



COMMERCIAL SPACE

SYSTEM ACCESS AND INTEGRITY

DEFENSE SCIENCE BOARD

May 2024

FINAL REPORT

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OFFICE OF PREPUBLICATION AND SECURITY REVIEW

This report is a product of the Defense Science Board (DSB). The DSB is a Federal Advisory Committee established to provide independent advice to the Secretary of Defense. Statements, opinions, conclusions, and recommendations in this report do not necessarily represent the official position of the Department of Defense.



DEFENSE SCIENCE
BOARD

OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
WASHINGTON, DC 20301-3140

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE FOR RESEARCH AND
ENGINEERING

SUBJECT: Defense Science Board (DSB) Report on Commercial Space System Access
and Integrity.

I am pleased to forward the DSB report on *Commercial Space System Access and Integrity*,
co-chaired by General (ret) Ellen M. Pawlikowski and Ms. Mandy Vaughn.

The DSB was asked to study how the Department of Defense (DoD) should best use
commercial space systems in support of DoD objectives. The DSB provided
recommendations on acquisition models for commercial space systems and evaluated the risks
accompanying both U.S. and potential adversary use of these systems.

The DSB made five recommendations:

- Implement an end-to-end framework to better integrate existing and planned
commercial capabilities into national security space architectures;
- Integrate evaluation of and provision for commercial space services into institutional
processes;
- Incentivize trust and build resilience in commercial providers;
- Develop a suite of capabilities to monitor, assess, and respond to adversary use of
commercial space capabilities; and
- Account for the maturity of the market when making decisions on investing,
regulating, or buying in the commercial market, avoiding overregulation, investing for
market creation rather than monopolization, and minimizing unique requirements.

I fully endorse all the study's recommendations and urge their careful consideration and
adoption.

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Dr. Eric D. Evans
Chair, DSB

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DEFENSE SCIENCE
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OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
WASHINGTON, DC 20301-3140

MEMORANDUM FOR THE CHAIR, DEFENSE SCIENCE BOARD

SUBJECT: Report of the Defense Science Board (DSB) Task Force on Commercial Space System Access and Integrity

Attached is the final report of the DSB Task Force on *Commercial Space System Access and Integrity*. The Task Force was asked to study the Department's use of commercial space systems and explore how best they may be further leveraged in support of DoD objectives. Specific questions in the Terms of Reference included:

- Identify the commercial space systems most useful for current and future DoD needs.
- Identify potential enhancements to commercial space systems that will improve resilience or protection against current and future threats.
- Recommend approaches for managing the priorities and governing the use of commercial space systems used for DoD strategic and tactical needs.
- Provide recommendations on models for acquiring commercial space services and products.
- Investigate the potential risks and vulnerabilities associated with adversary exploitation of U.S. use of commercial space systems, or attacks on these systems.
- Investigate the impact and possible mitigations for potential adversary use of commercial space systems against U.S. defense systems.

The study examined the historical and emerging use of commercial space systems in national security applications and explored the best means by which they can be integrated into an inherently resilient, truly hybrid national security architecture. It examined possible models for management and contracting of commercial space services, and institutional impediments to further commercial integration on the parts of both government and industry. It also provided a risk management framework pertaining to potential adversary exploitation of U.S. use of commercial, and for use of commercial by adversaries. Finally, the study made recommendations for the role of government as an economic actor in the commercial space marketplace.

A handwritten signature in black ink, appearing to read "Mandy Vaughn".

Ms. Mandy Vaughn
Co-Chair

A handwritten signature in black ink, appearing to read "Ellen M. Pawlikowski".

Gen. Ellen M. Pawlikowski, USAF (ret.)
Co-Chair

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Purpose of the Commercial Space System Access and Integrity Study

In November 2022, the Under Secretary of Defense for Research and Engineering (USD(R&E)), tasked the Defense Science Board (DSB) to study Department of Defense use of commercial space technology and services to understand how best to leverage these capabilities and manage their associated risks. Specific questions in the Terms of Reference included:

1. Identify the commercial space systems most useful for current and future DoD needs.
2. Identify potential enhancements to commercial space systems that will improve resilience or protection against current and future threats.
3. Recommend approaches for managing the priorities and governing the use of commercial space system use for DoD strategic and tactical needs.
4. Provide recommendations on models for acquiring commercial space services and products.
5. Investigate the potential risks and vulnerabilities of an adversary's exploitation of or attack on U.S. use of commercial space systems.
6. Investigate the impact and possible mitigations for potential adversary use of commercial space systems against U.S. defense systems.

A classified annotated briefing complements this unclassified report and can be accessed through the DSB office.

Revolution in Commercial Space

Space applications were once the preserve of governments and a limited number of commercial actors. Since the early 2010s, the commercial space sector has expanded dramatically and received an enormous outpouring of capital investment. To cite one such analysis, per the consulting firm McKinsey and Company, the space market was valued at some \$447 billion in 2023, with projections into the next decade exceeding \$1 trillion.¹

SpaceX has distinguished itself as an epochal trailblazer, having built a commercially competitive launch capability while simultaneously driving down launch costs and eliminating barriers to space access—to world-changing effect. Beyond launch, commercial providers now offer such services as earth sensing and observation, deep analytical capabilities, and ground operations for command and control of satellites. By the century's third decade, ***space had shifted decisively from the province of large nation-states to a burgeoning global commercial market.***

As in other science and technology (S&T) fields, the Department played a historical foundational role in space systems development. Its role as a market actor remains indispensable. But the DoD has been slow to capitalize on the opportunities presented by the very marketplace its patronage helped

¹ "A Giant Leap for the Space Industry," McKinsey & Company, <https://www.mckinsey.com/featured-insights/sustainable-inclusive-growth/chart-of-the-day/a-giant-leap-for-the-space-industry>.

create. This report therefore assesses how the Department can better leverage commercial capabilities, and the implications of these capabilities for risk management.

In some contrast to other domains of military operations, military and commercial space missions are not firmly separated by areas of responsibility. Therefore, while a hybrid architecture (integrated commercial and DoD-specific capabilities) offers considerable potential to provide more robust and integrated capabilities, it also carries novel risks of which the Department must be cognizant.

The Task Force was comprised of government leaders in space system acquisition and operations (DoD and the intelligence community (IC)), policymakers, technologists, program managers, investors, and commercial executives. The complete Task Force membership is in Appendix B. The Task Force solicited inputs from the Office of the Secretary of Defense (OSD), Military Services, DoD agencies, academia, the House Armed Services Committee, IC, and industry leaders (see Appendix C for briefings received).

Commercial Space Provides a Spectrum of Opportunities and the Role of Government Will Vary

The term “commercial space” covers a broad conceptual spectrum, organized for the study’s purposes into four elements. *Commercial innovation* (CI) refers to the incorporation of commercially derived, market-based ideas into DoD’s space activities—SpaceWERX, AFWERX and the Defense Innovation Unit are examples of this. *Commercial Development* (CD) refers to the use of commercial components in bespoke DoD systems— this is the construct applied by the Space Development Agency (SDA). *Commercial Products* (CP) are near-off-the-shelf systems, potentially tailored somewhat to DoD’s particular needs—e.g., Wideband Global SATCOM. Finally, *Commercial Services* (CS) refer to those capabilities purchased from commercial providers, with little-to-no direct control over said capabilities by the Department. Examples of this include satellite communications (SATCOM) and launch.

This study focused primarily on commercial products and commercial services and some discussion of commercial development, those elements being more capable of supporting DoD missions in the near-to-medium term than the innovation activities comprising the left two elements (CI and CD). Other efforts (such as the DSB’s *Advise Implementation and Prioritization of National Security Innovation Activities* study) address the issues associated with infusing the innovation ecosystem into DoD systems and activities broadly, not just for space missions.



Figure 1. Spectrum of Opportunities

In leveraging commercial products and services, government must be cognizant of its importance as a customer, regulator, and investor, the particulars of which can and should vary significantly depending upon where on this spectrum a desired capability resides. This conscious curation will be addressed in greater detail throughout the study.

The commercial space sector’s market-driven economics depart considerably from the more ponderous traditional DoD model. Commercial firms are driven by the exigencies of the market to deliver new products quickly and cost effectively, incentivizing innovation and high productivity. Though space capabilities have proliferated globally over time, the United States remains market dominant, with American firms outnumbering their nearest peer (itself the closely allied United Kingdom) ten to one.² The Department has much to gain by leveraging these world-leading efficiencies.

Commercial Capabilities are Key to a Resilient Hybrid Architecture

The study referenced previous work on space resiliency and different technical and architectural elements to increase system and mission resiliency.³ From those previous efforts, the Task Force identified how commercial systems and technologies can be leveraged to create truly hybrid architectures that include elements of orbital diversity, supply chain diversity, and mission options that can be complementary to bespoke DoD “resiliency” measures.

The study featured vignettes from historical, current, and emerging mission areas of DoD use of commercial space systems. Examples included communication satellite’s (COMSATCOM) historical use by the DoD, the National Geospatial-Intelligence Agency (NGA) use of commercially collected and analyzed geosynchronous earth orbit (GEO) intelligence (GEOINT) products, and some recent use of commercial space products in the Ukraine conflict. Each case demonstrated the past and present value of commercial as well as the potential of further integration of commercial space.

Role for Commercial Space

- Shared, transparent capabilities to enable partners and allies
- Shaping and messaging in “gray zone”
- More proliferated architecture complicating adversary targeting
- Increase capacity for high priority areas and/or support disadvantaged users
- Enable options in other layers

The study also examined DoD efforts to integrate commercial SATCOM capabilities, and commercial GEOINT collections in joint warfighting concepts. Both efforts demonstrated the real benefit of seamless integration of commercial space into military operations.

Commercial Use Case: Warfighting Operations Today

Commercial space capabilities have supported military operations, sometimes including combat, since the 1960s. Principally, this has entailed support through COMSATCOM and imagery, as well as other classified programs. Use cases in contemporary warfighting have only grown stronger: three examples of such include the use of SATCOM for unmanned aerial systems (UAS), detection as a service, and the involvement of commercial GEOINT in the Russo-Ukraine conflict.

² Landry Signé and Hanna Dooley, “How Space Exploration Is Fueling the Fourth Industrial Revolution,” Brookings, March 28, 2023, <https://www.brookings.edu/articles/how-space-exploration-is-fueling-the-fourth-industrial-revolution/>.

³ “Defense Strategies for Ensuring the Resilience of National Space Systems,” Defense Science Board, 2017.

SATCOM enables beyond visual line of site capability to UASs. The importance of this capability in the conflicts of the 21st century is well-established. As UAS employment grows to even greater scale, the case for integration of commercial efficiencies in warfighting will grow commensurately.

Satellite maneuver detection is an important component of space domain awareness. The trajectory of satellites and their associated propulsion systems can be ascertained algorithmically.

The role of commercial satellite imagery products in Ukraine is renowned. Commercial imagery and persistent surveillance have been indispensable to Ukraine's war efforts. Because it is unclassified, rapid sharing between international partners is possible. Public release of such imagery as Russia's abortive "40-mile convoy" have been a pioneering influence in the information domain, "fundamentally chang[ing] the frame of the conflict..."⁴

Improve U.S. Use of Commercial Space Capabilities

The Task Force explored several approaches to contracting or managing commercial space services. One concept, favored by the U.S. Space Force (USSF), is U.S. Transportation Command's Commercial Reserve Air Fleet (CRAF) model for DoD use of commercial aircraft during conflict. Through the Charter Airlift Services contract, participating air carriers commit 30% of their passenger fleet and 15% of their cargo fleet to an array of national security contingencies. As recompense for backend risk, air carriers are incentivized by access to Department airlift business in peacetime.

While the CRAF model has some applicability to space, civil airlift differs from space applications in important ways. Owing to the nature of satellite orbits, commercial space systems will inherently occupy a more persistent threat environment than civil aircraft activated under CRAF, which are generally not expected to operate in contested environments. Moreover, as this study will contend, commercial space services should become more integrated into warfighting operations. They should therefore be expected to take a more leading role than the participants of CRAF, which serve as more of an auxiliary called upon during acute crisis. This is to say, CRAF is an augmentation measure, not a model for full integration as advocated for commercial space systems by this study.

An important attribute of the CRAF construct is the acquisition of services through a working capital fund (WCF), much as how DoD manages government depots and commercial repair facilities. WCFs provide greater flexibility, eliminate the erroneous perception of government-owned services as costless, and dismantle the barriers to integration posed by different funding appropriations for commercial and government-owned services. The different "colors of money" in the latter paradigm drive decisions on allocation between commercial and government-owned based solely on the type of

⁴ "New Documentary on Ukraine Underscores the Importance of Maxar's...", Maxar Blog, <https://blog.maxar.com/earth-intelligence/2023/new-documentary-on-ukraine-underscores-the-importance-of-maxars-commercial-satellite-imagery-and-capabilities>; "The Game-Changing Role of Commercial Satellite Imagery and Analytics...", Maxar Blog, <https://blog.maxar.com/earth-intelligence/2023/the-game-changing-role-of-commercial-satellite-imagery-and-analytics-in-Ukraine>; J. Mezey, "Game-Changers: Implications of the Russo-Ukraine War for the Future of Ground Warfare," Atlantic Council, February 27, 2024, <https://www.atlanticcouncil.org/in-depth-research-reports/issue-brief/game-changers-implications-of-the-russo-ukraine-war-for-the-future-of-ground-warfare/>.

funds available. This would be particularly applicable to the provision of SATCOM to combatant commands.

The managed service contracts used in the commercial SATCOM market provide another model, providing a stable demand signal to the vendor while allowing it to retain significant flexibility. In this construct, commercial customers hold long-term service contracts, providing high levels of availability, surge capacity, and global coverage through service-level agreements.

Finally, “signals as a service,” a construct the Task Force proposes that results from enduring relationships with commercial providers. This capability could also provide a reliable and seamless approach to integration in a variety of mission areas. This model envisions ownership of all user equipment and software by the vendor, with needs particular to the Department priced into the service.

Concerns and Perceptions Limiting Use of Commercial Space

Government and industry representatives spanning legacy and emerging mission areas, technology development, and mission uses provided their perspective on the challenges and opportunities for commercial space. Areas of discussion included acquisition trades, leveraging innovation from the commercial sector, models for financial incentives and protections, and barriers to entry for new and legacy participants. The Task Force explored in detail how to strike a balance between commerciality and support of heretofore government functions.

Concerns and Perceptions: Government Perspective

The synergies of market forces and achieving an improvement in mission resiliency through a hybrid approach are the *raison d'être* of commercial integration. The emergence of vendor lock, or dependence upon a sole vendor, has the potential to negate the strengths of the market by stifling innovation and inflating prices. This can culminate in a *de facto* monopoly, cementing a stagnant and wasteful anticompetitive paradigm. Moreover, vendor lock has the potential to create “cells” that experiment without integrating with operations. The interest of government in avoiding vendor lock, however, is in direct conflict with the imperative of firms to maximize market share.

Government is wary of the commercial services’ long-term reliability, particularly during acute crisis. Firms, in hoc to market forces and shareholder concerns, may not wholly share the government’s interests and lack its comparative stability. The decision of Starlink to limit its use by the Ukrainian Armed Forces in their offensive operations is a poignant illustration of government concerns in extremis. The SDA model leverages commercial for system components for input into government-owned systems over which it holds final control, mitigating some concerns. In so doing, SDA envisions creating its own market valued at some \$4 billion per annum.

Government is hesitant to cede control over missions it views as inherently governmental. This largely owes to a conflation of law and policy (the former is more permissive than the latter), as well as concerns with cyber security and interfaces with foreign firms. In general, government tends to prefer direct ownership of no-fail assets, even if commercial products may be equal or greater in effectiveness, in whole or even in part, to the conduct of a mission.

Concerns and Perceptions: Industry Perspective

From industry's perspective, government buying practices are suboptimal. For example, government purchases SATCOM transponders in lieu of services, eschewing stabilizing long-term agreements. The government separates the user equipment from the service provided. This approach has been described as transactional and not to the same level of efficiency or global reliability of commercially procured managed services.

Industry's potential is sometimes poorly understood by government. In the particular of cases of the National Reconnaissance Office (NRO) and SDA, industry believes that limits are imposed on them that fail to account for what a less constrained commercial sector could provide.

The potential for damage or destruction of space systems implicated in warfighting operations is significant. There remains no industry consensus on how government should compensate industry for loss of assets (e.g., indemnification, war risk insurance). For example, some providers which are strongly reliant upon DoD as an anchor seek compensation, while others do not.

Concern about availability of threat and vulnerability information was a consistent theme heard from commercial operators. Firms are often willing to self-resource added protection measures, which often make ample business sense. But absent sufficient information, they cannot allocate their resources effectively.

Finally, mirroring the government's own concerns, industry actors fear being locked out of the market by incipient monopolies should the government act as an anchor tenant or misuse acquisition tools to purchase platforms instead of services.

Policy Interpretations Limits Role of Commercial Space System Integration

Elements of policy, requirements, or tradition in DoD architectural premises limit commercial systems and services integration. ***In particular, Department definitions of "inherently governmental" tend to be broader and therefore more constraining than the law demands; this carries important implications for the behavior of government customers through the acquisition and purchasing processes.*** Policy, informed by restrictive interpretation, limits commercial space applications to smaller portions of the mission than law permits.

Functions, not missions per se, can be the legal preserve of the government. Conflation of these categories can inhibit further commercial integration. Moreover, certain functions (e.g., SATCOM, imagery, or launch) within a mission set deemed inherently governmental by policy may nonetheless be assigned to commercial capabilities while maintaining policy compliance.

Acquisition and Operations Barriers to Commercial Space

The Task Force assessed a series of acquisition and operations barriers to commercial integration, listed below. In general, Department practices are poorly aligned with their commercial counterparts. DoD is poorly appraised of the state of the art in both technology and process. It does not sufficiently factor industry into its planning and exercises, nor does it adequately coordinate with industry in terms of threat sharing and security.

Acquisition	Operations
<ul style="list-style-type: none"> DoD acquisition models not consistent with modern commercial space business practices <ul style="list-style-type: none"> E.g., DoD buys SATCOM as dedicated GEO transponders for one year lease despite COMSATCOM providers moving to managed services and hybrid architectures leveraging LEO, MEO, GEO Analysis of alternatives not keeping up with rapid commercial development – options are uninformed or out of date Requirements process and funding models not aligned to purchasing commercial services Lifecycle cost estimation requirements not amenable to commercial service pricing models Lack of training and education on commercial business practices Lack of support in granting clearances to companies providing commercial data products/services 	<ul style="list-style-type: none"> COMSATCOM not included in most Combatant Command Plans <ul style="list-style-type: none"> Only JSOC includes COMSATCOM in mission planning Limited to no play of commercial services in exercises and war games No commercial systems are part of USSPACECOM’s Critical Asset List (CAL)/Defended Asset List (DAL) Commercial Integration Cell concept doesn’t scale to the need <ul style="list-style-type: none"> Only 10 companies via Cooperative Research and Development Agreement, pay-to-play Limited information exchange on threats and operational environment between military operations and commercial providers Lack of support in granting clearances to companies providing commercial data products/services

Findings and Recommendations for Improving U.S. Use of Commercial Space Capabilities

Despite their demonstrated utility, cultural and bureaucratic barriers slow the integration of commercial space capabilities into national security missions. Policy interpretation, security, acquisition practices, funding models, operational employment, and military exercises limit the potential reach and application of commercial space. Bottom line: ***Integrated Deterrence Requires Integrated Operations.***

Recommendation 1: Implement an end-to-end framework to better integrate existing and planned commercial capabilities into national security space architectures.

- Architecture analysis, test and evaluation, military operations and planning, capability development, and sustainment and support. [***Space Warfighting Analysis Center (SWAC), USSPACECOM, USSF, Assistant Secretary of the Air Force for Space Acquisition and Integration (SAF/SQ)***]
- Develop initial prototype for “integrated commercial Command, Control, C4ISR” to demonstrate end-to-end integration. [***Strategic Capabilities Office (SCO)***]

Action Area	Means	Funding and Responsibility
Requirements: Integrate commercial capabilities early in definition of requirements	<ul style="list-style-type: none"> Start with the question: “How can I use what is available?” Explore commercial capabilities upfront vs late in the process 	<ul style="list-style-type: none"> OPR: JCS/J8 (lead) and the Military Services
Development: Create a strategic funding increase (STRATFI)-like program to enable PEOs to leverage emerging and developing commercial capabilities in Program of Record efforts. STRATFI efforts funded by SBIR funds and limited to small business	<ul style="list-style-type: none"> Assign all PEOs responsibility for executing Commercial Capability Funding Initiative (CCAPFI (akin to STRATFI)) efforts. Forming partnerships with commercial providers which leverage private investment sharing 	<ul style="list-style-type: none"> Fund through 2% tax on programs of record assigned to a PEO OPR: SAF/SQ

Action Area	Means	Funding and Responsibility
<p>Test & Evaluation: In every TTX, exercise, and evaluation where Space capabilities are applied, include commercial space capabilities as well</p>	<ul style="list-style-type: none"> • Broaden inclusion of Commercial Space in TTXs, exercises, across the spectrum of live, virtual, and constructive • Create and maintain digital twins for commercial space integration • Leverage results of Red Team vulnerability assessments to improve resiliency 	<ul style="list-style-type: none"> • OPR: SWAC lead for integrating commercial capabilities in all analyses • OPR: USSPACECOM lead in incorporating into exercises • OPR: USSF allocate budget exclusively for integrating commercial Space into TTXs, exercises, training • OPR: SAF/SQ include commercial space systems in digital enterprise tools and environment
<p>Operations: Create dedicated efforts to integrate existing commercial space capabilities into operations</p>	<ul style="list-style-type: none"> • Create the equivalent of Tactical Exploitation of National Capabilities (TENCAP) for Commercial Space (e.g., Technical Exploitation of Commercial Capabilities) with a separate program element (PE) for funding 	<ul style="list-style-type: none"> • Initial responsibility assigned to SCO with longer term objective for SAF/SQ and CSO decision on reassignment within the USSF • DoD PE funding line of \$XXM (TBD) • OPR: USD(R&E)
<p>Sustainment and Support: Implement seamless and flexible funding to support operations of integrated capabilities by using a working capital fund approach to supporting both DoD and commercial services</p>	<ul style="list-style-type: none"> • Pilot: Implement a working capital funding approach for wideband SATCOM where both USSF MILSATCOM operations, support, and commercial services contracts are funded. Leverage the already established working capital fund efforts in commercial SATCOM today. Target 2025. • Expand pilot to tactical ISR and space domain awareness 	<ul style="list-style-type: none"> • OPR: USD(A&S)
<p>Interagency Collaboration: Initiate interagency effort on the spectrum and terminal certification efforts to streamline policy for joint approval process</p>	<ul style="list-style-type: none"> • DoD engage agency counterparts to streamline certification of user equipment (terminals) for both commercial and military use • DoD engage FCC to improve spectrum management • DoD outline framework for "signals as a service" to be implemented with commercial providers 	<ul style="list-style-type: none"> • OPR: National Space Council Secretary • OPR: DoD CIO

Recommendation 2: Integrate evaluation of and provision for commercial space services into institutional processes [Under Secretary of Defense (Comptroller) (USD(C)), Under Secretary of Defense for Acquisition and Sustainment (USD(A&S)), SAF, USSPACECOM]

- Including planning, programming, budgeting, and acquisition.

Action Area	Means	Funding and Responsibility
Planning	<ul style="list-style-type: none"> • USSPACECOM and Joint Staff adapt existing analysis and force planning efforts to fully integrate commercial services capabilities • In requirements definition, start with the question: “How can I use what is there today?” 	<ul style="list-style-type: none"> • OPR: USSPACECOM (lead), JSC/J8, JCS/J5
Programming	<ul style="list-style-type: none"> • OSD adapt existing analysis techniques to fully integrate commercial services capabilities • CAPE and SAF modify cost estimating approaches, to include lifecycle costing, to fully integrate commercial space capabilities 	<ul style="list-style-type: none"> • OPR: OSD/CAPE • OPR: OSD/CAPE (lead), SAF/FM, SAF/SQ, USSF/S8
Budgeting	<ul style="list-style-type: none"> • See Recommendation 1 with respect to establishing working capital funding for space services • See recommendation 1 with respect to establishing a CCAPFI • Move to mission area vs platform budgeting. Explore reallocation to more operations and management (O&M) funding to support the enduring relationships and management of services/functions (vs buying platforms) 	<ul style="list-style-type: none"> • OPR: OSD/COMP (lead), USD(A&S), SAF/FM • OPR: SAF/SQ (lead), SAF/FM • OPR: OSD/COMP (lead), USD(A&S), SAF/SQ, SAF/FM
Acquisition	<ul style="list-style-type: none"> • See Recommendation 1 with respect to establishing a CCAPFI • Pursue capability area budgeting vs individual programs of record to provide funding flexibility in year of execution • Pursue OMB and Congressional approval to enter into long term service agreements • Initiate training courses for USSF personnel about commercial business and the tools needed to integrate into operations (e.g., Commercial Acq-101) • Continue to pursue opportunities to streamline and accelerate DoD acquisition processes 	<ul style="list-style-type: none"> • OPR: SAF/SQ (lead), USD(A&S) • OPR: SAF/SQ (lead), OSD/COMP, SAF/FM • OPR: SAF/SQ (lead), USD(A&S) • OPR: Space Training and Readiness Command (lead), SAF/SQ (lead for acquisition processes)

The study includes specific examples and steps through the lifecycle of a program (requirements, acquisition, test and evaluation, and operations and sustainment) as well as the planning, programming, budgeting, and execution process to aid in implementation. These recommendations aim to institutionally integrate commercial operations and systems into DoD missions.

Managing Risks of Commercial Space Capabilities

Commercial space systems and architectures are, by their nature, intended for global access and use. While this openness is a necessary component of a world marketplace, it presents distinct risks and challenges, real and perceived.

Vulnerabilities of U.S. Use of Commercial Space Capabilities

The integration of commercial space systems brings a degree of inherent resiliency through diversification and proliferation. However, these systems remain vulnerable to the same adversary threats as their bespoke government-owned counterparts, while bringing additional risks through their greater exposure to market and political-economic forces. Nonetheless, ***opportunities exist to increase resilience of commercial systems through protection technologies consistent with commercial markets and missions.***

Findings and Recommendations to Address the Risks and Vulnerabilities of Use of Commercial Space Capabilities

The study concluded that commercial satellite systems are vulnerable to the same threats as dedicated national security satellites, but that opportunities exist to mitigate many of these risks.

Recommendation 3: Incentivize trust and build resilience in commercial providers.

- Include “resilience” as part of quality-of-service requirement in commercial contracts and apply resources to shape commercial investments in hardening.
- Establish the “market” for premium pricing for more resilient services.
- Enable tech transfer of key U.S. Government (USG) technologies (i.e., cyber protection).
- Improve sharing of threat intelligence and timely indications and warnings.

Action Area	Means	OPR/Funding
Improve Information Sharing	<ul style="list-style-type: none"> • Initiate efforts to get security clearances for existing and emerging commercial service providers, to include facility clearances • Expand capacity of existing information sharing forums • Broaden the DARPA BRIDGES model for initiating clearances process for companies in targeted technical sectors 	<ul style="list-style-type: none"> • OPR: SAF/SQ (lead), Defense Counterintelligence and Security Agency • OPR: SPACECOM (lead), IC (NRO, NGA) • OPR: Initially DARPA; OUSD(R&E) and CSO considering assigning to USSF
Conduct Vulnerability Assessments	<ul style="list-style-type: none"> • Implement vulnerability assessment red teams with select existing providers as a pilot. Expand to others • Incorporate lessons learned as quality-of-service requirements in service-level agreements with commercial service providers • SAF/SQ and USSF apply lessons learned to the present and future supply chain 	<ul style="list-style-type: none"> • OPR: USAF Red Team • OPR: SAF/SQ • OPR: SAF/SQ
Surge Capability	<ul style="list-style-type: none"> • Incorporate surge capacity and geographic coverage requirements upfront in commercial services contracts as quality-of-service requirements in service level agreements 	<ul style="list-style-type: none"> • OPR: SAF/SQ (contracts) and USSPACECOM (requirements)

Risks of Adversary Use of Commercial

A truly global commercial marketplace is by its nature open to a breadth of world actors, friendly and otherwise. Historically, the United States has controlled the proliferation of space systems through a regulatory regime consisting of International Traffic in Arms Regulations restrictions, licensing, and other means. This structure grew somewhat obsolescent, being incapable of controlling rising foreign competition which exists beyond its writ even as it undermined the competitiveness of U.S. firms. Consequently, its restrictions have been relaxed in recent years. The technologies discussed in this report therefore are substantially available to competitors and adversaries.

Findings and Recommendations to Address the Risks of Adversary Use of Commercial

The study addressed various mitigation options that could be applied to state and non-state actors in this regime and concluded that response options beyond regulation alone are required.

Recommendation 4: Develop suite of capabilities to monitor, assess, and respond to adversary use of commercial space capabilities.

Government Role in the Commercial Space Marketplace

The government plays a pivotal role in shaping the commercial marketplace. This role varies considerably depending upon where in the spectrum of development a given product resides and the maturity of the market. Inaction by DoD, however, can have consequences as profound as action. Excessive aversion to “picking a winner” or vendor lock can undermine support of emerging markets critical to future U.S. techno-economic dominance.

In established commercial markets (such as GEO SATCOM), the role of government is principally as a customer. In this capacity, it is often one of many demand sources, and not necessarily the largest or most important. The government may cause undesired market perturbations as regulator, though mature industries by their nature are less sensitive to regulatory inputs. Government inaction arguably poses a greater risk by allowing commercial trends to diverge excessively from its unique mission requirements.

Nascent markets emerging from traditionally government missions (such as intelligence, surveillance, and reconnaissance (ISR)) are more sensitive to political economic forces. In these mission sets, for which there may be limited early pure commercial demand, the government can be indispensable as an anchor tenant and source of a stable demand signal. The absence of the latter may starve the embryonic industry of needed resources and incentives to continue technical innovation. Contrarily, government monopsony can stunt the market’s long-term development should commercial businesses cases fail to grow beyond it. Emerging markets will also be more acutely sensitive to overregulation, which can undermine international competitiveness.

Government may play a role as an investor or early customer in emerging disruptive capabilities such as proliferated low Earth orbit. Patronage of a dominant supplier may lead to an undesirable monopoly. Contrarily, government inaction may stunt market growth.

Finally, capabilities without an established market, or that are government-only (such as on-orbit servicing) require government as investor and anchor customer. Inherently, they will carry USG-unique requirements, potentially to such a degree as to preclude the emergence of truly commercial demand.

Market	Example	Government Role	Risk of Government Involvement	Risk of NO Government Involvement
Established commercial market	GEO SATCOM	Regulator, customer, some unique requirements	Minimal, commercial market forces dominate	DoD missions can mature orthogonally to commercial trends if no interaction/relationship
Emerging market from traditional government-only mission	ISR (EO, radar, RF)	Regulator, anchor tenant, strong demand signal	Competition for government contract drives commercial business case. Government regulation prevents international competitiveness	Anti-trust market forces/pricing schemes can emerge. Stagnation in technical innovation if government does not continue to “buy”
Emerging disruptive capability to an established market	Proliferated LEO services	Investor and/or early customer, some unique requirements	Government contributes to a dominant supplier, potentially leading to a monopoly	Market does not develop to proper scale without government “buy” at some level
No established market or government capability	On orbit servicing	Investor, anchor customer, unique requirements	Government requirements so unique that commercial market never develops	Lack of a demand signal delays commercial application (build it and they will come, e.g., GPS)

Figure 3. Government Role in Commercial Space Marketplace

Findings and Recommendations to Further Refine the Government Role in the Commercial Space Marketplace

The role of the government in the commercial marketplace is as a regulator, investor, and customer. In emerging markets, the government has been and could be the anchor customer and has the potential to disrupt market forces.

Recommendation 5:

- DoD must account for maturity of the commercial market when making decisions on how it regulates, invests, and buys commercial space services. [USD(A&S), USD(R&E), Space Systems Command Commercial Space Office (SSC/COMSO)]
- Avoid overregulation of U.S. companies to enable international competitiveness.
- Invest for market creation, not market monopolization.
- Minimize unique requirements when buying commercial services.

Summary

Commercial space capabilities continue to evolve rapidly and offer considerable potential to the United States and its allies and partners. To best leverage these capabilities, the USG must implement new end-to-end processes: to wit, changes in analysis, testing, operations, development, and sustainment; and planning, programming, budgeting, and acquisition. Management of commercial space has several potential models, selection of which is contingent upon the respective roles of government and commercial. The growth of commercial space applications presents distinctive risks pertaining both to U.S. and adversary use. USG and commercial systems hold many risks in common,

and improvements to the latter are substantially underway on industry's initiative. Finally, the government must remain cognizant of its potential to perturb the market both for good and ill. **Bottom line: Integrated Deterrence Requires Integrated Operations.**

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Appendix A: Terms of Reference



UNDER SECRETARY OF DEFENSE

3030 DEFENSE PENTAGON
WASHINGTON, DC 20301-3000

- 9 NOV 2022

MEMORANDUM FOR CHAIR, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference – Defense Science Board Task Force on Commercial Space System Access and Integrity

The Department of Defense (DoD) increasingly uses access to commercial space systems for imagery, communication, and other purposes. Technological improvements in commercial space technology continues to enhance the quality and accessibility of commercial space products in ways that provide significant value for DoD operational needs. Because of the rapidly improving commercial space capabilities and access, a comprehensive plan for using commercial space systems in the context of classified U.S. space capabilities is needed.

Utilization of commercial space is accelerating throughout DoD at all operational levels. Mounting demand is leading to heightened competition between traditional consumers of space products at the strategic level and users operating at the operational and tactical levels. DoD faces an impending challenge in deconflicting the prioritization of those needs, efficiently managing distributed demand, and optimizing commercial space acquisition activities.

Moreover, space has become a contested environment with emerging and evolving threats to space systems. In addition to direct threats to space architecture, adversaries could disrupt DoD access to space products and services by competing as users of the same systems or by controlling access through economic means. As use of commercial space rises, such threats must be evaluated and mitigated to ensure DoD does not become overly dependent on capabilities that may or may not be available in times of armed conflict.

I am establishing the Task Force on Commercial Space System Access and Integrity (“the Task Force”) as a subcommittee of the Defense Science Board (DSB) to provide advice and recommendations on commercial space systems. The DSB, working through the Task Force, should:

- Identify the commercial space systems most useful for current and future DoD needs;
- Identify potential enhancements to commercial space systems that will improve resilience or protection against current and future threats;
- Recommend approaches for managing the priorities and governing the use of commercial space system use for DoD strategic and tactical needs. Governing options should include government-owned, contractor-operated models, as well as direct purchase or lease of products and services;
- Provide recommendations on models for acquiring commercial space services and products that best balance governmental security, accessibility, and cost factors;

- Investigate the potential risks and vulnerabilities of an adversary's exploitation or attack on U.S. use of commercial space systems. Potential vulnerabilities include privacy corruption, integrity corruption, espionage, and reduction of system availability.
- Investigate the impact and possible mitigations for potential adversary use of commercial space systems against U.S. defense systems.

The Task Force findings, observations, and recommendations will be presented to the full DSB for its thorough, open discussion and deliberation at a properly noticed and public meeting, unless it must be closed pursuant to one or more of the Government in the Sunshine Act exemptions. The DSB will provide its findings and recommendations to the USD(R&E) as the Sponsor of the DSB. The nominal start date of the study period will be within 30 days of the initial appointment of Task Force members. In no event will the duration of the Task Force exceed 12 months from the start date.

In support of this Terms of Reference (ToR) and the work conducted in response to it, the DSB and the Task Force have my full support to meet with Department leaders. The DSB staff, on behalf of the DSB and the Task Force, may request the Office of the Secretary of Defense and DoD Component Heads to timely furnish any requested information, assistance, or access to personnel to the DSB or the Task Force. All requests shall be consistent with applicable laws; applicable security classifications; DoD Instruction 5105.04, "Department of Defense Federal Advisory Committee Management Program"; and this ToR. As special government employee members of a DoD federal advisory committee, the DSB and the Task Force members will not be given any access to DoD networks, to include DoD email systems.

Once material is provided to the DSB and the Task Force, it becomes a permanent part of the DSB's records. All data/information provided is subject to public inspection unless the originating Component office properly marks the data/information with the appropriate classification and Freedom of Information Act exemption categories before the data/information is released to the DSB and the Task Force. The DSB has physical storage capability and electronic storage and communications capability on both unclassified and classified networks to support receipt of material up to the TS/SCI level.

The DSB and the Task Force will operate in conformity with and pursuant to the DSB's charter, the Federal Advisory Committee Act (5 United States Code (U.S.C.), Appendix), the Government in the Sunshine Act (5 U.S.C. § 552b), and other applicable federal statutes, regulations, and policy. Individual DSB and Task Force members and the Task Force as a whole do not have the authority to make decisions or provide recommendations on behalf of the DSB nor report directly to any Federal representative. The members of the Task Force and the DSB are subject to certain Federal ethics laws, including 18 U.S.C. § 208, governing conflicts of interest, and the Standards of Ethical Conduct regulations in 5 Code of Federal Regulations, Part 2635.



Heidi Shyu

Appendix B: Task Force Membership

Co-Chairs

Ms. Mandy Vaughn

Gen Ellen M. Pawlikowski, USAF (Ret.)

Members

Mr. Mike Appelbaum

Dr. Daniel Hastings

Ms. Kari Bingen

Dr. Paul Kaminski

Mr. D. Marshall Brenizer

Mr. John Paul (JP) Parker

Dr. Alison Brown

Dr. Dhanurjay “DJ” Patil

Mr. James Carlini

Dr. Brad Tousley

Ms. Laetitia de Cayeux

Government Advisors

Mr. Tom Ainsworth, *OSD Strategic Capabilities Office*

Executive Secretary

Dr. Lindsay Millard

Defense Science Board Secretariat

Ms. Elizabeth Kowalski, *DSB Executive Director*

Mr. Kevin Doxey, *DSB Executive Director (former)*

Dr. Troy Techau, *Designated Federal Officer (DFO)*

Study Support

Mr. Robert Kolterman, *SAIC*

Mr. Mark Brophy, *SAIC*

Appendix C: Briefings Received

Meeting 1 (14 Feb 2023)

Commercial Systems Program Office Overview
NRO

Counterspace Cyber Threats to Commercial SATCOM
National Security Innovation Capital (NSIC)

Electronic Warfare Threats to Commercial Space Systems and Services
NSIC

Commercial Remote Sensing Overview
David Gauthier

Commercial Space Efforts
SCO/MIT-LL

Killer Bee Phase II Study Outbrief
SCO/MIT-LL

Meeting 2 (28-29 March 2023)

CSA Protection and Indemnification
General Counsel, Department of the Air Force

Space Counterintelligence
Office of the Director of National Intelligence

Commercial Space Protection Policy Discussion
International Conference on Circuit, Systems and Communication (ICCSC)/National Security Space Organization (NSSA)

Space Architecture Integration
*Office of the Assistant Secretary of the Air Force for Space Acquisition and Integration
Director of Architecture, Science, and Technology (SAF/SQA)*

Intelsat and the Hybrid Networks of the Future
Intelsat

Space and Counterspace, China
Defense Intelligence Agency (DIA)

Space and Counterspace, Russia
DIA

Commercial Integration
Maxar

Meeting 3 (5 April 2023)

Discussion with Bill Adkins
House Appropriations

Meeting 4 (17 and 19 May 2023)

Commercial Integration

Inmarsat

U.S. Space Command Perspective

U.S. Space Command

Leveraging Commercial Space for Rapid Capability Delivery

Space Development Agency

OUSD(P) Perspective

Assistant Secretary of Defense for Space Policy

Air Force Research Laboratory (AFRL) Perspective

ARFL

Zero Trust

Xage Security

Meeting 5 (13-14 June 2023)

Thoughts on Resilience

Marshall Brenizer brief to Position, Navigation, and Timing Task Force, 29 Mar 2023

Discussion with Strategic Capabilities Office

SCO

General Counsel Perspective

Associate General Counsel

Appendix D: Acronyms

AFRL	Air Force Research Laboratory
CD	commercial development
C4ISR	Command, Control, Communications, Computers (C4) Intelligence, Surveillance and Reconnaissance (ISR)
CI	commercial innovation
COMSATCOM	commercial satellite communications
CP	commercial product
CRAF	Commercial Reserve Air Fleet
CS	commercial service
DIA	Defense Intelligence Agency
DoD	Department of Defense
DSB	Defense Science Board
GEO	geosynchronous earth orbit
GEOINT	geospatial intelligence
ISR	intelligence, surveillance, and reconnaissance
NGA	National Geospatial-Intelligence Agency
NRO	National Reconnaissance Office
OSD	Office of the Secretary of Defense
SAF	Secretary of the Air Force
SAF/SQ	Assistant Secretary of the Air Force for Space Acquisition and Integration
SATCOM	satellite communications
SCO	Strategic Capabilities Office
SDA	Space Development Agency
SSC/COMSO	Space Systems Command Commercial Space Office
STRATFI	Strategic Funding Increase
SWAC	Space Warfighting Analysis Center
UAS	unmanned arial system
USD(A&S)	Under Secretary of Defense for Acquisition and Sustainment
USD(C)	Under Secretary of Defense (Comptroller)
USD(R&E)	Under Secretary of Defense for Research and Engineering
USG	United States Government
USSF	U.S. Space Force
WCF	working capital fund
