Space-Based Networks

Commercial Space Integration at the Department of Defense

by

Agustin Lopez-Padilla
Maria Miller
Jeffrey Moore
Fayokemi Olawode

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University of Nebraska-Omaha
College of Information Science & Technology
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Introduction

The Problem

The Department of Defense (DoD) faces growing challenges in maintaining and enhancing its space-based capabilities amid increasing threats from near-peer adversaries, such as Russia and China, as well as rogue states like North Korea and Iran. These challenges are further compounded by the complexity of managing multiple space acquisition programs and integrating new technologies with legacy systems. In particular, the rapid development of advanced counter-space systems by adversaries, including cyber and jamming capabilities, places pressure on the DoD's existing space infrastructure, requiring significant modernization and resilience improvements (GAO, 2019). The current architecture, which heavily relies on geostationary satellites (GEO), must adapt to a more dynamic environment, which increasingly demands a multi-orbit solution that incorporates Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) satellites.

The DoD's ability to meet emerging operational needs in space is further challenged by its reliance on complex acquisition processes and outdated technologies. Space systems are often acquired in isolation, creating interoperability challenges between different satellite networks and with commercial sector assets. This lack of standardization hinders the ability to seamlessly integrate new capabilities, leading to inefficiencies and increasing the risk of mission failure (GAO, 2024). Additionally, as the DoD moves toward a more hybrid approach, involving partnerships with the commercial sector, the lack of open standards and coordination between commercial and military assets presents another barrier to achieving true interoperability across satellite networks.

With the increasing volume of space data and the need for real-time communication, the DoD must address the significant gap in technological infrastructure and workforce capabilities. While advancements such as laser communication and multi-orbit systems offer potential solutions, integrating these technologies into the DoD's current operations requires a shift in both strategic planning and acquisition practices (Welch, 2024). The DoD must also contend with limited resources and capacity, especially as multiple space acquisitions progress concurrently, potentially overburdening the department's ability to effectively manage these initiatives. This paper explores the critical issues and opportunities for overcoming these challenges, focusing on how the DoD can modernize its space architecture and improve collaboration with coalition partners to achieve greater mission success.

Why Commercial Procurement?

The commercial sector has demonstrated significant progress and has outpaced government-led space initiatives in many areas leading to increasing DoD interest in

commercial procurement. For example, commercial providers have achieved rapid innovation cycles, advanced technological capabilities, and cost-effective solutions through market competition (United States Government Accountability Office, 2024). The upper hand the commercial industry has in these areas has led to faster deployment of new capabilities, a strong indicator of the commercial sector's edge over traditional government-led projects (Covington & Burling LLP, 2024). On the government-end, the DoD faces two key pressures in its procurement strategy: legal obligation to procure commercially available technologies rather than develop them internally and the risk of falling behind strategic competitors who are rapidly advancing their space capabilities (Schwartz & Johnson, 2023).

More areas where the commercial procurement would benefit the DoD include:

- Freedom from antiquated procurement practices
- Continuous innovation driven by market forces
- Rapid technology refresh rates that enhance resilience (United States Government Rapid replacement capabilities
- Advanced threat detection and response mechanisms (CPR Institute, 2010)
- Strengthened deterrence capabilities
- Leveraging billions in private sector investment (Covington & Burling LLP, 2024)

The DoD's Commercial Space Integration Strategy

The Department of Defense (DoD) released its first-ever Commercial Space Integration Strategy in 2024, marking a significant shift in the Pentagon's approach to leveraging commercial space capabilities for military operations (Department of Defense, 2024a; Erwin, 2024). The strategy aims to remove barriers and integrate commercial space solutions into the DoD's national security space architecture, indicating a recognition of the rapid advancements and innovations in the commercial space sector (Department of Defense, 2024a; DLT Solutions, 2024). Four main principles are outlined in the document: **balance**—seeking an appropriate mix of government and commercial solutions without overreliance on any single provider, **interoperability**—strengthening interoperability between government and commercial solutions, **resilience**—enhancing space mission assurance across the spectrum of conflict, and **responsible conduct**—adhering to international norms and standards (Department of Defense, 2024b; DLT Solutions, 2024).

In addition to the four principles, the document outlines four main priorities in implementing this strategy:

- Ensuring secure access to commercial space solutions across all stages of conflict, including the ability to surge commercial capacity when needed (Department of Defense, 2024a, 2024b).
- Achieve integration of commercial space solutions prior to crisis, incorporating them into wargames, exercises, and day-to-day operations (Department of Defense, 2024a, 2024b).
- Establish security conditions to promote commercial space integration by addressing cyber, data, and supply chain security requirements (Department of Defense, 2024b).
- Encourage the development of new commercial space solutions for use by the Joint Force (Department of Defense, 2024a, 2024b).

To further implement this strategy, the DoD plans to leverage new contracts and agreements to ensure access to commercial solutions, incorporate commercial space solutions into wargames, tabletop exercises, and training; mitigate fiscal and security risks for companies working with the department, and use available financial, contractual, and policy tools to support the commercial sector in developing relevant capabilities (Department of Defense, 2024a).

Industry Response to the DoD's Commercial Space Strategy

While the DOD's commercial space strategy has been generally well-received by the commercial space industry as a positive first step, some industry leaders emphasize the need for concrete action plans, aligned funding, and accountability to truly realize its potential (Erwin, 2024). Rebecca Cowen-Hirsch, senior vice president of Government Policy & Strategy at Viasat, commented on the policy, "This is the first time that you have a written strategy that talks about what is now national policy to leverage commercial first" (Jewett, 2024). Daniel Gizinski, Comtech chief strategy officer, praised the collaborative approach of the strategy, "A lot of what you see in those policies is a consensus position that results from a very collaborative discussion" (Jewett, 2024).

There is particular interest in whether these strategies will lead to concrete changes in incentives for program offices and funding commitments. Charles Beames, chairman of York Space Systems, emphasizes the need for changes in the bureaucratic structure, stating, "Layers in the bureaucracy are not rewarded for doing this" (Jewett, 2024). His statement summarizes the fundamental misalignment between the goals of these new commercial integration strategies and the existing structures within the DoD and Space Force (Jewett, 2024). Ultimately, the success of this strategy will be measured by how well the

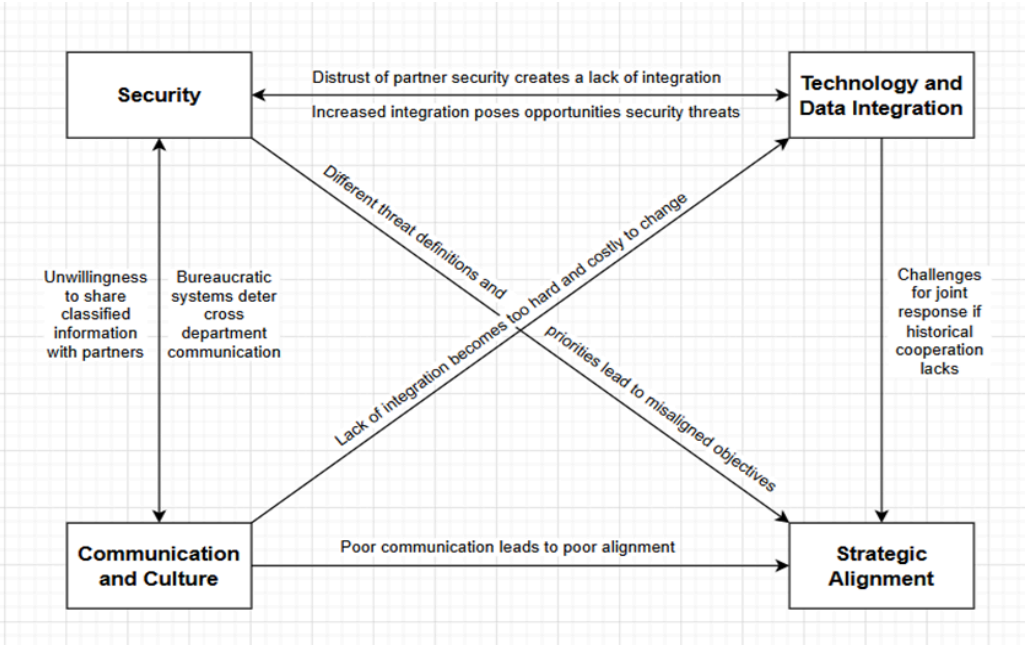
department can integrate commercial solutions into its operations, not just in peacetime but more importantly during conflicts (Department of Defense, 2024a).

Stakeholders: DoD, Coalition Partners, and Contractors

The Department of Defense (DoD) is the primary stakeholder in the U.S. space sector, responsible for maintaining and advancing national security capabilities through space-based assets. The DoD's space operations are managed by the U.S. Space Force (USSF), which was established to streamline military space operations and enhance collaboration across defense agencies (GAO, 2019). The DoD's stakeholders include both military personnel and government agencies such as NASA and the National Reconnaissance Office (NRO), which contribute to space situational awareness and satellite communication efforts. These stakeholders play a central role in the development and execution of space defense strategies, ensuring that the U.S. can compete and maintain dominance in the increasingly contested space domain.

Coalition partners, including NATO allies and countries such as Japan, the United Kingdom, and France, are critical collaborators in global space operations. These partnerships enable shared technology and operational expertise, particularly in the areas of space situational awareness (SSA) and satellite defense systems (C4ISRNet, 2022). However, the integration of commercial space capabilities with military systems has created challenges in information sharing and data integration between the DoD and its international partners (Atlantic Council, 2024). These challenges are exacerbated by differing definitions of the space domain, with the U.S. viewing space as a warfighting domain, while NATO considers it an operational domain (Federal News Network, 2024). Aligning the strategic goals of the DoD and its coalition partners is essential for creating a unified, interoperable approach to space security.

Figure 1 - Considerations for Integrating with Coalition Partners



Contractors and investors, both commercial and defense-focused, are essential stakeholders in the space acquisition process. Commercial companies, such as SpaceX and Telesat, provide critical satellite technologies and services that supplement the DoD's space operations (Satellite Today, 2024). As the DoD shifts towards a hybrid space architecture, leveraging both government and commercial assets, contractors must ensure their technologies meet stringent interoperability and security standards. These private-sector stakeholders face the challenge of meeting the rapidly evolving needs of the DoD while navigating complex acquisition processes and delivering solutions on time and within budget (GAO, 2024). The successful collaboration between the DoD, coalition partners, and contractors is vital to developing resilient, adaptable, and cost-effective space solutions that address both current and future challenges.

Certain government agencies and organizations are also important stakeholders in the integration of commercial space capabilities. The U.S. Space Force, the newest military branch dedicated to space operations, is responsible for developing and implementing the Space Force Commercial Space Strategy (U.S. Space Force, 2024). U.S. Space Command (USSPACECOM) oversees military operations in the space domain, and the integration of commercial space capabilities directly impacts its ability to conduct space operations and maintain space superiority (U.S. Space Command, 2024). The Space Development Agency (SDA) focuses on rapidly developing and deploying innovative space-based capabilities, often in collaboration with commercial partners (Space Development Agency, 2024). Other key stakeholders include U.S. Strategic Command (USSTRATCOM), which is responsible for

strategic deterrence and global strike operations, and various Joint Task Forces (JTFs), who rely on space-based capabilities for military operations (U.S. Strategic Command, 2024). These agencies face the challenge of coordinating efforts, streamlining acquisition processes, and ensuring interoperability between government and commercial systems while maintaining security and resilience in an increasingly contested space environment (Government Accountability Office, 2024).

Obstacles to Integrating Commercial Capabilities at the DoD

The Department of Defense (DoD) faces a multifaceted array of barriers and challenges in its efforts to maintain and advance U.S. space capabilities. The DoD's commercial integration strategy takes an important first step to address these challenges by acknowledging internal structural and cultural barriers stemming from a historical overreliance on government systems. This DoD commercial space strategy explicitly acknowledges this barrier: "There is risk in not integrating commercial solutions and failing to capitalize on the commercial sector's technological innovation and speed" (Department of Defense, 2024). Although this acknowledgment is an important first step, industry experts like Ellen Chang, vice president of ventures at BMNT, point out a critical gap. Chang notes that these strategic documents present a compelling vision for collaboration, but they fall short in providing detailed implementation plans and concrete funding commitments (Jewett, 2024), a sentiment that is shared across the commercial space industry. The discrepancy between the vision articulated in the strategy and its practical execution remains a primary concern for the commercial space industry. The industry's cautious optimism is fueled by the need for specific action plans and resource allocation to bridge the gap between strategic intent and operational efficiency. Other challenges range from budget overruns and acquisition delays to cybersecurity threats and workforce constraints. Additionally, as the space domain becomes increasingly congested and contested, the DoD must adapt to evolving technological, strategic, and geopolitical realities. Addressing these issues will require innovation, collaboration, and investment in both new technologies and workforce development.

Despite these challenges, the commercial integration strategy outlines significant opportunities for commercial integration in various space-related missions. The Space Force strategy identifies priority mission areas for new commercial integration, including Tactical Surveillance, Reconnaissance, and Tracking (TacSRT), Space-Based Environmental Monitoring (SBEM), Positioning, Navigation, and Timing (PNT), and Space Access, Mobility, and Logistics (SAML) (U.S. Space Force, 2024). These new integration strategies have the potential to transform the relationship between the DoD and the commercial space industry by delivering new capabilities at speed and yielding greater returns on private investments (Center for Strategic and International Studies [CSIS], 2024).

Current Challenges

One of the most pressing challenges for the DoD in space acquisitions is the problem of budget overruns and delays. Large-scale space programs, such as satellite communications and missile warning systems, have experienced cost increases of over 100%, coupled with significant schedule delays (GAO, 2024). These issues are compounded by complex procurement processes and the technical difficulties involved in developing cutting-edge space systems. The DoD's acquisition system has been criticized for inefficiency, which results in long lead times and operational gaps between the deployment of new systems and the decommissioning of outdated ones (GAO, 2019). This challenge is particularly concerning as it impacts the DoD's ability to maintain technological superiority and readiness in the face of emerging threats from peer competitors like China and Russia.

Another critical area of concern is workforce constraints, particularly the shortage of technical expertise and skilled personnel needed to manage complex space programs. As the demand for space-based assets grows, the DoD must rely on a specialized workforce with deep knowledge in areas such as satellite technology, cybersecurity, and space operations. However, there is a notable gap between the DoD's needs and the availability of qualified candidates in the workforce (Federal News Network, 2024). This shortage of talent extends to both the DoD itself and its contractors, who are struggling to fill positions with the necessary skill sets to support high-level space operations. Without sufficient expertise, the DoD risks falling behind in its ability to effectively develop, operate, and maintain critical space assets.

System interoperability is another major challenge the DoD faces. Space systems, particularly satellites, are often built in isolation and optimized for specific mission requirements, which creates compatibility issues when trying to integrate new systems with existing ones. The lack of interoperability hampers the DoD's ability to efficiently share data and coordinate operations across different platforms, especially when working with coalition partners and commercial contractors. The DoD has no automated means to seamlessly integrate space situational awareness (SSA) data from its allies, which leads to inefficiencies and delays in mission-critical decision-making (C4ISRNet, 2022). These integration challenges are particularly problematic as the DoD looks to create a more unified, multi-orbit architecture involving both military and commercial assets.

The communication and cultural divide between the DoD and the intelligence community poses significant challenges to information sharing, as systems and processes are designed to prioritize internal security, restricting collaboration. These barriers, while protecting sensitive information, hinder cooperation, especially in high-pressure situations requiring

quick and coordinated responses. Distrust and misalignment of strategic objectives often arise when partners lack access to relevant and necessary documentation about the DoD's systems and challenges, leading to frustration and a sense of exclusion. This disconnect is further enhanced by the compartmentalized nature of operations, where agencies operate in silos with limited visibility into each other's priorities and capabilities. The absence of shared frameworks or standardized processes for communication creates additional inefficiencies, slowing decision-making and undermining the ability to present a unified approach to addressing shared threats. Ultimately, success in overcoming these challenges will largely depend on effective implementation and overcoming existing cultural and bureaucratic challenges within the DoD and Space Force.

Future Challenges

As the space domain continues to evolve, the DoD must prepare for future challenges that may require new approaches to space strategy and acquisition. One such challenge is the growing threat of cybersecurity vulnerabilities in space systems. While optical communication technologies such as laser communication terminals offer significant advancements in speed and efficiency, they also expose systems to new risks, such as data interception and cyberattacks (GAO, 2019). To ensure the security of space-based communications, the DoD must invest in robust encryption protocols, real-time threat detection, and secure tracking mechanisms. Additionally, the potential for cyber-attacks on commercial satellites, which are increasingly integrated into DoD operations, presents a growing risk to national security. The challenge lies in balancing the need for innovation in space communications with the imperative to protect these systems from malicious actors.

Another future challenge is the increasing competition in the space domain, both from near-peer adversaries like China and Russia and from emerging space-faring nations. As these countries develop and deploy advanced counter-space technologies, the DoD must ensure that its space assets are survivable and resilient against potential threats. The DoD's reliance on a mix of legacy and modern space systems makes it particularly vulnerable to disruptions, whether from kinetic attacks or cyber intrusions (Federal News Network, 2024). To mitigate these risks, the DoD must continue to evolve its satellite architectures, integrating redundancy, and employing innovative solutions such as small satellite constellations and hybrid space architectures that enhance operational flexibility and survivability

The challenge of strategic alignment with coalition partners is another area of concern. As the U.S. expands its collaboration with international allies in space operations, discrepancies in space doctrines and mission priorities can create tensions and

inefficiencies. NATO's view of space as an operational domain contrasts with the U.S. perspective that space is a warfighting domain, a difference that complicates joint strategy development (Federal News Network, 2024). The DoD must find ways to bridge these differences and develop a unified framework for space operations that aligns with both U.S. and allied objectives. Additionally, diverging priorities regarding the protection of commercial space assets and the use of military force in space may lead to conflicting strategies and resource allocation. Achieving consensus on strategic goals and threat assessments will be critical to enhancing interoperability and maintaining a collective space security posture.

In the future, when aligning strategic space resources with DoD missions, not only domestically, but internationally as well, processes and initiatives will need to be developed to promote trust. Partners may feel as if there are vulnerabilities within another nation's system which could compromise the integrity of the shared network. These concerns could arise due to differing national policies regarding security standards, data protection, and technological maturity levels. Currently, space resources are fragmented, shared threat assessments will allow partners to come together to voice security concerns, allowing the ability to reduce the risks associated with having a shared network of satellites. There is a need for a more transparent governance framework that promotes consistency and communication amongst partners that frequently work together within the space domain to avoid distrust that has the potential to undermine defense operations globally.

The Technical Aspect

Technological innovation underpins the Department of Defense's (DoD) ability to maintain strategic advantages in the increasingly contested and congested space domain. A diverse array of current and emerging technologies is shaping the landscape of U.S. space operations, enabling enhanced capabilities in communication, intelligence, surveillance, reconnaissance, and more. These technologies are critical for ensuring operational effectiveness, resilience, and adaptability in the face of evolving threats and mission requirements. The DoD is leveraging advances in satellite communications, optical technologies, artificial intelligence, and multi-orbit architectures to address both present and future challenges.

Current technologies

The DoD's reliance on satellite communication technologies forms the backbone of its space operations. Today's geosynchronous Earth orbit (GEO) satellites provide secure,

high-throughput communication capabilities critical for global military operations. Medium Earth orbit (MEO) and low Earth orbit (LEO) satellites complement GEO systems by offering lower latency and higher resilience through diverse constellations. These systems are supported by advances in digital signal processing and frequency management, which optimize data transfer across a variety of mission requirements (GAO, 2024).

One particularly promising advancement in current technology is the deployment of laser communication terminals. For instance, TESAT's Constellation Laser Communication Terminal (ConLCT80) has demonstrated compliance with the Space Development Agency's (SDA) interoperability standards and offers high-speed, low-latency data transfer capabilities (Satellite Today, 2022). These optical communication systems enable secure, high-bandwidth connections between satellites in different orbits and with ground stations. Furthermore, technologies like the Digital Intermediate Frequency Interoperability (DIFI) standard promote the integration of satellite systems by enabling the digitization of signals and reducing reliance on proprietary interfaces. This standardization ensures compatibility and prevents vendor lock-in, which has historically hindered interoperability across the space enterprise (DIFI Consortium, 2022).

Future Technologies

Looking forward, the DoD is exploring cutting-edge technologies that promise to redefine the space landscape. Multi-orbit architectures are at the forefront of this effort, leveraging the unique advantages of LEO, MEO, and GEO satellites to support diverse mission requirements. Future satellite constellations aim to combine the low-latency capabilities of LEO, the high-capacity throughput of GEO, and the balanced attributes of MEO to create a resilient and versatile network capable of operating in contested environments (GAO, 2024).

Additionally, artificial intelligence (AI) and machine learning are poised to revolutionize space operations. AI-driven systems will enhance capabilities such as automated data analysis, anomaly detection, and predictive maintenance of satellites. These tools will enable the DoD to process vast amounts of space situational awareness (SSA) data, facilitating real-time decision-making and improving operational efficiency. Automated integration tools are also being developed to address the current limitations in ingesting and processing data provided by international allies, reducing time delays and increasing accuracy (C4ISRNet, 2022).

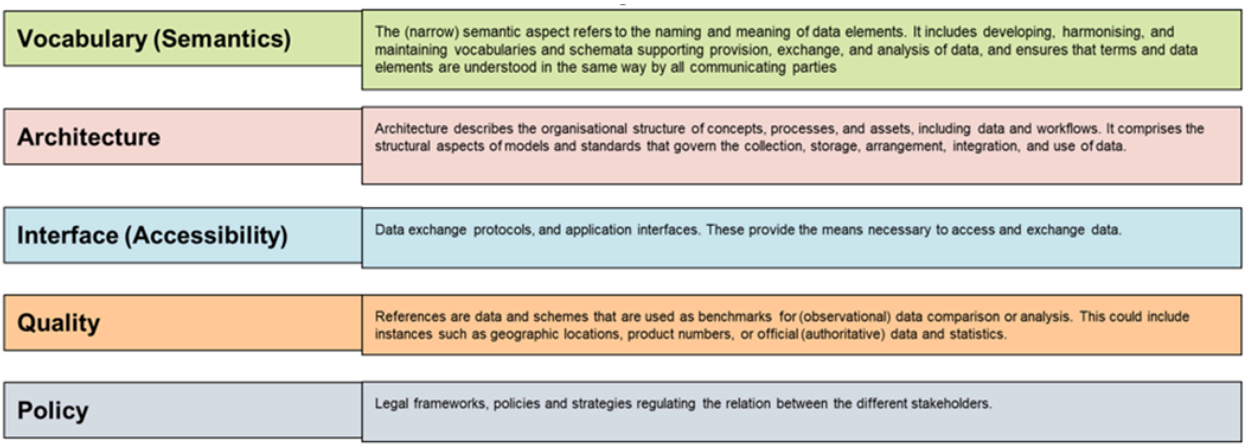
Another transformative area of research is the integration of quantum communication and encryption technologies. These systems promise unparalleled security through quantum key distribution, which is virtually impervious to eavesdropping or interception. The implementation of these technologies in future space systems could provide the DoD with secure communication channels capable of withstanding the most advanced cyber threats.

Bridging Current and Future Technologies

The integration of current and future technologies presents both opportunities and challenges. The SDA's exploration of "translator satellites" or "space exchange points" represents a hybrid approach to bridging government and commercial satellite systems, ensuring seamless communication across diverse platforms (GAO, 2019). These solutions would enable a unified space network capable of supporting a wide range of military and commercial objectives. Additionally, emerging technologies like flexible ground station architectures, enabled by advancements in digital IF/RF standards, will allow for greater scalability and adaptability in managing satellite communications (DIFI Consortium, 2022).

However, successfully transitioning to these advanced technologies requires addressing several critical challenges. Robust cybersecurity measures must accompany the adoption of new systems to mitigate vulnerabilities in optical and quantum communications. The DoD must also navigate the complexities of integrating proprietary commercial systems into its broader architecture, ensuring interoperability without compromising innovation or security. As these technologies mature, they will play a pivotal role in enhancing the DoD's ability to maintain dominance in the increasingly contested space domain.

Figure 2 -Five areas have been identified as critical 'factors' needed to move towards greater interoperability of EO datasets. Each factor has several components. (Committee on Earth Observation Satellites, n.d.)



The Complex Landscape of Commercial-Defense Partnerships

The Commercial Sector's Role

The commercial sector plays a critical role in the Department of Defense's (DoD) efforts to modernize and maintain space capabilities. Contracts with private companies have enabled the development of advanced satellite technologies, launch services, and infrastructure, reducing the cost and time required for deployment. For example, SpaceX and Blue Origin have revolutionized launch systems with reusable rockets, making frequent and cost-effective missions possible. Despite these advancements, challenges remain, such as limited competition among commercial providers, which can lead to inflated prices and dependency on a small number of vendors (Government Accountability Office, 2019).

Integration Challenges

Integration and interoperability between commercial and government systems present substantial challenges where commercial space integration is concerned. Many commercial satellites are designed for proprietary ecosystems, making it difficult to integrate them seamlessly with military networks (C4ISRNet, 2022). The lack of standardized interfaces and protocols not only impedes data sharing but also increases the complexity of managing these systems during critical operations. Initiatives like the Digital Intermediate Frequency Interoperability (DIFI) Consortium aim to address these issues by promoting open standards, enabling greater flexibility and preventing vendor lock-in (Satellite Today, 2022).

However, the development and adoption of such standards face hurdles due to the diverse needs of different stakeholders and the rapid pace of technological advancement in the

space sector (Corrado, 2022). The U.S. Department of Defense has recognized these challenges and is working towards developing common standards and interfaces, particularly for emerging technologies and mission areas, to facilitate innovation both domestically and among allies (Albon, 2024). Despite these efforts, the lack of interoperability remains a significant barrier to achieving a truly integrated commercial and military satellite architecture, which signifies the undeniable importance of continued collaboration between the DoD and the commercial sector to establish interoperable space systems

Hurdles for Commercial Contractors

Bureaucratic Challenges

One major challenge contractors face when partnering with the DoD is bureaucratic hurdles. The DoD acquisition process is often characterized by excessive bureaucracy, making it difficult for companies to navigate. According to a survey by the National Defense Industrial Association (NDIA), 66% of companies found dealing with the DoD to be "very difficult" or "somewhat difficult" (Norquist, 2023). This experience can make it particularly challenging for smaller firms seeking to make entry into the defense market.

Security and Compliance Requirements

Security clearances and access to classified environments present significant challenges for commercial providers seeking to enter the defense market, particularly for new entrants and non-traditional contractors. The process of obtaining and maintaining a facility clearance, along with implementing the necessary industrial security protections, is often a major burden that can disadvantage these companies when competing for classified work (Federation of American Scientists, 2024). According to a survey published in the Texas National Security Review, 44% of companies ranked "accessing classified environments as the greatest barrier to working with the government" (Federation of American Scientists, 2024). This barrier is further worsened by lengthy timelines and high costs associated with establishing classified infrastructure, which can deter many organizations from competing in the classified marketplace. As a result, government contracting officers may limit their vendor selection to those with existing classified access, further restricting the pool of available commercial technologies for national security applications (Federation of American Scientists: Shining a Light on the Defense Department's Industrial Base Problems, 2024).

Second, the DoD's acquisition process often involves lengthy procurement cycles, which can be particularly challenging for companies in fast-moving technology sectors. Contractors also face significant administrative burdens and paperwork, which can be especially taxing for smaller firms with limited resources. Additionally, many non-traditional contractors

struggle to identify and access DoD contracting opportunities due to the complexity of the system. These challenges are acknowledged in the DoD's Commercial Space Integration Strategy, which recognizes “internal structural and cultural barriers related to a historic overreliance on exquisite government systems” (Jewett, 2024).

Financial Hurdles

The financial implications of non-compliance are also a significant concern. Almost half of defense contractors could lose about 40% of their revenue if they lost a contract with the DoD due to non-compliance (Charles IT, n.d.). Moreso, the evolving nature of DFARS regulations presents an ongoing challenge. Contractors must stay updated with changes in the regulations, which can be time-consuming and resource-intensive (Winvale, 2023). The constant need for adaptation can strain the operational and financial capacities of many contractors, particularly smaller ones.

Other financial hurdles commercial contractors face include:

1. Unstable budgets: 22% of companies cited lack of budget stability as their biggest challenge (Norquist, 2023).
2. Cash flow issues: The slow and unpredictable nature of DoD contracts can strain companies’ finances (Coalition for Government Procurement, 2023).
3. Profit margin limitations: Arbitrary profit limitations can make the defense market less attractive compared to commercial opportunities (Coalition for Government Procurement, 2023).

Regulatory Requirements

Another challenge contractors face when working with the DoD has to do with regulation. Complex regulations, such as the Federal Acquisition Regulation (FAR) and its DoD supplement (DFARS), make compliance difficult for many companies (Jewett, 2024).

The Defense Federal Acquisition Regulation Supplement (DFARS) presents several challenges for contractors working with the U.S. Department of Defense (DoD). One of the primary issues is the widespread non-compliance among defense contractors. According to research commissioned by CyberSheath, an estimated 87% of U.S. defense contractors are failing to meet DFARS compliance requirements (Charles IT, n.d.). This high rate of non-compliance poses significant risks to national security and the defense supply chain.Another major problem is the complexity of DFARS requirements, particularly in the area of cybersecurity. DFARS clause 252.204-7012 mandates that contractors protect covered defense information and report cybersecurity incidents (Winvale, 2023). Another layer of challenges is added by the fact that contractors must ensure that their subcontractors also comply with relevant DFARS clauses, which can be challenging to monitor and enforce (BigID, 2023). These requirements, along with associated standards like NIST 800-171 and the Cybersecurity Maturity Model Certification (CMMC), can be

challenging for contractors to implement and maintain, especially for smaller firms with limited resources.

Bureaucratic challenges have led to a decline in the number of companies willing to enter or remain in the Defense Industrial Base. The NDIA reported a net loss of 3,300 companies in the Defense market in fiscal year 2021 alone (Norquist, 2023), and the decline in the supplier base is concerning for the DoD, as it potentially limits competition, innovation, and resilience in the defense supply chain.

Market Entry and Growth Barriers

New entrants and small businesses face significant barriers when trying to enter or grow within the DoD market:

1. Difficulty identifying customers and aligning users, buyers, and contracting officers (Shining a Light on the Defense Department's Industrial Base Problems, 2024).
2. Limited opportunities for small businesses that outgrow set-aside programs (Berteau, 2022).
3. Slow and unpredictable procurement processes that discourage new entrants (Berteau, 2022).

These challenges have contributed to a decline in the number of companies in the Defense Industrial Base, with a net loss of 3,300 companies in fiscal year 2021 alone (Norquist, 2023).

Figure 3 - Status of Major Department of Defense (DOD) Space Acquisitions

Table 1: Status of Major Department of Defense (DOD) Space Acquisitions

Program	Cost and percentage change from first full estimate (in FY 2019 billion dollars)	Quantity	Associated new programs
Advanced Extremely High Frequency (AEHF) (satellite communications)	$15.5 116.7%	**Original:** 5 **Current:** 6	Evolved Strategic SATCOM (ESS); Protected Tactical SATCOM (PTS); Protected Tactical Enterprise Service (PTES)
Enhanced Polar System (EPS) (satellite communications)	$1.5 -0.9%	**Original:** 2 **Current:** 2	Enhanced Polar System Recap (EPS-R)
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T) Command Post Terminals (CPT) (satellite communications terminals)	$1.9 7.2%	**Original:** 95 **Current:** 109	FAB-T Force Element Terminals (FET)
Global Positioning System (GPS) III (positioning, navigation, and timing)	$5.8 31.8%	**Original:** 8 **Current:** 10	GPS IIIF
Global Positioning System Next Generation Operational Control System (GPS OCX) (command and control system for GPS III satellites)	$6.2 68.1%	**Original:** 1 **Current:** 1	Not determined
Joint Space Operations Center Mission System (JMS) Increment 2 (space situational awareness data system)	$0.5 42.0%	**Original:** 1 **Current:** 1	Space Command and Control (C2)
Military GPS User Equipment (MGUE), Increment 1 (GPS receiver)	$1.5 -5.1%	**Original:** N/A **Current:** N/A	MGUE Increment 2
Mobile User Objective System (MUOS) (satellite communications)	$7.1 -6.0%	**Original:** 6 **Current:** 5	Not determined
National Security Space Launch (NSSL) (launch)	$57.0 193.2%	**Original:** 181 **Current:** 161	Not determined

Figure 3.1 - Status of Major Department of Defense (DOD) Space Acquisitions Continued

Program	Cost and percentage change from first full estimate (in FY 2019 billion dollars)	Quantity	Associated new programs
Space Based Infrared System (SBIRS) (missile warning, infrared intelligence, surveillance, and reconnaissance)	$19.9 265.0%	**Original:** 5 **Current:** 6	Next Generation Overhead Persistent Infrared (Next Gen OPIR); Future Operationally Resilient Ground Evolution (FORGE); Enterprise Ground Services (EGS)
Space Fence Ground-Based Radar System Increment 1 (space object detection)	$1.6 -5.7%	**Original:** 1 **Current:** 1	Not determined
Wideband Global SATCOM (WGS) (satellite communications)	$4.2[a] 216.3%	**Original:** 3 **Current:** 10	To be determined following Analysis of Alternatives
Weather System Follow-on (WSF) (weather)	$0.5 N/A	**Original:** 2 **Current:** 2	Electro-Optical/Infrared Weather Systems (EWS); Electro-Optical/Infrared Weather Systems Geostationary (EWS-G)

Contracting Challenges

Contracts define the terms, responsibilities, and expectations of partnerships between the Department of Defense and the commercial sector. Well-structured contracts ensure that both parties align on objectives, timelines, and deliverables while mitigating risks. However, the complexity of space programs often necessitates specialized contract frameworks that can accommodate evolving requirements and technological advancements. Traditional fixed-price contracts, while beneficial for cost containment, may not always be suitable for highly innovative or uncertain projects. In these cases, cost-reimbursement or incentive-based contracts are often more effective in balancing risk and promoting innovation (GAO, 2019).

A recurring challenge in DoD contracts is balancing accountability with flexibility. Cost overruns and schedule delays have plagued numerous space programs, with some projects exceeding their initial budgets by over 100% (GAO, 2019). This trend highlights the need for performance-based incentives that reward timely and efficient execution while penalizing underperformance. Additionally, the inclusion of clear metrics for success in contracts ensures that contractors meet DoD's stringent operational standards. By fostering accountability through well-defined terms, the DoD can minimize inefficiencies and maintain fiscal discipline.

Another critical element in contracts is the management of intellectual property (IP) rights. As the DoD increasingly relies on commercial innovation, defining ownership and usage rights for technologies developed under government contracts becomes crucial. While contractors often seek to retain IP to leverage commercial markets, the DoD requires sufficient rights to modify and maintain systems independently. The department's insistence on owning commercial IP or demanding extensive rights can delay contract awards and reduce the number of companies willing to work with the DoD (Grayson, 2024). Commercial companies are often reluctant to agree to the DoD's intellectual property contractual clauses as their primary interest is to protect their proprietary technology and maintain market competitiveness, and consequently, profitability. Striking a balance between these interests requires careful negotiation and the incorporation of clauses that protect both national security interests and commercial viability.

Finally, international partnerships add another layer of complexity to contracting. Collaborations with allied nations or multinational corporations require contracts that navigate diverse legal, regulatory, and cultural landscapes. Ensuring compliance with international trade agreements and safeguarding sensitive technologies are paramount. The establishment of standardized contracting practices, coupled with a commitment to

transparency and mutual trust, can facilitate smoother collaborations with global partners, aligning efforts toward shared security goals.

Contracting and Supply Chain Management

The Department of Defense (DoD) faces significant challenges in managing and tracking its supply chains, with three key issues at the forefront. First, the department suffers from limited visibility into its supply network, particularly below the third-tier level, hindering its ability to fully understand and monitor the entire chain (Greenwalt, 2024). Second, recent global events such as the COVID-19 pandemic and escalating geopolitical tensions have exposed the fragility of the defense supply chain and its vulnerability to disruptions (Greenwalt, 2024). Lastly, persistent concerns about quality control, including risks of inferior or counterfeit components infiltrating the supply chain, pose serious threats to mission-critical systems, potentially compromising national security and the safety of military personnel (Greenwalt, 2024).

The global nature of the space industry further exposes supply chains to geopolitical risks, such as export controls and reliance on foreign components. To mitigate these risks, the DoD can incentivize domestic production and increase partnerships with allied nations (Sandrone, 2024). Simultaneously, contract structures need to be redesigned to reward performance and innovation while penalizing delays and non-compliance (Department of Defense [DoD], 2023). Such measures can ensure that commercial collaborations align with DoD's strategic goals while maintaining accountability and efficiency.

To address these challenges, the DoD is implementing several strategies. The National Defense Industrial Strategy (NDIS) focuses on four main areas: flexible acquisition, economic deterrence, resilient supply chains, and workforce readiness (Wiley, 2024). The DoD is also expanding the use of Performance-Based Logistics (PBL) contracts, which incentivize providers to improve reliability and supply chain efficiency while controlling costs (Defense Acquisition University [DAU], n.d.). Additionally, the department is working to enhance supply chain visibility through improved data analytics and real-time decision-making capabilities (Sandrone, 2024).

Budgeting

Budgeting within the commercial collaboration framework also presents significant hurdles. Large-scale programs often experience cost overruns and delays, straining fiscal resources and impacting project timelines. According to the Government Accountability Office (2019), some satellite communication systems have seen cost increases exceeding 100%. Furthermore, commercial providers, driven by market dynamics, may prioritize

short-term profitability over long-term strategic goals, leading to misaligned objectives between the DoD and its partners. Addressing these concerns requires a balance between stringent contract oversight and fostering innovation.

Budgeting for space acquisitions presents a formidable challenge for the Department of Defense (DoD) as it seeks to modernize aging systems, counter emerging threats, and maintain global dominance in the space domain. The DoD's space budget must account for long-term investments in research and development, operational costs, and unexpected contingencies. However, space programs often experience cost overruns, with some exceeding their initial budgets by more than 100% (GAO, 2019). These overruns, coupled with delays, place additional strain on already constrained resources, forcing the DoD to prioritize programs and adjust timelines.

One key issue is the unpredictability of costs associated with advanced technologies. Cutting-edge systems like resilient satellite architectures and laser communication terminals require significant upfront investments, while their long-term financial impacts remain uncertain. Furthermore, evolving adversarial capabilities compel the DoD to continually reassess and reallocate funding to address emergent threats. This dynamic environment creates a perpetual cycle of budgetary adjustments, often impacting the stability of multi-year programs (C4ISRNET, 2022).

Collaboration with commercial entities introduces both opportunities and challenges in budgeting. On one hand, leveraging the private sector's cost efficiencies can alleviate some financial pressures. However, integrating commercial technologies often involves complex contractual agreements and additional expenses for ensuring interoperability with DoD systems. For example, hybrid architectures that combine government and commercial satellites require funding not only for procurement but also for the integration of diverse platforms and data streams.

Finally, international partnerships add complexity to the budgeting process. Collaborations with allies require joint funding arrangements, often necessitating negotiations on cost-sharing mechanisms. Ensuring equitable contributions while maintaining operational control is a delicate balancing act. To address these challenges, the DoD can explore innovative budgeting approaches, such as adopting agile funding models that allow for iterative adjustments and incentivizing cost-saving measures among contractors. These strategies can help mitigate financial risks and enhance the DoD's ability to execute its ambitious space initiatives.

DoD Scalability Needs vs. Industry Profit-Driven Motives

The Department of Defense also faces significant challenges in aligning its need for scalable solutions with the commercial sector's focus on return on investment (ROI) and profitability. As defense dollars are no longer seen as a primary driver of growth by many companies, competition and innovation in the defense market have diminished (National Defense Magazine, 2023). This misalignment is exacerbated by the DoD's complex budgeting process and bureaucratic structures, which often impede the rapid adoption of innovative technologies and contracting methods (National Defense Magazine, 2023). Furthermore, current procurement mechanisms tend to favor legacy government systems over commercial integration, thus creating substantial barriers for new, innovative solutions attempting to enter the defense market (National Defense Magazine, 2023). These factors collectively contribute to a widening gap between the DoD's technological needs and the commercial sector's willingness to engage, ultimately hindering the military's ability to access cutting-edge technologies and maintain its competitive edge in an increasingly dynamic global security environment.

Risk Distribution Imbalance

The DoD often bears a disproportionate amount of risk in its contracts with the commercial sector. This imbalance can stifle innovation among contractors, as it could lead to them being less incentivized to be innovative or improve their processes (Schwartz & Johnson, 2023). Moreover, the DoD's assumption of most risks can result in higher overall project costs, with studies suggesting that inappropriate risk allocation can add at least a 3% contingency or risk premium to bids (Construction Industry Institute, 2006, as cited in CPR, 2010). Additionally, the risk imbalance can lead to contractors becoming overly reliant on DoD contracts, potentially compromising their competitiveness in the defense market.

The Need for Equitable Risk-Sharing

To address the risk distribution problem, a more balanced approach to risk allocation is necessary. Studies have shown that such practices can result in a 5% savings in a project's total cost, which can even help alleviate cost overrun issues (Construction Industry Institute, 1986, as cited in CPR, 2010). When contractors have more at stake, they are more likely to be driven to innovation and efficiency and a more equitable distribution of risk can also lead to an improved relationship between the DoD and its contractors, thereby increasing the chances of a win-win situation for both parties (Schwartz & Johnson, 2023). To achieve this balance, the DoD needs to undertake a comprehensive reassessment of its

contracting practices and risk allocation strategies. This may involve updating existing policies, providing enhanced training for contracting officers, and engaging in more open and transparent dialogue with industry partners about risk-sharing mechanisms. If the DoD can create a more balanced and effective partnership with its commercial contractors, potential benefits include better innovation, cost-effective solutions, and successful defense projects.

DoD Acquisition Framework and Commercial Integration

Gaps in Acquisition

The Department of Defense (DoD) currently grapples with several significant challenges in its acquisition framework. Traditional acquisition mindsets persist, limiting innovation potential and hindering the adoption of transformative technologies (Grayson, 2024). Inflexible budgets and bureaucratic inefficiencies continue to impede rapid procurement processes, slowing down the DoD's ability to respond to emerging threats and technological advancements (Berteau, 2022).

Current procurement mechanisms predominantly favor legacy government systems over commercial integration, creating substantial barriers to modernization (National Academies of Sciences, Engineering, and Medicine, 2015). The preference for established systems often results in missed opportunities to leverage innovative commercial solutions that could enhance military capabilities..

Modern Business Model Integration

Leveraging contemporary business models that facilitate capability acquisition as a service is essential to the evolution of government procurement (Smith, 2023). This approach should integrate well-defined and reliable service level agreements, which are now standard offerings in the private sector (Johnson & Lee, 2022). The current procurement system, predominantly based on the historical broadcast lease model that typically involves spectrum or MHz allocations, has become obsolete, inefficient, and financially burdensome (Brown et al., 2024). As previously highlighted in this paper, the persistence of this outdated acquisition method can be attributed largely to institutional resistance to change and a conservative mindset that adheres to historical precedents rather than embracing innovation (Wilson, 2023). As Garcia and Thompson (2024) argue, “Government procurement strategies must adapt to the rapidly changing technological landscape to ensure optimal resource utilization and cost-effectiveness.”

DoD Efforts to Smoothen the Acquisition Process

Acquisition Authorities and Pathways

The Department of Defense's Adaptive Acquisition Framework (AAF) represents a significant shift in the approach to defense acquisitions, with six distinct pathways tailored to different types of capabilities and services). According to Mike Coolican from the Defense Acquisition University, the AAF aims to simplify acquisition policy and empower program managers (Federal News Network, 2021). However, its overall success is still being evaluated.

The six pathways include **Urgent Capability Acquisition**, **Middle Tier of Acquisition** (MTA), **Major Capability Acquisition**, **Software Acquisition**, **Defense Business Systems (DBS) Acquisition**, and **Defense Acquisition of Services**. Each pathway is designed to address specific acquisition needs, from rapidly fielding critical warfighter capabilities to developing complex, enduring military systems. Coolican noted that "out of everything that's come out of the Adaptive Acquisition Framework, the software acquisition pathway is the most powerful" (Federal News Network, 2021). As of 2021, fourteen programs were using this pathway, with many more in the pipeline.

The Middle Tier Acquisition pathway is designed for rapid prototyping and fielding and has shown a lot of promise. However, the Government Accountability Office (GAO) noted that programs using MTA may face increased risks of falling short of performance goals if they start without sound business cases (GAO, 2021). Another pathway of the AAF, the Urgent Capability Acquisition pathway, is intended for needs identified by commanders in ongoing contingency operations, while the MTA pathway focuses on rapid prototyping and fielding within a 2-5 year timeframe (AcqNotes, 2024).

The AAF represents a departure from the previous one-size-fits-all approach to defense acquisition. It empowers program managers to tailor their acquisition strategies by starting with a baseline of rules specific to their chosen pathway and then "tailoring-in" additional requirements as needed (Federal News Network, 2021). This approach aims to simplify acquisition policy, facilitate data-driven analysis, and emphasize sustainment from the outset of programs. However, the Government Accountability Office (GAO) has noted that while the new framework offers opportunities to speed up the acquisition process, programs using pathways like MTA may face increased risks of falling short of performance goals if they start without sound business cases (GAO, 2021).

Other DoD Efforts to Smoothen Acquisition

The Department of Defense (DoD) has implemented various initiatives to streamline its acquisition processes. One of such is the Tradewinds Solutions Marketplace, which has demonstrated promising results in expediting the procurement of innovative products and services (Barnett, 2024). This platform has been particularly advantageous for smaller enterprises seeking to penetrate the defense market (Brown, 2021).

Despite these efforts, the DoD continues to grapple with significant acquisition challenges. The current acquisition processes, while improved, still have considerable room for enhancement (Gansler & Lucyshyn, 2024). The Defense Innovation Board has identified

several barriers to modernization, including the need to streamline acquisitions, rapidly field new technologies, and promote competition (GovCIO Media Staff, 2024).

To address these persistent issues, the DoD has implemented the Back-to-Basics (BtB) Acquisition framework, which aims to improve the agility of the defense acquisition workforce by streamlining the functional area framework and prioritizing limited training resources (U.S. Army Acquisition Support Center, 2024]. However, as the Government Accountability Office (GAO) notes in its 22nd annual assessment, the DoD still struggles to deliver new technologies quickly, even in the face of constantly evolving threats (U.S. Government Accountability Office, 2024).

Desired Future State

We believe that the desired future state of a space-based network, like other global networks, will remain dynamic and continually evolving. With the rapid pace of technological advancements and the ever-changing mission requirements, it is unrealistic to envision a singular, definitive future state. The initiatives being undertaken in space represent relatively new concepts, and they come with a multitude of challenges to overcome. Many current-state issues lack straightforward solutions, further complicating efforts to chart a fixed trajectory.

Observations

In the global IT and networking landscape, many major corporations depend on a small number of providers for their critical infrastructure. This model poses significant challenges for the Department of Defense (DoD). The work being conducted by the DoD and the U.S. Military is of utmost importance to national security, necessitating a level of reliability that precludes dependence on a singular provider or even a limited number of providers. Such reliance creates single points of failure—a vulnerability that the nation cannot afford.

However, minimizing these dependencies introduces challenges in standardization. Achieving interoperability across data transmission protocols, hardware configurations, and software systems is a complex endeavor. Additionally, the DoD and the U.S. Military utilize proprietary hardware and software solutions that must seamlessly integrate with any future mesh network. These factors add layers of complexity that must be addressed to achieve a robust, standardized, and interoperable system capable of meeting the demands of national security and mission-critical operations.

Conclusion

Truly interoperable networks that are secure, low latency and global will be the cornerstone of operations for nations and organizations seeking to maintain influence on the global stage. These networks will not only underpin economic and social systems but will also serve as critical infrastructure for defense and national security. The United States, in collaboration with coalition partners, must remain committed to leading the silent but pivotal race in space. Maintaining space superiority is not merely an aspirational goal, it is an operational necessity. Without it, access to systems that drive modern life could be compromised, threatening the stability of everyday services many take for granted.

The systems that support banking, weather forecasting and global positioning are integral to the seamless functioning of our economy and society. The absence or disruption of these services could bring critical sectors of the economy to a standstill, resulting in widespread consequences. As we have highlighted throughout this paper, future battles will likely be fought in space, leveraging the very networks the United States is now working to establish. The challenges of creating these networks, from securing standardized protocols to ensuring their resilience against adversarial threats must be overcome through deliberate and innovative efforts.

The US DoD and its coalition partners must address the significant technical, commercial and acquisition challenges to build a space-based infrastructure capable of supporting the growing demands of a contested and complex environment. By fostering collaboration with the commercial sector, implementing scalable technologies, and prioritizing interoperability, the DoD can ensure these networks remain robust and agile.

Finally, as space becomes increasingly contested, the ability to deploy, maintain and protect this infrastructure will determine the outcome of future conflicts and the balance in global power. The work outlined in this paper is a call to action for continued investment, innovation and partnerships to safeguard the networks that underpin not just our national security but also our way of life for generations to come.

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