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Contested Space Operations, Space Defense, Deterrence, and Warfighting: Summary Findings and Integration Report

Prepared for

Strategic Multilayer Assessment

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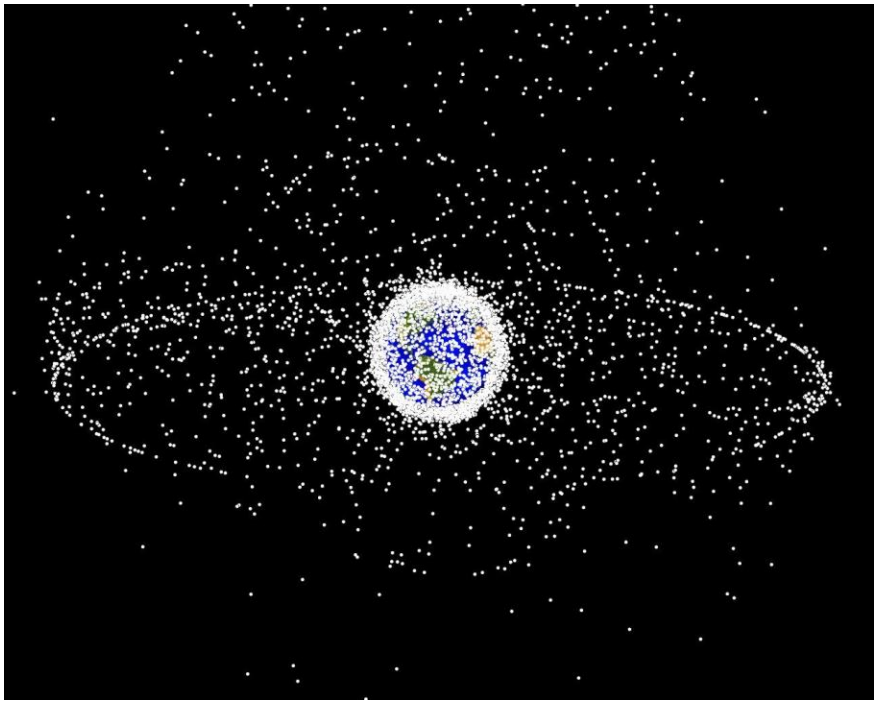

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Summary of Findings

Dr. Allison Astorino-Courtois, NSI and Dr. Robert Elder, GMU

The following are key findings from eleven quantitative, qualitative, and simulation studies conducted for the 2017-2018 Strategic Multilayer Assessment (SMA) Space Project requested by the Headquarters Air Force (HAF/A3) in cooperation with United States Strategic Command (USSTRATCOM) and Air Force Space Command (AFSPC).*

Commercial vs. National Security Space

- The National Security Space (NSS) community and its potential commercial space partners think about space differently, have different agendas, and different perspectives on responsibility for space activities and which partner "is in the driver's seat."
- In the US and elsewhere, National Security Space is rapidly becoming a minority player in the space environment. Commercial satellites significantly outnumber those operated primarily for military purposes.
- US national security and the profitability of commercial space are indelibly linked.
- The USG and commercial space must establish a clear and integrated set of national security and commercial space objectives, along with a strategy for achieving these.
- The ways in which US civil and National Security Space (NSS) operates presently is at odds with the attributes that make for an attractive business environment.

Resiliency of Space Services

- Commercial satellite capabilities offer resiliency for military operations and increased stability during crises, reducing the benefit of pre-emptive attacks on satellites.

Space as a Conflict Domain

- Space operations are significantly more important for expeditionary military operations than for defense of the homeland.
- Space operations provide information services for use by all domains, so it is critical that operators in other domains understand what it means to "operate in space," the time scales in space operations, etc.
- Because space has been seen as "separate" or a set of assets in space, vulnerabilities in the entire system from ground station to space and back can be underappreciated. Counter-space activities executed against the ground and communication link segments are perceived and treated differently than activities directed against the satellite segment.
- Space operations are not homogenous: To improve cross-domain understanding of space operations, it is useful to describe the actions using unambiguous terminology commonly used in other domains.
- There is a pressing need to clarify and clearly articulate deterrence and operational concepts involving space.
- Space superiority or dominance in space are not always critical to US and ally defense.
- Conflict domains are interdependent, but absolute space dominance is not a necessary prerequisite for success in other domains.

* All team reports are available on the SMA publication website: http://nsiteam.com/nsi-grid-search-filter/

Bolstering Security Partnerships via Space

- The US must act rapidly to use its advantages in space to strengthen ties to regional partners.

DOTMLPF Insights

Doctrine

- Impacts of the rapidly increasing priority of space as a critical economic domain, which arguably is greater than its importance as a military operations domain.
- Difficult to contain the effects of combat operations in space to prevent unacceptable collateral damage or even fratricide.
- Importance of commercial space in reducing risk of unacceptable behaviors affecting the domain.
- Importance of differentiating (and understanding the relevance of) strategic, operational, and tactical military space operations.
- Use of space for military operations is of significantly less importance to actors operating with easy access to alternative means for communication, navigation, and surveillance operations.
- Space community would benefit from developing terminology for use when communicating with members of other communities to reduce potential for confusion or errors.

Organization

- Use of commercial and partner space capabilities requires Unified Action processes and organizations, as well as joint military and tactical coordination processes—and to be effective, these should be established well ahead of when they might be needed.
- Organizations are needed to develop and vet strategic courses of action and associated comprehensive risk assessments of non-defensive military space operations for national-level decisionmakers.
- Joint C2 organizations would benefit from greater space integration than just embedded liaison cells.

Training

- Non-space military personnel lack sufficient understanding of tactical-level space operations to integrate them properly into multi-domain operations.
- Military operators need training on how to leverage the capabilities available through commercial space.

Materiel

- Military platforms cannot leverage commercial space capabilities without compatible terminal equipment (e.g., waveforms, spectrum, encryption).
- Military capabilities should be adapted for use with commercial rapid launch capabilities.

Leadership

- Military commanders from outside the space community must understand space operations at the operational level to properly integrate them into multi-domain operations.
- Senior officers need leadership development to understand use of military force in concert with other instruments to influence competitor and partner decisions, particularly when military operations would have detrimental economic and/or civilian safety effects.
- Senior space leaders need better understanding of how other domains exploit space to achieve joint effects, as well as cross-domain opportunities to minimize risk of critical space capabilities.

Personnel

- Benefits demonstrated from civilian government participation in space C2 cells suggests opportunities to leverage additional non-military government civilian participation in military space C2 organizations.

Facilities

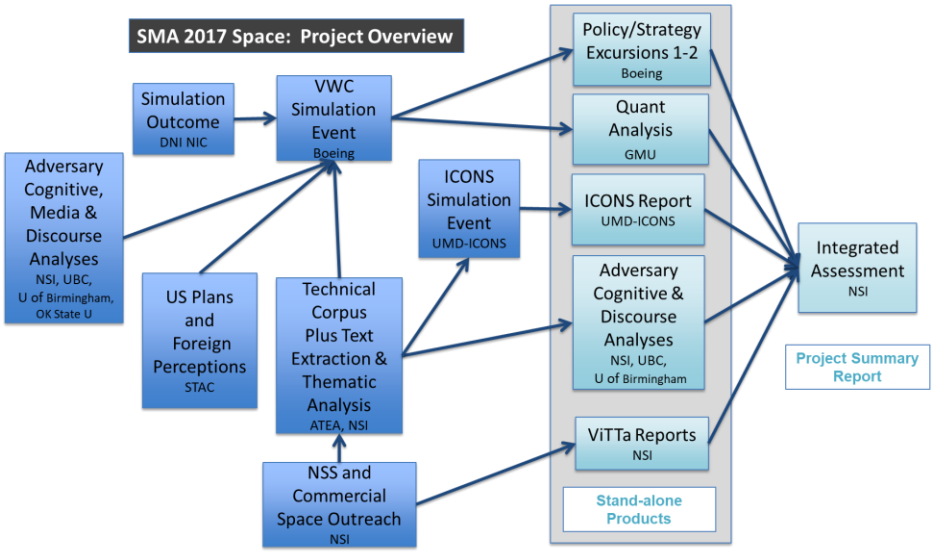
- Value of resiliency and redundancy in the space ground segment, perhaps leveraging multi-domain military, government agency, and allied partners.

Integration Report

Dr. Belinda Bragg, NSI

Introduction

The space domain has changed rapidly and fundamentally in the past decades. There are more actors, activities, and "stuff" in space than ever before, and there is no reason to believe this trend will not continue. Space is no longer the exclusive domain of highly sensitive and well-protected military and intelligence satellites operated by a small number of major power states. Commercial satellites significantly outnumber those operated for primarily military purposes, and have significantly reduced the cost and accessibility of data from space for anyone with internet access. To fully grasp the space-related threats to US national security, and develop strategies to minimize these threats, requires the National Security Space (NSS) community to take a new perspective on space. Namely, that it can no longer be considered an exclusively military domain with only national security relevance.



Headquarters Air Force (HAF/A3), in cooperation with United States Strategic Command (USSTRATCOM) and Air Force Space Command (AFSPC), requested the Joint Staff J39 conduct an SMA effort to:

1. "determine how the US Government can maintain its initiative in the space domain";
2. "enhance its understanding of potential threats and develop mitigation options"
3. "address the advantages and disadvantages (rewards and risks) to the US adopting a policy of space as a joint warfighting domain."

This report provides an integrated synthesis of the findings and recommendations from eleven sub-efforts including quantitative discourse and media analysis and simulations and expert elicitation from commercial, academic, US, allied and the National Security Space (NSS) communities.

Note on Citations

Brief in-text citations are provided throughout this report. A table at the end of the document lists all unclassified project deliverables and provides a link to the individual reports. This report also draws on the unclassified summary of findings produced from the Boeing VWC simulation.

Maintaining US Initiative

Partnering with Commercial Space Actors

Recent US space policy[2] has signaled a change in the approach to maintaining US technological leadership in space. There appears to now be an expectation that the United States government (USG) will partner with commercial space actors for a variety of primary and supplementary space services, although the degree of reliance on commercial services is still a subject of debate. This approach has potential advantages. First, the organizational advantages of commercial actors suggests that "new space" companies in particular will be the dominant innovators in the space domain in the very near to long-term. Exploiting this innovation capability has the potential to help the USG maintain the initiative in space technology and services.

Second, because the commercial space industry now accounts for about 75% of the global space economy, partnering with commercial space actors once again could be an effective way for the USG to maintain its initiative in space. Commercial satellite capabilities are advancing rapidly, and as an enterprise, have exceeded the capabilities of military space in key areas such as sensor revisit rates and system loss recovery time, which collectively may be altering the decision calculus for aggression in space. In addition, the availability of commercial space-based information services (remote sensing, communications, and PNT) can provide resiliency for targeted systems, which would increase the cost and difficulty to the aggressor of initiating attacks on satellites; it also can reduce the cost to the target of failing to act pre-emptively to prevent an attack (GMU).

However, the use of commercial space as a source of service resiliency for military operations requires installation of equipment compatible with commercial space services on military platforms well in advance of a crisis. The USG (and NSS in particular) need to be aware that commercial space actors have different interests and constraints, which create considerable barriers to effective partnership that must be recognized and overcome if this approach to maintaining US initiative is to be successful. Greater reliance on commercial partnerships also has implications for the level of control NSS can maintain over space capabilities and assets (Boeing VWC Simulation; ViTTa Q9; Q12).

Commercial space actors think about space very differently than does NSS

Commercial space actors' interests center around the health and success of their operations as business ventures, whereas the NSS community is focused on security and defense, including preparing for a conflict or kinetic attack in space. This means that there is a significant difference in how each entity conceptualizes security and threat in the space domain. Commercial actors' perceptions of security are informed by the potential of any situation or action–intentional, accidental or natural–to threaten profitability. Unless they have mainly military clients, most commercial actors do not expect their assets to be the targets of military attacks or threats. To the extent that they do consider security in the military sense, there is a recognition that they lack the capability to counter aggressive actions, and a corresponding assumption that the USG will offer protection. Instead, their focus is centered on avoidance of natural or accidental damage (e.g., space debris, collisions), spectrum interference, intellectual property (IP) violations, and cyber attacks (ViTTa Q6).

Furthermore, because commercial space actors often have an international customer base, their estimation of the threat represented by a particular action or situation can be grounded in a wider perspective than that of NSS, which is tasked with ensuring the security and defense of US interests. In fact, one commercial contributor indicated that their company had a deliberate policy of "selling to all

[2] 2010 National Space Policy; 2011 National Security Space Strategy

sides" to "keep us neutral or 'gray'" (ViTTa Q6). The globally determined interests of commercial entities cannot, therefore, be assumed to be in complete accord with the USG's US-focused security interests and priorities. Expert contributors from commercial space argue that it is imperative that the USG recognizes this difference in thinking, particularly as it continues to expand its reliance on commercial space capabilities for national security purposes (ViTTa Q5; Q6; Q9; Q11). Developing a shared understanding of fundamental concepts, such as security, therefore, will be critical to avoiding costly misunderstandings and miscommunications.

There are significant barriers to commercial partnership, especially with "new space"

It is often presumed that the USG ability to use commercial space to increase space service capacity and resilience for military operations is a simple matter, but this is far from the case. Contributors identified bureaucratic, technical, and cultural barriers that will need to be overcome if US NSS is to leverage partnerships with commercial actors (ViTTa Q9; Q12). Some of these barriers stem from the fact that the USG has never clearly articulated its role relative to commercial space, which can be a customer, manufacturer, partner, or regulator (ViTTa Q9; Q12).

Bureaucratic barriers including opaque, convoluted, and slow US regulatory and acquisition/contracting processes were most frequently mentioned by expert contributors as impediments to doing business with NSS. All of these factors increase the costs (in money, time, and knowledge) and risk of doing business with NSS for commercial companies, who work on shorter timelines and need to demonstrate profitability to shareholders and investors. The bureaucratic structure and organization of the federal government creates additional hindrances. Many contributors feel that NSS space is understaffed and underfunded, control over regulation and acquisition processes can be unclear, shared, or outdated; and, as policy priorities change, funding decisions can be affected. Currently, USG funding and payment decisions can be too unpredictable and slow for all but the largest corporations to manage, making it hard for the USG to engage with smaller, often more innovative firms (ViTTa Q9; Q11; Q12). The culture of disruption—changing accepted ways of doing things—and "failing quickly and moving on" that characterizes commercial space further reduces the appeal of working with US NSS. There can be a resulting tendency among some commercial space actors to lose sight of the significant role played by the government in setting the legal conditions, funding innovative research and development, and purchasing services that underwrite commercial space (ViTTa Q12).

The technical barriers most commonly associated with partnerships between NSS and allied or commercial actors center around issues of interoperability. However, there are other concerns that must also be addressed. Commercial actors' interests are dominated by the need to remain profitable, which may constrain their ability to provide some of the services identified by NSS. In particular, there has been discussion of the potential for increasing the resilience of NSS space capabilities by relying on commercial services, especially for communications, in the event that NSS capabilities are lost or interrupted. This implies that, at a moment's notice, a commercial actor would either have the excess capacity to provide service, or, would be willing to divert capacity from existing customers to accommodate NSS needs. Neither of these options is consistent with a commercial actor's need to maintain profitability, and the USG cannot assume that commercial actors will be willing or able to turn over access to space assets to the military in times of conflict, or to replace the loss of military assets.

Intellectual property protection and ownership are also critical components of profitability that have implications for commercial-NSS partnerships. While there is a recognition that government oversight of technologies with national security implications is necessary, current regulations are often burdensome or outdated (ViTTa Q12). Regulations that many US companies feel put them at a competitive disadvantage to foreign companies create incentives for companies to relocate to countries with less restrictive business environments, and invites foreign governments to attempt to attract business away

from the US[3], diminishing USG influence with space companies and its ability to secure access to services. In the longer term, this could position commercial space actors to disrupt US national security operations (ViTTa Q9; Q12).

There are also "cultural" barriers to NSS-commercial partnerships. For example, the USG desire to maintain control, particularly in the area of information, is another barrier cited by expert contributors, many of whom were critical of what was seen as the government's lack of transparency and tendency for "over-classification" of space-related information (ViTTa Q11; Q12). As space becomes more crowded, open access to accurate, complete, and timely tracking data will become critical to ensuring the security of all space assets—military, civil, and commercial. Failure to recognize and respond to the changing nature of the space environment could mean the policies put in place to protect NSS assets could end up putting them at greater risk.

Partnering with commercial space

Implications and Recommendations

- The USG must decide quickly how it wants to manage US interests in, with, and through space by removing barriers to partnerships with "old" and "new" commercial space actors and improving understanding of, and relationship with, the commercial space sector.
    - Establish a common understanding of interests and develop a shared lexicon.
- Failure to manage interests will put the US decades-long strategic and commercial advantage in space at risk.
- How well the strategy of relying on commercial partnerships to maintain US initiative and capabilities in space works will depend significantly on how NSS decides to interact with and accommodate commercial space.
- US space companies will relocate if they cannot meet their profitability goals, diminishing US influence and ability to secure space services.
- Achieving mutually beneficial partnerships with commercial space will require cooperation with other USG agencies, such as the Department of Commerce.
- USG and commercial space need to establish an integrated set of national security and commercial space objectives, and a strategy for achieving these.
- Clearly articulate USG requirements and expectations to commercial partners.
- Limit impediments arising from the organization and structure of the US bureaucracy itself.
    - Non-onerous and consistently implemented export controls.
    - Synchronization of internal government agendas and decision making with regard to space.
    - Regulatory and policy frameworks and lines of authority need to be developed.
    - Technical and funding support to build a strong, stable commercial sector.
    - Ease undue government red tape, especially the method of funding decisions and payments.

Working with Allies and Partners

For many countries, access to space has long been a source of national pride and international prestige (Oklahoma State; NSI Discourse Analysis; ViTTa Q2). Motivated by the perception that regional instability is increasing, many states, including US allies in Europe, that previously conceived of their space operations as primarily civil in nature, are beginning to regard space as essential to their national security and defense. The increasing reliance on space capabilities and services for communication, precision

[3] For example, countries such as Luxembourg, have already begun to change national laws to attract commercial space actors.

navigation and time (PNT), and data transmission has also made access to space crucially important to states' involvement in the global economy. These changes offer both opportunities and challenges to the US when maintaining its relative advantage in space capabilities.

There is great opportunity for the US to take advantage of its strength in the space domain to expand relationships with ally and partner nations. Space is widely seen as an opportunity for international and private-public collaboration and cooperation (ViTTa Q2; Q7). Collaboration lowers entrance costs into space for states with fewer resources. The US could capitalize on its space dominance to strengthen relations with existing allies and forge new partnerships with others. Time is of the essence, however, because other countries, notably China and Russia, are already moving ahead with partnerships and developing regulatory environments to attract commercial space actors.

The US, Russia, and China have the most diversified commercial capabilities in launch, satellites, and science and exploration. However, India and the European Space Agency (ESA) have very similar levels of coverage in launch, satellite, and science and exploration. Other states, such as Israel, Singapore, South Korea, and the UK are investing in research and development in niche areas. Even states and commercial actors that do not have their own space capabilities have access to increasingly precise and detailed data from space, at sharply decreasing cost, that can be used for civil, security, or commercial purposes. These changes are quickly eroding the competitive advantage the US has assumed for so long.

The number of actors in the space domain presents many opportunities for collaboration and cooperation, a factor that has not escaped the notice of other governments. Both Russia and China are providing space capabilities to commercial and foreign government clients. China's activity is particularly robust; they are currently working with developing nations to provide space services to those with little independent space capability, and with the European Space Agency and individual European countries. As China and Russia build more partnerships, both with developing nations and traditional US allies, such as Western European states, the US risks being sidelined; losing both influence and the potential advantages of collaboration.

Cooperation to further develop legal regime in space

Another way in which the US can expand its collaboration with allies and partners relates to laws and norms regulating activity in space. Many experts believe existing space law and norms are insufficient to manage the rapidly evolving nature of space activities (ViTTa Q19/23; Q20; Q22). As space becomes more crowded, the risk of accidental or intentional harm to an actor's assets increases. Moreover, as space capabilities become more critical to actors' economic and security activities, the costs of losing those assets also increases. Both of these conditions create a collective action problem that international norms and regulation could help mitigate.

The rapid increase in commercial space actors and activities has also highlighted the state-centrism of the current legal regime. While there is debate regarding whether the Outer Space Treaty (OST) limits commercial activities in space, there is consensus that regulations need to be strengthened and clarified. In fact, both China and Russia have been pushing for the international adoption of an alternative treaty to the OST[4] (ViTTa Q19/23; Q20).

The reality is that the rapidly evolving nature of space activities makes the further development of international law and norms inevitable; it will happen whether the US participates or not. The existing space regime has, for the most part, proven consistent with US interests; there is no guarantee, however, especially given the current geopolitical climate and the diverse range of actors active in space, that new regulations will serve US interests, unless the US is at the table to advocate for them.

[4] Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force Against Outer Space Objects

Working with Allies and Partners

Implications & Recommendations

- Failure to develop partnerships with allies and partner states puts the US decades-long strategic and commercial advantage in space at risk.
- Partnerships with existing allies and new partners can bolster US international influence.
- International law and norms regarding space will evolve. If the US is not party to this process, it risks an outcome that is not compatible with US interests and priorities.

Potential Threats and Mitigation Options

Space is the ultimate gray zone

The nature of the space environment itself—and how humans tend to relate to it—can pose risks to stable governance and crisis management in the space domain (Wright; ViTTa Q16; Q19/23). Specifically, cognitive science tells us that ambiguous and high-stakes environments create significant potential for misperception and miscommunication (Wright). Physical and technical limitations on direct observation of events in space limit space situational awareness and increase the difficulty of distinguishing between intentional acts, unintentional events, and natural events. As a result, actors rely on other methods for understanding the nature and causes of events in space. Misperception, mistakes, and/or miscommunication can lead to incorrect inferences and either unintended escalation or unaddressed security threats. Managing escalation requires manipulating an adversary's perception of the risks inherent in that escalation. However, the inherent ambiguity of the space domain makes effective communication of that risk more complicated (Wright).

The "grayness" of the space domain is intensified by the increase in dual-use (military/civilian) technologies (Wright). For example, as a number of contributors pointed out, the same rocket engines used to boost satellites into orbit can be used to deliver conventional or nuclear warheads (ViTTa Q8; Q9: Q19/23). Partly in response to increasingly unstable regional security environments, more and more actors are starting to think about the national security applications of dual-use aspects of space technologies. Unlike the US, where there has traditionally been a clear division between civil, military, and commercial space industries, in most countries active in space, there is a more permeable division between government and commercial space. This creates fewer institutional barriers to military use of civil capabilities. In many non-Western states, commercial space enterprises are partially or even wholly state-owned (ViTTa Q2).

Increasing the cost of gray activities

The prevalence of dual-use technologies in a physical environment that can make a weapon of nearly every object suggests that thinking about threats and threat mitigation in terms of capabilities may be less effective than thinking in terms of behaviors. As discussed above, the range of activities and actors in space has evolved faster than existing laws and norms. Clearly communicating which behaviors the US regards as unacceptable will not guarantee that adversaries will heed those lines (GMU). It will, however, help discriminate intent and thus enable the US to better mitigate threats while reducing the risk of unintended escalation (Wright). Supporting and participating in the development of international rules and norms to address new space activities, capabilities, and threats will also reduce the ambiguity of the

space environment for all actors. The absence of clear rules and norms provides greater room for actors to engage in gray activities and strategies (ViTTa Q19/23; Q22).

Space as a Gray Zone

Implications and Recommendations

- The nature of the space environment creates great potential for misperception.
  - Benign actions can be interpreted as threatening, leading to unintended escalation.
  - Threatening actions can be interpreted as innocent or accidental, compromising security.
- The US must clearly articulate which actions against space assets will be considered threatening and prompt response.
- US signals regarding escalation risk involving space will need to be made extremely clear.
- Increased transparency (e.g., sharing SSA-relevant information), particularly in times of crisis, could reduce the risk of misperception leading to unintended escalation.

Environmental Threats

Not all threats, or the most likely threats, arise from intentional actions. As discussed above, while the NSS community is ultimately concerned with the threat of attack, space remains a dangerous environment even without adversaries. Space debris and increased space traffic both present growing threats to the security of space assets and the continued viability of all space-based operations and services (ViTTa Q6; Q19/23; Wright). Both are also examples of the classic collective action problem—they create potential risk to every space actor, and if not addressed, ultimately could render space unsafe for all, but cannot be "solved" without cooperation between most or all space actors.

Again, US interests in this area can best be secured by cooperation with other actors. Collaboration to produce accurate, complete, and timely tracking data can mitigate some risk to military, civil, and commercial assets. Improving orbital debris guidelines and creating enforcement measures, as well as updating space traffic regulations to reflect evolving activities (e.g., satellite servicing, refueling, on-orbit inspections) will also help. To be effective, however, such regulations must be accepted and adopted by the majority of space actors, which indicates that it is at the international level that such changes to the legal regime must be made (ViTTa Q19/23; Q22).

Environmental threats in space

Implications and Recommendations

- The US must clearly articulate which actions against its space assets it will interpret as threatening, and what response it will take to such actions.
- The development of clearer international regulations for space debris mitigation and traffic management would be in the economic and security interests of the US.

Space as a Warfighting Domain

US strategic risk in space

The US is significantly dependent on space for critical national security, military, and economic services and infrastructure. As such, it is considered by most to be the international actor with the greatest strategic risk in the space domain. The level of dependence of course varies, for example, being significantly greater for expeditionary efforts than for defense (GMU).

Absolute space dominance is not a necessary prerequisite for success in other domains

Space is a crucial domain without which the US currently may be unable to "win" a serious conflict because a loss or extreme degradation of space services also affects military capability in other domains. While loss or degradation of space capabilities can significantly affect capabilities in other domains, achieving space superiority or dominance in space is not always critical to US and ally defense (ViTTa Q17). Not only is absolute space superiority infeasible, policy and force postures intended to assure it could reduce rather than enhance US security (ViTTa Q14; Q17; Q18). Specifically, experts argued that the US could "lose" in one domain—even if that domain is space—and yet succeed overall. However, there are important caveats. While the US can lose space dominance and prevail, given the degree of domain interdependence, the US cannot lose its entire capability in space and still prevail. The US must retain the ability to maneuver through space and other domains. This suggests that the US will need to become more agile overall, including ensuring that there are appropriately robust plans and infrastructure in place to enable continued operation, whether conditions are ideal or suboptimal.

Everyone needs space

While the US may be relatively more dependent on space for national security than are other states, it is far from alone in relying on space. Nuclear armed states are dependent on space for important command and control functions, and major powers are increasingly using space for battlefield situational awareness and communications. China and Russia were identified as having significant (and fairly equal) levels of strategic risk in space (ViTTa Q16), although their regional security priorities and (to date) less space-dependent economies place them at an advantage to the US. They may, therefore, see the strategic risk of conflict is space as lower than does the US. Still, space capabilities remain a source of economic expansion and national pride for both, and their calculations of the cost of conflict involving space may include consideration of these factors.

Even now, there is a general consensus that the US and other actors have more to gain from space than they have from the loss of space-based capabilities (ViTTa Q3). This suggests that, although the US is more vulnerable in the space domain than are other states, the likelihood that aggressive action against an adversary's space assets would be reciprocated may provide a degree of security. It also creates another incentive for actors to use diplomacy and international law to reduce risk and increase transparency in the space domain.

US dependence on space

Implications and Recommendations

- The US is simultaneously more capable and more vulnerable in space than are other states, but all states need space.
- Space superiority or dominance in space are not always critical to US and ally defense.
- Success in every domain is not required, as long as the US becomes and remains agile.
- There are terrestrial alternatives to space-based capabilities that could reduce US dependence on space, but none offer the speed, coverage, and low cost of space-based systems.
- Diplomacy is the most frequently cited affordable non-space alternative for mitigating strategic risk in the space domain.
- The US needs to ensure that it has robust plans and infrastructure to enable continued operations under suboptimal conditions.
- Greater international reliance on SSA is a disincentive for kinetic military action.
- The US should work cooperatively with other countries to develop regulations and laws that can reduce the incentives for kinetic actions in space.

Space operations are not independent of operations in other domains

Space operations within the US military are not homogenous, but instead differ by segment (satellite, ground station, or communication links), activity (kinetic, directed energy, electronic attack, cyber), effect (degrade, disrupt, destroy), and effect duration (temporary, permanent) (GMU). Added to this complexity, the language used by different branches to describe space capabilities and activities is inconsistent. Although all branches of the US military rely on space, there is currently neither an integrated system for training and planning for the use of space in military operations, nor a consistent, shared vocabulary for talking about space (Boeing VWC Simulation; ViTTa Q1). If the US is to maintain its initiative, mitigate threats, and optimize its space-based capabilities for warfighting, the use of space in military operations must be normalized.

Contributors identified several ways in which training is needed to integrate space across US military operations. “Non-space” military personnel lack sufficient understanding of tactical-level space operations to integrate them properly into multi-domain operations (Boeing VWC Simulation; GMU). Military operators need training on how to leverage the capabilities available through commercial space. Senior leaders need training in the use of space-based capabilities to influence competitor and partner decisions, particularly when military operations would have detrimental economic and/or civilian safety effects. Senior space leaders also must better understand how operations featuring capabilities in other domains rely on space to achieve joint effects, as well as cross-domain opportunities to minimize risk of critical space capabilities (Boeing VWC Simulation).

Integrating space into military training

Implications and Recommendations

- NSS and the DoD must assure that operators in other domains are well trained and socialized into what it means to "operate in space."
- Military commanders from outside the space community must understand space operations at the operational-level to properly integrate them into multi-domain operations.
- Senior space leaders need better understanding of how other domains can exploit space to achieve joint effects. Provide senior leadership development to understand potential of non-kinetic instruments to influence competitor and partner decisions, particularly when military operations would have detrimental economic and/or civilian safety effects.
- Multi-domain planners and operators require a common, unambiguous lexicon to describe actions in space, similar to those used in other domains.
- Improve training in tactical-level space operations for non-space military personnel.
- Train military leaders and operators in the capabilities of commercial space actors.

Deterrence in Space

As space systems are integral to US and allied defense in all domains and are essential facilitators of cross-domain operations, strikes against US space and cyber assets likely will feature in the earliest stages of future conflicts. Consequently, space systems should be a prominent feature of US deterrence thinking and policy. Furthermore, the US needs to effectively articulate and communicate which specific actions, under which specific conditions, it considers unacceptable (GMU).

There is nothing fundamentally different between the logic of deterrence in space or on earth. However, the nature of the space environment does mean that some aspects of deterrence take on a different significance. Space effects and services directly affect US ability to attribute attacks and retaliate (ViTTa Q14; Wright). As a result, they contribute to the credibility of deterrent threats made in any domain. For example, capabilities like space situational awareness support the credibility of threatened retaliatory strikes at sea. On the other hand, given the possibility of causing military and/or economic devastation without necessarily causing loss of life, response principles and means of escalation control for attacks on space systems have not yet been well-articulated (ViTTa Q14; Wright).

Deterrence in Space

Implications and Recommendations

- Defense and protection of space systems should be an integrated and prominent feature of all US deterrence thinking and policy.
- The US must clarify and communicate which actions are considered provocations.
- The US must clearly delineate and articulate response principles and means of escalation control involving space.
- The US should establish and promote the use of confidence building measures and recognized means to determine attribution.
- The US should support the development of international norms of behavior that increase the costs of aggressive or otherwise unacceptable behaviors.

Conflict in space

The consequences of conflict in space are potentially immense. Stable relations and norms of behavior in orbital space are critically important for the global economy (GMU), and the potential costs of conflict in space are both profound and almost impossible to quantify. Damage to space-based systems could wreak economic havoc, creating potential for political and social instability. All space capable actors are current signatories of the OST, which bans the placements of weapons in space and commits states to the principle of peaceful use. China and Russia have gone further, and in the media, public statements and policy present the militarization of outer space as being led, and instigated by, the United States (Oklahoma State, NSI Discourse). Media in both nations present the development of offensive and defensive space related armaments as being in response to the actions of the United States in the space domain. Further, media in both nations overwhelmingly project their governments as seeking peaceful space developments, political alliances, and treaties to de-weaponize outer space (Oklahoma State).

The expansion of commercial and civil applications of space-based technologies means that there is virtually no state on Earth that does not benefit from space. The transition of space to a business domain has created a set of international commercial companies dependent on secure use of space for the continuity of their businesses and shareholder value. The greater the number of actors invested in space, the larger the set of actors who have something to lose from aggression and conflict in space. The fact that space systems are expensive to deploy, and too critical to many actors' economic and military capabilities to lose, may create security through restraint. Almost every expert contributor interviewed considered increased spending on space systems among adversaries to be a disincentive for kinetic military action. The argument is that both commercial and government spending in space increase the potential losses from conflict in space (ViTTa Q10; Q14).

As the discussion of environmental threats and the commercial sector's perception of security also suggested, ultimately all actors in space or dependent on space-based services stand to lose if the space environment is compromised. Treaties, conventions, UN discussions, norms of behavior, 'trust-but-verify' monitoring, and other forms of international cooperation are all suggested as the most effective way to reduce risk in the space domain.

Legal justifications for use of force are unclear

The UN Charter and the OST, which form the foundation of international space law, prohibit use of force by states, but do allow for self-defense. However, which actions against a state's space asset would be considered to justify self-defense remains unclear. The Law of Armed Conflict also provides some applicable principles for responding to aggression in space, in particular the principle of proportionality.

As discussed earlier, however, space is in many ways a gray environment, characterized by high levels of ambiguity (Wright; GMU; ViTTa). Even determining which objects in space are considered weapons can be fraught (ViTTa Q1). As discussed in the section on dual-use technologies, any object in space is a potential weapon, and even ground-based assets, such as launch facilities, can be dual-use. Furthermore, as recent Chinese ASAT tests demonstrate, determining whether a capability is a weapon or not can come down entirely to intent. The question of intent is critical to defining an action as aggressive and thus potentially justifying use of force for self-defense. Given the limitations of SSA and the lack of clearly defined norms and rules regarding threatening or aggressive actions in space, aggressive intent is particularly difficult to determine definitively in space.

The findings of the University of Maryland's ICONS simulation reflect the current ambiguity regarding what constitutes a legal justification for kinetic action against an adversary's space assets. There was also a lack of agreement among simulation participants regarding which elements of international law applied to such actions.

Conflict in space

Implications and Recommendations

- US collaboration to increase investment in space by other states could decrease the risk of kinetic attacks against US space assets.
- Military planning needs to take into account the economic, social, and political implications of conflict in space.
- The development of clearer international rules and norms, and greater information sharing and transparency can help in determining aggressive intent.
- The US should work cooperatively with other countries to develop the legal regime in space.
- Countering Chinese and Russian popular perception of the US as aggressive and reluctant to cooperate in space could increase pressure on the Chinese and Russian governments to increase their own cooperation with regard to actions in space.

Conclusion

Space is no longer predominantly a military domain, controlled and accessed by a few major power states. Stability in space has become critically important for the global economy and integral to the social infrastructures of many states. As the space domain has become more complex and the types of actors and actions more diverse, the potential for miscommunication and misperception increases dramatically. This has implications for both cooperation and conflict. Without clear understanding of how our allies and commercial partners perceive their interests, and therefore perceived opportunities and threats to those interests, forging partnerships to maintain the US initiative in space will be hampered. A lack of clearly articulated rules and norms of behavior in space also contributes to the "grayness" of the space domain, and the concomitant potential for either unintentional escalation or increased threat to US interests when the intentions of others are misinterpreted. Further, the costs of conflict in space are not just military, but also economic, social, and political. They are also potentially immense and long-lasting. Contributions to this project indicate that the types and current levels of risk and uncertainty in the space domain are most likely to be mitigated by the further development of the legal regime in space to reflect the changing nature and interests of the diverse range of actors in space. Rather than seeking security through dominance, when it comes to space, US interests may be better served by collaboration with other space actors—both foreign governments and commercial. Influence, rather than control, may be the more effective principle for guiding US policy and actions in space.

Project Deliverables

Title	Author	Method	Affiliation
Chinese Worldview and Perspectives on Space: An Analysis of Public Discourse	Aviles and Kuznar	Discourse Analysis	NSI Inc.
Enforcement as Verification, and the Problem of Dual-Use	Kuznar and Stevenson	ViTTa	NSI Inc.
How Disagreement Over Space Terms Can Create Barriers to Transparency in the Space Domain	Pagano and Stevenson	Concept Paper	NSI Inc.
Kim Jong Un's Worldview and Perspectives on Space: An Analysis of Public Discourse	Aviles and Kuznar	Discourse Analysis	NSI Inc.
Malicious Non-state Actors and Contested Space Operations	Gabriel and Koven		START
MIND-SPACE: Cognitive assessment of potential space competitors	Wright		U. of Birmingham
Outer Space in the Media Space: Russian & Chinese News Media Presentations of the Commercialization and Militarization of the Space Domain	Cooley, Kluver and Stokes	Media Analysis	Oklahoma State U. and U. Alabama
Q1: (Outer) Space: An Exploration of Definitional Issues	Pagano	ViTTa	NSI Inc.
Q2: Ally, Adversary, and Partner Use of Space	Aviles, Bragg, Peterson and Popp	ViTTa	NSI Inc.
Q3: Motivations and Costs to Contest Uses of Space	Stevenson	ViTTa	NSI Inc.
Q4: Space Services Among Actors Without Space Capabilities	Bragg	ViTTa	NSI Inc.
Q5: Exploring the Economic Effects of Conflict in Space	Aviles	ViTTa	NSI Inc.
Q6: Commercial Companies' Perceptions of Security Space	Peterson	ViTTa	NSI Inc.
Q7: Use of the Commercial Space Industry for Military Purposes by Non-Western States	Bragg	ViTTa	NSI Inc.
Q8: Allocation of Commercial Space Industry Components	Bragg and Pagano	ViTTa	NSI Inc.
Q9: Hindrances Between Private and Gov't Space Sectors	Astorino-Courtois	ViTTa	NSI Inc.
Q10: Effects of Investment on Pathways to Space Security	Stevenson	ViTTa	NSI Inc.
Q11: Allied/Commercial Capabilities to Enhance Resilience	Bragg	ViTTa	NSI Inc.
Q12: Commercial Space Actors: Disruptors or Solid Partners	Astorino-Courtois and Bragg	ViTTa	NSI Inc.
Q13: National Security Implications of Space-Launch Innovation	Stevenson and Popp	ViTTa	NSI Inc.
Q14: How Should Space Feature in US Deterrence Strategy	Astorino-Courtois	ViTTa	NSI Inc.
Q15: Pre-Space Age Approaches to Military Capabilities	Popp	ViTTa	NSI Inc.
Q16: Strategic Risk in the Space Domain	Popp	ViTTa	NSI Inc.
Q17: Is US Success Contingent on Dominance in Every Domain	Pagano	ViTTa	NSI Inc.
Q18: Principles of Response to Aggression in Space	Stevenson	ViTTa	NSI Inc.
Q19/23: Governing in a Crowded Space – The Legal Regime for Space	Bragg	ViTTa	NSI Inc.

Title	Author	Method	Affiliation
Q20: International Rules and Norms: Constraints on Space Operations	Bragg	ViTTa	NSI Inc.
Q22: Effectiveness of International Agreements in Space	Stevenson	ViTTa	NSI Inc.
Space Deterrence: The Vulnerability-Credibility Tradeoff in Space Domain Deterrence Stability	Jafri and Stevenson	Concept Paper	NSI Inc.
Space Virtual Think Tank Summary Overview	Popp	ViTTa	NSI Inc.
The Clash of Sectors: Why Public Private Partnerships Can Reduce 'Coerced Cooperation' in Commercial-Government Joint Ventures	Aviles and Stevenson	Concept Paper	NSI Inc.
Vladimir Putin's Worldview and Perspectives on Space	Aviles and Kuznar	Discourse Analysis	NSI Inc.