Air Force's 10th Wideband Global SATCOM communications satellite, atop United Launch Alliance's Delta IV rocket, lifts off from Space Launch Complex 37B at Cape Canaveral Air Force Station, Florida, March 15, 2019 (U.S. Air Force/Van Ha)

Mind the Gap

Space Resiliency Advantages of High-Altitude Capabilities

By Benjamin Staats

Adversaries continue to pursue new, improved, and expanded counterspace capabilities to target and exploit the perceived reliance by the United States and its allies on space-based systems.[1] Furthermore, adversaries continue to strengthen and expand antiaccess/area-denial (A2/AD) strategies designed to disrupt or degrade warfighting command systems so as to slow or otherwise deter the U.S. military from protecting its interests.[2] Since 2010, the United States has attempted to mitigate these growing threats by pursuing a strategy of improving space architecture resiliency.[3] However, neither space systems nor space capabilities and their effects have attained a level of resiliency commensurate with the existing and emerging threats. To remedy this lingering deficiency, then–Chief of Space Operations General John W. Raymond stated that the top priority of the U.S. Space Force in 2022, and probably for the next decade, was to shift to a more resilient architecture.[4]

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This more resilient architecture must include cross-domain capabilities, specifically high-altitude systems, to improve overall capability and mission resiliency and better enable a Joint All-Domain Command and Control (JADC2) framework that achieves greater warfighting mission assurance in a heavily contested and complex operational environment (OE). Although improving the resiliency of space-based architecture alone is an important effort to assure space capabilities and their missions and effects, it should not be the only means. As part of this deterrence-by-denial strategy, the joint force should concurrently develop high-altitude capabilities to improve space mission resiliency, better assure warfighting mission requirements, and better enable the joint force to accomplish its objectives. These high-altitude capabilities can fill critical operational gaps and requirements anticipated to emerge in a future contested OE. Integrating and layering them into existing tactical and operational organizations, networks, and frameworks will help to offset the vulnerabilities and disadvantages of both space and air assets.

The counterspace threat and need for a resilient architecture resemble conditions faced by the newly independent British Royal Air Force (RAF) during the interwar period. The anticipated air threat from France, and later Germany, compelled the RAF to develop a more efficient and highly organized air defense command and control (C2), communications, and intelligence architecture.[5] The emergence of radar provided a critical battlefield intelligence capability that the RAF was able to rapidly integrate into an already developing architecture.[6] Not only did the improved air defense architecture initially help deter Germany from planning to invade Great Britain, the integration of radar proved to be a critical factor in the country's successful defense during the Battle of Britain. Just as radar served as a critical capability to improve the RAF's air defense C2, communications, and intelligence architecture, high-altitude capabilities can serve as critical enablers to improve space architecture, mission resiliency, and JADC2 for the U.S. joint force.[7]

This article argues that the joint force must develop high-altitude capabilities and integrate them into joint operations to improve space mission resiliency. High-altitude capabilities ensure that warfighting mission requirements are met and will enable the joint force to achieve its objectives in a conflict when adversaries attempt to heavily contest both air and space. The following section recommends a joint definition for the high-altitude region, continues with a historical review of the development and importance of high-altitude capabilities, describes how their use will improve space mission resiliency, and concludes with recommendations for ways the joint force should develop and budget for these important high-altitude capabilities as it prepares for the next conflict.

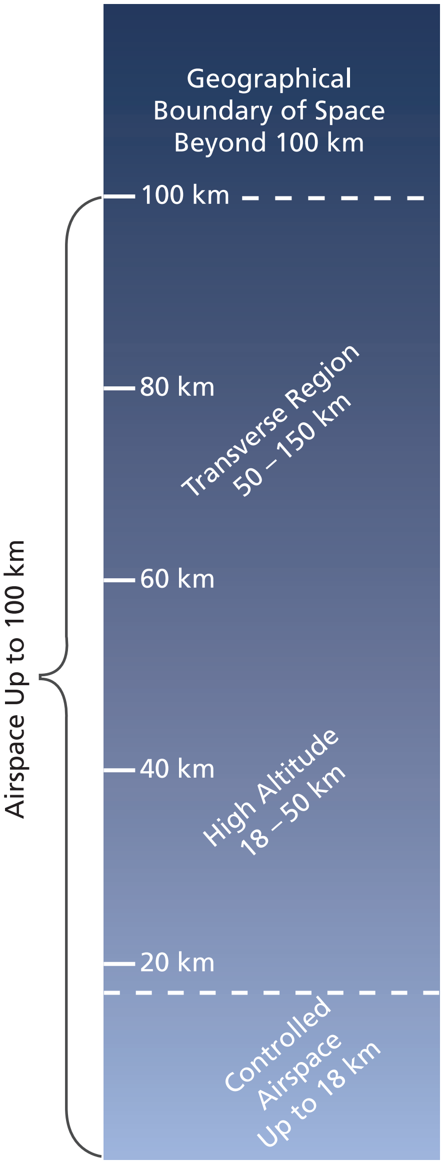
Defining the High-Altitude Region for Joint Doctrine

Joint doctrine needs to provide clear operational definitions for the extended regions between traditionally exploited airspace and outer space. A portion of upper airspace remains undefined despite having significantly different physical attributes from those of both space and the airspace traditionally exploited by aircraft. Without a definition of this part of the OE in joint doctrine, there is a lack of clarity and shared understanding, particularly as technology further enables the potential for capabilities to exploit these regions.

The figure illustrates a proposed concept for delineating the distinct regions of airspace leading up to the geographical boundary of space at 100 kilometers. This high-altitude region is bounded by two well-established demarcations: the ceiling of controlled airspace, at roughly 18 km (60,000 feet), and the beginning of the transverse region, at roughly 50 km (164,000 feet).

Lower Boundary of High Altitude. The Federal Aviation Administration (FAA) officially considers anything above 18 km as upper-class E airspace and provides no airspace management services for the range of high-altitude capabilities that operate within it.[8] Further, given the lower density of air molecules at higher altitudes, only a few traditional air assets, such as the Global Hawk and the U-2, have the capacity to reach beyond controlled airspace.[9] As a result, the airspace region above 18 km remains largely vacant and unexploited by anything other than nontraditional air platforms, such as high-altitude balloons or aerostats.

Figure. Undefined Regions Between Air and Space



Upper Boundary of High Altitude. The unique principles of physics beyond 50 km, aptly named the transverse region, permit only the act of traversing it, primarily via rockets and missiles. Essentially, the transverse region lies between air and space, where neither aerodynamic flight nor orbital rotation is possible.[10] The physical upper boundary of high-altitude systems seems to be at the beginning of the transverse region, roughly 50 km, given operational testing thus far. In 2018, the National Aeronautics and Space Administration's record-breaking test demonstrated a high-altitude balloon could sustain altitude at roughly 49 km.[11]

Given these demarcations, neither the Department of the Air Force's nor the Department of the Army's definition is suitable. The U.S. Air Force unofficially defines the near-space region as between 20 km and 99 km, but this definition seems too broad, given that the upper 49 km of this region is distinctly different from the part below 50 km.[12] More recently, the U.S. Army has defined the high-altitude region as between roughly 18 and 30 km (specifically, 60,000 to 100,000 feet).[13] However, whereas the unofficial Air Force definition is too broad, the Army's is too restrictive, considering the potential for some high-altitude assets to reach well beyond 30 km. Thus, to establish a shared understanding of what is meant by the high-altitude region, joint doctrine should define it with boundaries at 18 km and 50 km.

Besides defining its boundaries, another way to understand and frame the high-altitude region is to consider it a littoral zone between airspace and outer space. Just as the U.S. Navy has increasingly determined the importance of littoral zones in its operations, so too should the joint force consider the importance of the high-altitude region for achieving greater resiliency.

Taking Insights From History

Much as Sputnik triggered the beginning of the space age in 1957, the first human flight in an untethered balloon in 1783 sparked the era of "balloonomania" across the United States and Europe.[14] Just 10 years later, a French military hydrogen balloon called *L'Entreprenant* floated above several battles in the 1890s to relay detailed aerial reconnaissance information to the commanding general.[15] Both civil and military balloon activity carried on throughout the 19th century, and a segment of balloonists competed seriously for altitude records well into the 20th century.[16] By 1935, the record altitude had reached over 21 km, far beyond the record-breaking 6 km established in 1803 and well into what is now considered the high-altitude region.[17] While the airplane overshadowed the value of balloons throughout most of the 20th century, the utility of balloons reemerged once they could reach altitudes unachievable by modern airplanes.

By the early 1950s, unmanned balloons, as part of the Navy's Helios and Skyhook projects, could achieve altitudes greater than 30 km.[18] This achievement spurred further high-altitude balloon research, engineering, and experimentation in the 1950s and 1960s, including strategic reconnaissance.[19] Most historians, in focusing on President Dwight D. Eisenhower's choice of the U-2 spy plane as the near-term stopgap solution for accurate intelligence on the Soviet nuclear threat until the United States could deploy reconnaissance satellites overlook the complementary high-altitude balloon programs.[20] For example, the Air Force developed the Moby Dick program to deploy high-altitude balloons equipped with cameras from Okinawa, Hawaii, and Alaska starting in January 1956 as part of a weather balloon cover plan called White Cloud.[21] In a 6-month period before the first U-2 flight over the Soviet Union, more than 250 high-altitude balloons recorded approximately 8 percent of the territory of the Soviet Union and China before they were discovered and a diplomatic spat ensued, leading to the program's termination.[22]

Overshadowed by the effectiveness of new air and space capabilities, the utility of high-altitude balloons did not emerge again until the 21st century. In response to observed operational shortfalls in Operation *Iraqi Freedom* (OIF) and Operation *Enduring Freedom* (OEF), the Air Force tasked Air Force Space Command (AFSPC) to develop, field, and execute tactical and operationally responsive space capabilities that included high-altitude capabilities (also described as "near-space" capabilities).[23] Despite the potential utility described by most Air Force research and experiments from 2005 to 2007, the Service was unable and unwilling to adequately pursue and fund high-altitude capabilities.[24] Ultimately, high-altitude capabilities were not required to address the immediate threat at that time.

Since then, the Air Force, the Navy, and the Army have increasingly pursued variations of high-altitude capabilities to fill niche operational gaps, particularly in response to emerging counterspace threats. However, the resurgence of interest in high-altitude capabilities fostered extravagant development programs, with unreasonable demands, untested technologies, and inexperienced developers all driving toward an ill-defined and disjointed problem set.[25] As a result, the inevitable failures of most of these programs have facilitated and exacerbated the poor reputation of high-altitude capabilities. For example, the Army unrealistically expected to develop the long-endurance multi-intelligence vehicle (LEMV) within just 18 months, but after spending $297 million and dealing with significant program mismanagement, the Pentagon finally terminated the program.[26] The LEMV failure highlights how high-altitude capabilities failed as a wartime innovation because of insufficiently stated requirements and a narrowly defined problem set that became increasingly irrelevant as OIF and OEF war efforts began to draw down.[27]

Instead, the joint force should seek to innovate high-altitude capabilities during periods of relative peace and Great Power competition but make sure to appropriately guide research and development (R&D) by anticipating the operational gaps and future requirements based on emerging threats.[28] Potential adversaries, such as China and Russia, continue to train and equip their military space forces with increasingly sophisticated and extensive counterspace weapons to hold the space assets of the United States and its allies and partners at risk.[29] Further, these developments enhance Chinese and Russian A2/AD strategies that continue to advance and accelerate in ways that will challenge joint all-domain operations.[30] This

Operators and engineers launch high-altitude balloon as part of U.S. Pacific Fleet's Unmanned Systems Integrated Battle Problem 21, Warner Springs, California, April 25, 2021 (U.S. Navy/David Mora)

evolving and expanding threat creates an increasingly complex OE that may exceed the threshold of near-future air- and space-based support capacities.

Given the anticipated and evolving threat, the joint force must develop and integrate high-altitude capabilities into joint operations to improve the resiliency of space missions during conflict. These systems will help assure warfighting requirements that enable the joint force to achieve its objectives despite the expected degradation or loss of space-based capabilities.

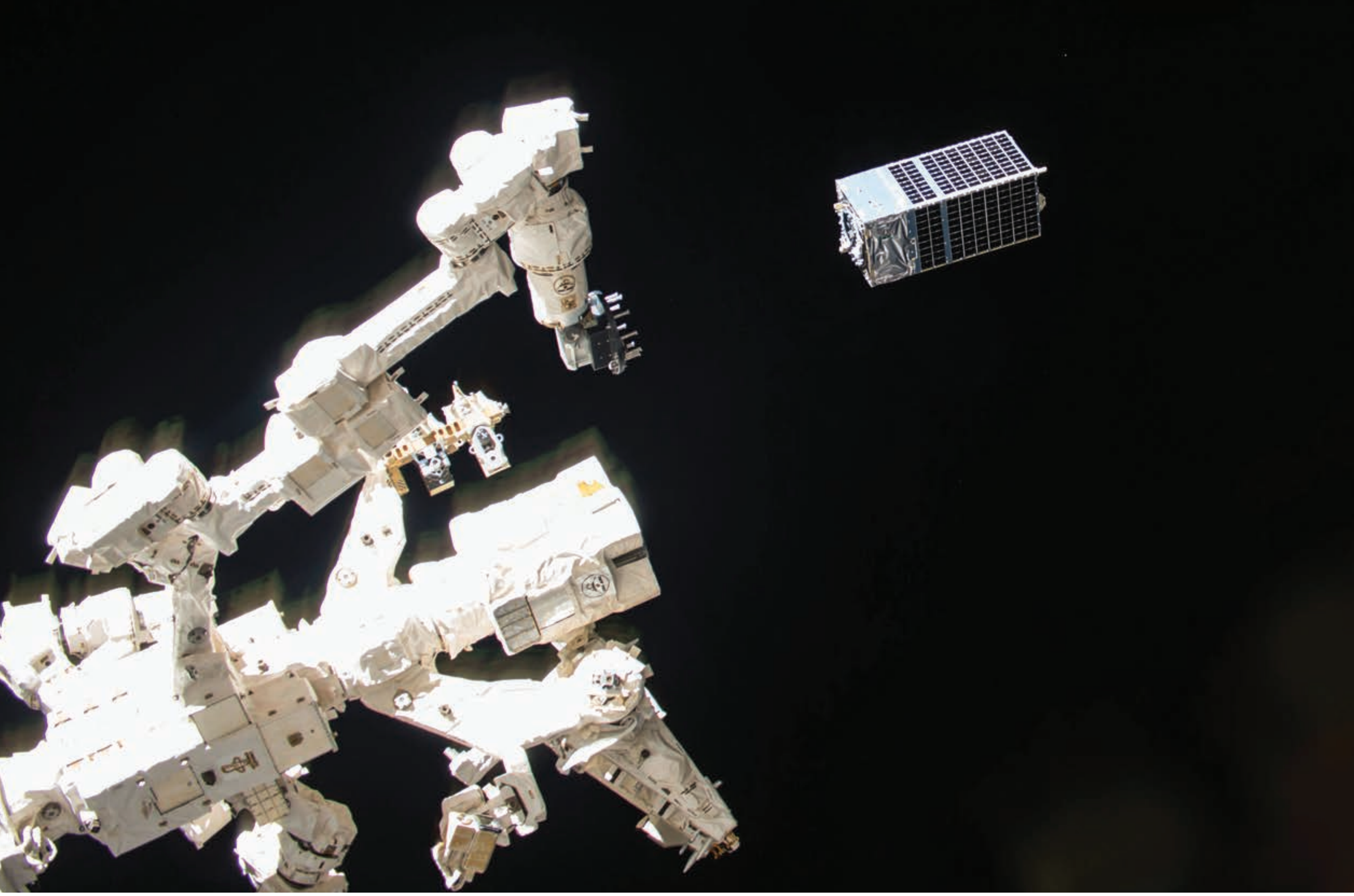
Improving the Resiliency of Space Missions With High-Altitude Capabilities

Strengthening the resiliency of the U.S. space architecture has been a key national-level space policy objective since 2010.[31] However, in 2016, the RAND Corporation noted that the prioritization of space resiliency by senior military leadership had not been promulgated formally down to space squadrons.[32] In December 2015, the Office of the Secretary of Defense recognized issues with discussing, implementing, and measuring space resilience efforts.[33] Further, AFSPC's 2015 Space Enterprise Vision study recognized the ongoing need to improve space architecture resiliency.[34] The AFSPC commander at the time, General John Hyten, later stated that the Space Enterprise Vision opposed "any of those big, exquisite, long-term satellites."[35]

Senior leadership across the Department of the Air Force stated in 2022 that increasing space resiliency is a top priority.[36] Specifically, General Raymond expressed the same concern General Hyten had when he stated that "we [need to shift] from a handful of exquisite capabilities that are very hard to defend to a more robust, more resilient architecture."[37] Despite some improvements over the years, the primary problem remains: space capabilities are not resilient enough, and it may take several more years to attain a more resilient space architecture. Further, attaining a degree of space resiliency commensurate with the emerging and evolving threat may be unfeasible with a space-domain-specific approach alone. In other words, the joint force needs more than just space systems resiliency; it needs space mission resiliency and assurance.

High-altitude capabilities can serve as critical cross-domain resiliency alternatives that fill the anticipated operational gaps and meet future operational requirements as the joint force attempts to further strengthen the resiliency of its space architecture and develop a robust JADC2 framework. Although domain-specific space architecture resiliency is important to assure space mission availability, it cannot be the only means to improve the overall resiliency of the space missions needed to assure warfighting requirements.[38] Integrating and layering high-altitude capabilities into existing tactical and operational organizations, networks, and frameworks to complement existing and future air and space capabilities can improve the much-needed resiliency of space missions and, ultimately, warfighter mission assurance. The joint force will need this sort of redundancy and resiliency to fill anticipated capability and capacity gaps in a future contested OE.[39]

High-altitude capabilities can improve resiliency because they can generate and provide space-like effects from altitudes above traditionally exploited airspace yet well below the threshold of



Kestrel Eye—low-cost, visible-imagery satellite prototype designed to provide near-real-time images to tactical-level ground Soldier—was launched to International Space Station as payload aboard SpaceX Falcon 9 from Kennedy Space Center in Florida, August 14, 2017, and deployed into space and activated on October 24, 2017 (U.S. Army Space and Missile Defense Command Technical Center/U.S. Army Acquisition Support Center)

space. By no means can, or should, high-altitude capabilities replace proven air and space capabilities, but they do provide an array of advantageous attributes, such as responsiveness, persistence, and field of view. The unique combination of these attributes helps offset inherent disadvantages and limitations in existing air and space capabilities. Although none of the individual attributes are unique to high-altitude capabilities, the brief summaries below will begin to illustrate how layering and integrating them into air and space architectures can help improve resiliency of space missions to enable warfighter mission assurance and enhance joint operations.

Responsiveness. The joint force can quickly launch and task high-altitude capabilities across the joint area of operations (JOA). Existing high-altitude systems have already demonstrated the ability to fill and launch from their launch platforms within 30 minutes from austere locations and in winds up to 45 knots while requiring a relatively minimal logistics footprint.[40] After launch, high-altitude systems can reach their altitudes within an hour or so and can be tasked throughout their ascents, and the payloads can be detached and recovered by means of technologies similar to those integrated into joint precision airdrop systems.[41] Launches can also occur well outside the JOA or from logistics and support hubs, though it could take several hours or days for the systems to drift into position, depending on the distance. In addition, the joint force could have a great number of these systems launched from across varying tactical and operational echelons.

Once high-altitude capabilities are in place, software advances have made them mostly autonomous, interoperable, and maneuverable, enabling the joint force to place them into positions of advantage or standoff.[42] In a complex, contested, and rapidly changing OE, these attributes could allow tactical- and operational-level commanders immediate, potentially on-demand access to alternate intelligence, surveillance, and reconnaissance (ISR), as well as communications, missile warning, and other capabilities typically provided by air and space assets. Further, these commanders could directly reallocate, reposition, or retask dedicated tactical high-altitude systems according to mission requirements, instead of reallocating strategic air and space assets.

Persistence. High-altitude capabilities can also provide persistent coverage over an entire JOA, given their unique loitering and endurance abilities. Existing high-altitude platforms have demonstrated the ability to maintain relative stability for weeks within acceptable loitering positions using little energy, by manipulating the winds to adjust their altitudes and to maneuver.[43] This degree of persistence is enabled by emerging technologies such as the stratospheric optical autocovariance wind lidar and the adaptable lighter-than-air balloon. These systems demonstrate the ability for high-altitude systems to maintain their loitering and altitude positions up to 27 km for weeks at a time.[44]

Given their persistence, these systems can achieve staring effects, like space capabilities in geostationary orbit, albeit vastly closer. This staring effect enables the joint force to integrate a unique and persistent ISR and communications capability that complements air and space capabilities in addition to filling gaps in a contested OE. Further, high-altitude systems are also relatively all-weather systems; they operate above the troposphere, where most terrestrial weather occurs. And commanders can deploy high-altitude capabilities in a proliferated manner to attain greater reliability for on-demand tasking.

Field of View. Given their high altitudes above the JOA, high-altitude capabilities can achieve large fields of view, up to a few hundred miles wide. Although not nearly as large as those achieved by satellites, high-altitude capabilities' fields of view are greater than those of traditional air platforms. For example, a high-altitude system can achieve a field of view of 400 miles across from an altitude of 100,000 feet.[45] In addition, a high-altitude system at 90,000 feet can image at a 45-degree off-nadir angle from up to 18 miles of horizontal standoff, whereas an MQ-1 at 25,000 feet and an MQ-9 at 50,000 feet can achieve approximately only 5 and 10 miles of horizontal standoff, respectively. The more expansive fields of view of high-altitude capabilities also enable them to extend beyond-line-of-sight communications from two to eight times the range attainable by unmanned aerial vehicles.[46]

Although the field of view of high-altitude capabilities pales in comparison to that of satellites, their proximity to terrestrial targets provides significant advantages. For example, the same lightweight optical sensors used on small satellites would generate significantly better image resolution—well beyond the 3- to 5-meter resolution achieved from low Earth orbit—if employed on high-altitude systems. The field of view achieved by high-altitude capabilities also enables a range of advantages for ISR, communications, missile warning, and other missions that greatly benefit tactical- and operational-level commanders.

The attributes discussed above represent only some of their advantages; there is clear significant value to layering high-altitude systems with existing air and space capabilities to improve resiliency of space missions that assure warfighter mission requirements. The joint force will not always be able to maintain total dominance in all domains.[47] High-altitude capabilities could fill the potential capacity and capability gaps created in a contested OE. For example, the responsiveness, persistence, and field of view attributes of high-altitude capabilities would enable reliable, all-weather, space-like ISR and communications across the JOA.

First, high-altitude ISR sensors can provide higher resolution and greater signal sensitivity relative to more costly space assets—and offer larger fields of view and endurance relative to air assets.[48] The ability to collect real-time imagery, information, and signal data across the battlefield would greatly enhance the decisionmaking process for commanders. The provided space-like ISR support could enhance the joint force's ability to confirm and deny priority information requirements, improve tracking and targeting processes, and generate a better shared understanding of the OE to help validate common operating pictures and contribute to the iterative planning process. Thus, not only would high-altitude ISR capabilities ensure greater space mission resiliency, they also could complement existing air and space capabilities and fill the potential gaps in ISR coverage in a competitive OE.

Second, high-altitude communications assets could serve as reliable primary, alternate, contingency, or emergency means of over-the-horizon communications within a contested OE. These platforms could expand and supplement existing joint C2 capabilities by serving as relays or repeaters capable of extending ground-based radio signals several hundred miles across the JOA.[49] Communication payloads would decrease the burden and risk to existing satellite communications (SATCOM) architectures by reducing user capacity requirements, offloading certain data signals, or relaying SATCOM signals to mitigate jamming attempts.[50] As high-altitude capabilities became more stable, they could also serve as ideal platforms to exploit free-space optical communications, particularly within a contested OE. Last, high-altitude communications positioned below the ionosphere could fill a capability gap when space weather hazards, such as shortwave radio fade and signal fade, occur.[51]

Although many more mission areas are promising for improving the resiliency of space missions, such as ongoing high-altitude missile-warning capabilities, the high-altitude-based ISR and communications alternatives provide two examples of opportunities for greater cross-domain resiliency that ultimately could assure warfighter mission requirements. High-altitude capabilities could not only enable greater cross-domain resiliency, they could also enable the joint force to allocate, prioritize, and preserve low-density, high-demand air and space assets more efficiently throughout operations—a key function of effective C2.[52] Further, during Great Power competition, the joint force deployment of high-altitude capabilities, particularly in a proliferated manner, would present an additional dilemma to an adversary by altering operational patterns and force posture while creating opportunities for the joint force to exploit adversary operational shortfalls.[53] In short, there would be many benefits to the joint force in pursuing high-altitude capabilities. The next section presents a discussion of how to move forward to take advantage of this region and exploit the gap.

U-2 from Beale Air Force Base, California, prepares to land at Royal Air Force Fairford, England, June 9, 2015 (U.S. Air Force/Jarad A. Denton)

Developing and Integrating Deliberate High-Altitude Capabilities

Before discussing how the joint force should more deliberately pursue the development and integration of high-altitude capabilities, senior leaders must understand why integrating high-altitude capabilities previously failed. Their development in the past two decades was a response to wartime requirements and thus was a wartime innovation effort. Unfortunately, historical lessons indicate that wartime innovation is possible, but often unsuccessful and imperfect, and, when successful, available only in the later phases of a war.[54] Wartime innovation takes time, and during war, time is short.[55] Capabilities not developed prior to war are often imperfectly cobbled together during conflict because military organizations often fail to identify and develop clear and concise warfighter requirements to meet objectives, to effectively establish or train a new organization to employ newly developed capabilities, or to sufficiently go through a wartime learning process to measure the capabilities' strategic effectiveness.[56]

The wartime innovation effort of integrating high-altitude capabilities in the 21st century experienced these same challenges. Despite some R&D prior to OIF and OEF, it was not until after a few years of war that military organizations sought to deliberately pursue the development and integration of high-altitude capabilities to meet their operational requirements. Then, because such programs take time to develop, there were no military organizations organized, trained, or equipped to effectively employ the new capacities, and uncontested air and space capabilities often overshadowed their utility, making it difficult to measure their true effectiveness. Thus, when scrutinized, the integration of high-altitude capabilities became an apparent wartime innovation failure that did not account for all aspects of doctrine, organization, training, materiel, leadership and education, personnel, and facilities. A clear example is the previously discussed LEMV; wartime innovation challenges directly contributed to its failure.

As the RAF's air defense network did with its integration of the radar innovation during relative peacetime, a resilient space mission framework must integrate new capabilities to attain cross-domain resiliency. If the joint force is certain that adversaries in the next conflict will contest space and air capabilities to impede its ability to achieve its objectives, then the force should deliberately pursue peacetime innovation efforts to develop and integrate high-altitude capabilities to improve space mission resiliency. Pursuing greater space mission resiliency now would give the joint force the necessary time to identify how high-altitude capabilities could improve resiliency, to establish the required organizations or processes to integrate those capabilities, and to conduct exercises, training, and wargaming to measure their effectiveness.

If the joint force commits to pursuing high-altitude capabilities during relative peacetime to prepare for the next conflict, it must address two significant challenges: organizational resistance and cost-effectiveness. The history of organizational resistance in the U.S. military to balloons dates to the Civil War, when it took a directive from President Abraham Lincoln to establish the Army Aeronautics Corps.[57] That organizational resistance remained largely entrenched until the innovation of the airplane rendered it moot. Given the utility of

integrating modernized balloons today at higher altitudes, organizational resistance, like that to any innovation, is a significant barrier. Despite this resistance, the U.S. Army Space and Missile Defense Command (USASMDC) remains committed to developing high-altitude capabilities that can enable the joint force to accomplish its objectives.[58]

USASMDC is uniquely postured to further develop and integrate high-altitude capabilities into the joint force because of its organizational acceptance and because it is organized to do so effectively across the joint force. First, USASMDC serves as the proponent for Army space operations officers (FA40s) and high-altitude capabilities doctrine as part of Army space doctrine. Second, these FA40s serve at division, corps, and Army Service Component Command Space Support Elements and at 1st Space Brigade as part of Army space control planning teams, all of which support combatant commands (CCMDs) and participate in joint theater-level strategic and operational exercises, Army warfighter exercises, project convergence, and national training centers. Third, this degree of joint integration presents multiple opportunities for FA40s to integrate high-altitude capabilities into joint operations and in coordination with joint staffs at CCMDs and the air operations center, as part of the combined space tasking order and, during exercises or conflict, the air tasking order.[59] This approach leverages an organization that already accepts high-altitude capabilities to further expand their integration into the joint force and measure their effectiveness at improving space mission resiliency, in addition to complementing air and space capabilities when training in a contested OE.

To address the challenge of cost-effectiveness, the joint force and its senior leaders must recognize that only high-altitude capabilities can achieve the cross-domain space mission assurance needed for the next conflict. When the Army developed the previously discussed LEMV to provide additional ISR to the theater commander, it was not cost-effective, given that air and space capabilities could readily meet most of those ISR requirements.[60] Because the next conflict will heavily contest air and space capabilities, the real value of high-altitude capabilities will be their ability to improve resiliency of space missions with space-like effects that enable warfighter mission assurance. Thus, if the joint force values such benefits from cross-domain resiliency, it should invest in high-altitude capabilities appropriately.

A common argument in support of high-altitude capability development is that it is significantly less expensive than satellites, costing approximately $100,000 per balloon in initial development and operating costs.[61] However, for the joint force to gain the space resiliency needed with these types of systems, it would likely need to deploy hundreds of these balloons, or even more expensive systems, up to $9 million, in a proliferated manner within a large JOA or across multiple JOAs.[62] Although this employment method raises the costs, the joint force's investment of tens of millions of dollars into high-altitude capabilities would be cost-effective because it would achieve greater space mission resiliency. Although this cost assessment makes high-altitude capabilities seem less appealing in comparison to developmental satellites, such as the USASMDC Kestrel Eye, which cost approximately $2 million apiece, the joint force must deploy Kestrel Eye in a proliferated manner across low Earth orbit and reconstitute it annually to gain any space resiliency.[63] And even if high-altitude capabilities approached the cost of a proliferated satellite constellation, they

United Launch Alliance Atlas V rocket carrying 6th Space Based Infrared System Geosynchronous Earth Orbit satellite launches from Space Launch Complex 41, on Cape Canaveral Space Force Station, Florida, August 4, 2022 (U.S. Space Force/ Joshua Conti) would provide significantly more value to the joint force, given the greater gain in the requisite cross-domain space mission resiliency needed for the next conflict.

Conclusion

There are challenges to exploiting the gap with high-altitude capabilities, but the joint force can overcome them. The U.S. Space Force's efforts to improve space architecture resiliency with space-domain-specific solutions alone are not a comprehensive solution for the emerging counterspace threat. The joint force and Services must identify an organizational lead to develop and integrate high-altitude capabilities into joint operations. Although the Space Force could be the entity to exploit this gap, it probably has significant organizational resistance—something USASMDC has already overcome.

In addition, although high-altitude capabilities may be more costly than they initially appear, the resiliency benefits they provide the joint force make them a cost-effective solution to a clearly defined requirement. Commercial high-altitude capabilities could be an option, but only the joint force can generate the demand for them. Although commercial space capabilities can thrive without government funding, commercial high-altitude capabilities can thrive only with government program commitment, as is true of many other military-specific capabilities.

Given the emerging threat as the joint force prepares for the next conflict and the utility of high-altitude capabilities for improving space mission resiliency, the joint force should mind the gap between air and space. Integrating high-altitude capabilities across this gap and into joint operations would improve space mission assurance and JADC2 by providing persistent and responsive ISR and communications across the JOA, which would assure warfighting mission requirements and enable the joint force to accomplish its objectives. Further, exploiting this gap with high-altitude capabilities would complicate the adversary's ability to deny, degrade, or disrupt space capabilities because of the proliferation, redundancy, and rapid reconstitution that high-altitude capabilities can provide. These capabilities can play a critical role in future deterrence-by-denial strategies.

Just as the RAF took care to leverage the full range of capabilities to improve its C2 architecture in preparation for war, the joint force should mind the gap and leverage high-altitude capabilities to improve its space architecture resiliency as it prepares for the next conflict. **JFQ**

Notes

[1] *Challenges to Security in Space: Space Reliance in an Era of Competition and Expansion* (Washington, DC: Defense Intelligence Agency, 2022), iv, 40, available at <www.dia.mil/Portals/110/Documents/News/Military_Power_Publications/Challenges_Security_Space_2022.pdf>.

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[6] Ibid., 15–18.

[7] Ibid., 15.

[8] *Upper Class E Traffic Management Concept of Operations*, vers. 1.0 (Washington, DC: Federal Aviation Administration, May 2020), 1, available at <https://nari.arc.nasa.gov/sites/default/files/attachments/ETM_ConOps_V1.0.pdf>.

[9] Loren Thompson, "U-2 Versus Global Hawk: Why Drones Aren't Always the Best Solution for Warfighters," *Forbes*, February 5, 2018, available at <https://www.forbes.com/sites/lorenthompson/2018/02/05/u-2-versus-global-hawk-why-drones-arent-always-the-best-solution-for-warfighters/#6f2278264d7e>. Designers of the Global Hawk and U-2 often refer to them specifically as high-altitude capabilities.

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[11] Doris Elin Urrutia, "This Giant, Ultrathin NASA Balloon Just Broke an Altitude Record," *Space.com*, September 12, 2018, available at <https://www.space.com/41791-giant-nasa-balloon-big-60-breaks-record.html>.

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