9] Peter W. Singer, cited by George Dvorsky, "What Would Happen If All Our Satellites Were Suddenly Destroyed?" *Io9*, June 4, 2015, available at <http://io9.gizmodo.com/what-would-happen-if-all-our-satellites-were-suddenly-d-1709006681>.

[10] Costello.

[11] Michael Peck, "The Pentagon Is Worried about Hacked GPS," *National Interest*, January 14, 2016, available at <http://nationalinterest.org/feature/the-pentagon-worried-about-hacked-gps-14898>.

[12] *Capstone Concept for Joint Operations: Joint Force 2020* (Washington, DC: The Joint Staff, September 10, 2012).

[13] Ibid.

[14] Dee Ann Divis, "Army Plans Awards, Solicitations for Assured PNT with(out) GPS," *Inside GNSS*, June 30, 2016.

[15] *Pseudolite* is a word-blend of "pseudo" and "satellite." Pseudolites include satellite-like transmitters that function similarly to GPS, but signals are transmitted closer to the Earth instead of coming from space, and the transmitters reside in terrestrial rather than on-orbit platforms such as a tent, vehicle, or low-flying aircraft. Chip-scale atomic clocks are small atomic clocks that use one one-hundredth the power (~100 milliwatts or 2AA batteries) of the conventional bread box–size counterparts. They do not keep track of the time of day; instead, they allow two or more geographically separated groups to stay exactly coordinated over time.

[16] Ibid.

[17] Air Force Doctrine Document 2, *Operations and Organizations* (Washington, DC: Headquarters Department of the Air Force, April 2007).

[18] Martin E. Dempsey, *Mission Command White Paper* (Washington, DC: The Joint Staff, April 3, 2012), available at <www.jcs.mil/Portals/36/Documents/Doctrine/concepts/cjcs_wp_missioncommand.pdf?ver=2017-12-28-162056-713>.

[19] Leonard David, "China's Anti-Satellite Test: Worrisome Debris Cloud Circles Earth," *Space.com*, February 2, 2007, available at <www.space.com/3415-china-anti-satellite-test-worrisome-debris-cloud-circles-earth.html>.

[20] Lori Robinson, "China's Military Closing Technology Gap with the U.S., Says American Air Force Chief," *South China Morning Post* (Hong Kong), February 16, 2016, available at <www.scmp.com/news/china/diplomacy-defence/article/1913442/chinas-military-closing-technology-gap-us-forces-says>.