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Effects of Investment on Pathways to Space Security

A Virtual Think Tank (ViTTa)[®] Report



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Author

Dr. John A. Stevenson

Please direct inquiries to Dr. John A. Stevenson at jstevenson@nsiteam.com

ViTTa® Project Team

Dr. Allison Astorino-Courtois
Executive VP

Sarah Canna
Principal Analyst

Nicole Peterson
Associate Analyst

Weston Aviles
Analyst

Dr. Larry Kuznar
Chief Cultural Sciences Officer

George Popp
Senior Analyst

Dr. Belinda Bragg
Principal Research Scientist

Dr. Sabrina Pagano
Principal Research Scientist

Dr. John A. Stevenson
Principal Research Scientist

Interview Team¹

Weston Aviles
Analyst

Nicole Peterson
Associate Analyst

Sarah Canna
Principal Analyst

George Popp
Senior Analyst

What is ViTTa®?

NSI's **Virtual Think Tank (ViTTa®)** provides rapid response to critical information needs by pulsing our global network of subject matter experts (SMEs) to generate a wide range of expert insight. For this SMA Contested Space Operations project, ViTTa was used to address 23 unclassified questions submitted by the Joint Staff and US Air Force project sponsors. The ViTTa team received written and verbal input from over 111 experts from National Security Space, as well as civil, commercial, legal, think tank, and academic communities working space and space policy. Each Space ViTTa report contains two sections: 1) a summary response to the question asked; and 2) the full written and/or transcribed interview input received from each expert contributor organized alphabetically. Biographies for all expert contributors have been collated in a companion document.

¹ For access to the complete corpus of interview transcripts and written subject matter expert responses hosted on our NSI SharePoint site, please contact gpopp@nsiteam.com.

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Question of Focus

[Q10] Does substantial investment and heavier commitment by both governments and commercial interests provide an avenue of approach for space ‘security’ and disincentive for kinetic military action?

Expert Contributors

Major General (USAF ret.) James Armor² (Orbital ATK); **Dr. Daniel N. Baker** (University of Colorado-Boulder); **Marc Berkowitz** (Lockheed Martin); **Wes Brown & Todd May** (NASA); **Robert D. Cabana** (NASA); **Caelus Partners, LLC**; **Elliot Carol³** (Ripple Aerospace); **Dean Cheng** (Heritage Foundation); **Dr. Damon Coletta & Lieutenant Colonel (USAF ret.) Deron Jackson** (United States Air Force Academy); **Colonel Dr. Timothy Cullen⁴** (Air University); **Falconer Consulting Group**; **Dr. Nancy Gallagher** (Center for International and Security Studies at Maryland); **Gilmour Space Technologies**, Australia; **Mike Gold** (Space Systems Loral); **Harris Corporation**; **Dr. Henry Hertzfeld** (George Washington University); **Theresa Hitchens** (Center for International and Security Studies at Maryland); **Dr. Moriba Jah** (University of Texas at Austin); **Dr. John Karpiscak III** (United States Army Geospatial Center); **Group Captain (Indian Air Force ret.) Ajey Lele⁵** (Institute for Defense Studies and Analyses, India); **Massimo Pellegrino** (Space and Policy Advisor); **Dr. Luca Rossetini** (D-Orbit, Italy); **Brent Sherwood** (NASA Jet Propulsion Laboratory); **Dr. Patrick A. Stadter** (Johns Hopkins University Applied Physics Laboratory); **ViaSat, Inc.**

Summary Response

Expert contributors wrestle with three factors in answering this question:

- Whether spending more will improve security and disincentivize kinetic action.
- Whether *either* or *both* commercial and government actors should spend more.
- If both, then whether commercial and government actors should do so independently or through partnership.

80% of the expert contributors affirm that increased spending would provide an avenue of approach for space security and disincentive for kinetic military action.⁶ The remaining 20% diverge on why they do not believe that spending would improve space security. Some contributors aver that the effect of spending on security and kinetic action is conditional on the type of adversary, or if the rules of the road resulting from increased investment reduced pathways toward inadvertent escalation, whereas others argue that increased spending increased the number of targets and increased the possibility of wasteful spending.⁷

² Armor’s personal views, and not those of his organization, are represented in his contributions to this work.

³ Carol’s personal views, and not those of his organization, are represented in his contributions to this work.

⁴ Cullen’s personal views, and not those of the United States Air Force, Department of Defense, or United States Government, are represented in his contributions to this work.

⁵ Lele’s personal views, and not those of the Indian Air Force, Indian Space Research Organization, or Government of India, are represented in his contributions to this work.

⁶ See contributions from Armor; Baker; Berkowitz; Brown and May; Cabana; Caelus Partners LLC; Carol; Cullen; Falconer Consulting Group; Gilmour Space Technologies; Gold; Harris Corporation; Hitchens; Jah; Lele; Pellegrino; Rossetini; Sherwood; Stadter; ViaSat, Inc.

⁷ See contributions from Coletta & Jackson; Karpiscak III (on conditionality), as well as Hertzfeld; Cheng; Gallagher (on increased number of targets and wasteful spending).

Almost every contributor supporting increased spending as a disincentive for kinetic military action argues that spending from *both* commercial and government actors would have the predicted positive effects, and that neither type of actors' spending would be more efficacious. Only one contributor, Group Captain (Indian Air Force ret.) Ajey Lele of the Institute for Defense Studies and Analyses, suggests that one type of actors' spending—state actors—would have greater impact.⁸ Finally, although most contributors did not specify whether they believe the positive effects from increased investment required partnership, or would occur even if commercial and government actors invested independently of each other, the few contributors that accounted for this parameter specifically mentioned *public-private partnerships* as the most effective vehicle for investment. See Figure 1 for a depiction of the consensus.

Does Increased Spending Lead to Increased Space Security?

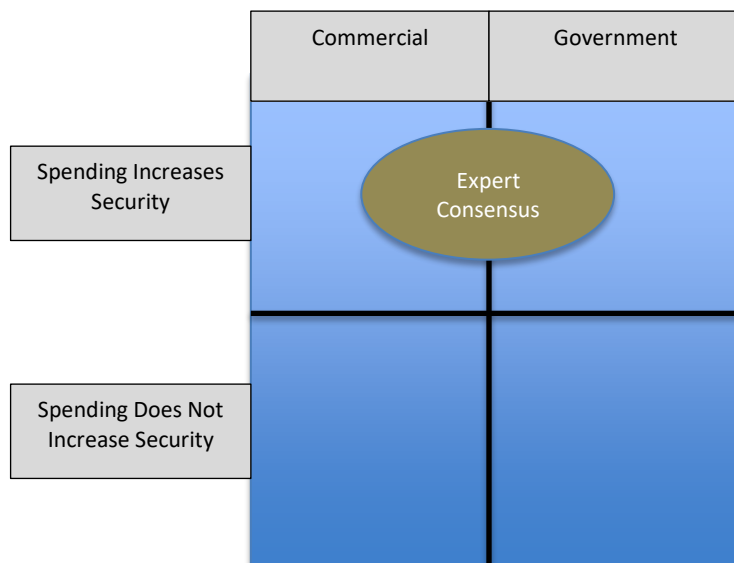


Figure 1: Visualization of Expert Opinions

Most contributors answer in the affirmative, positing that increased spending can create disincentives for kinetic action in four ways:

- increased space situational awareness (SSA);
- the self-interest of space-faring nations and space-operating commercial enterprises in protecting expensive assets;
- increased cooperation from collaboration among larger coalitions; and
- commercial actors' interest in order and stability make public-private partnerships a vehicle for reducing militarization and increasing restraint.⁹

Increased Space Situational Awareness

One way in which greater investment could reduce incentives for kinetic military action is through increasing SSA to have more “available eyes in the sky,” according to Dr. Daniel N. Baker of the University of Colorado-Boulder.¹⁰ These positive returns from investment in SSA could also be magnified through practices of data sharing, one vision of which Dr. Moriba Jah of the University of Texas at Austin vividly describes as “a data lake” of global data sharing and monitoring. According to the contributors, monitoring and transparency of SSA reduces this branch of uncertainty as a pathway to kinetic military action, without which “managing future space security will be quite difficult,” according to Lele.

⁸ Since there was almost no variation on this question, I will not expand on these views below.

⁹ Contributors from ViaSat, Inc. expound that “space is a growing ‘business’ domain, as in other examples, continuity of business operations becomes a source for domain stability and regulation.”

¹⁰ For other experts mentioning SSA, see: Lele; Jah; Pellegrino; ViaSat, Inc.

Greater SSA directly decreases the chances of wrongful attribution of aggressive intent to an unintentional or accidental event; according to the contributors, fewer instances of wrongful attribution should also lower the risk of unintended escalation. Jah notes that “uncertainty and ambiguity and a lack of transparency” characterize the space domain, creating an environment that is “rife for...some sort of military action.”¹¹ For example, the physical environment is sufficiently harsh (e.g., radiation, debris) that destruction or degradation of space assets can occur even without terrestrial actors’ involvement. Limited SSA can result in an assessment that an adversarial action is occurring even when it is not; this assessment in turn may lock state actors into pre-planned responses that are wholly inappropriate given the actual situation that triggered the response.¹² While “transparency in space” alone “does not directly ensure space security, it can be an aid to the maintenance of norms and disincentive for kinetic military action,” space and policy advisor Massimo Pellegrino observes.

Protecting Expensive Assets

This concern about costliness has two dimensions: that space capabilities are pricey, *and* that given the expense, actors invested in space have made functionally made trade-offs away from developing non-space alternative sources of their national power. This means that the effects of losing the capabilities would be extremely costly to both commercial and government actors who are heavily invested in space. Lele forwards that this pathway to space security obtains contemporaneously even when conflict is occurring in other domains:

There are currently sanctions on Russia because of its actions regarding the recent US election and its earlier actions in Crimea. [I]n spite of having those sanctions and other issues, neither side has brought those issues [into the] space [domain]...There is business as usual between Russia and NASA. Otherwise, what would happen if this were not the case, is that investments in space would be at jeopardy if major countries like US and Russia started fighting with each other.

The fact that space systems are expensive to deploy, and too critical for many economic and military capabilities to lose, creates security via restraint and non-escalation. Dr. John Karpiscak III of the United States Army Geospatial Center argues that only larger adversaries possess a disincentive for kinetic military action from costliness of space systems. Whereas “classical Warsaw Pact type” adversaries *may* see incentives for restraint, “up-to-date” adversaries, such as “terrorist or asymmetrical activity,” may not have that disincentive because “today [adversaries] don’t really need much to create quite a threat.”

Beyond the expense of the space capabilities, commercial investments in space are motivated by successful long-term continuity of growing profitable businesses and not the historical perspective of investments solely for government or military operations, contributors from ViaSat, Inc. explain. The transition of space to a “business” domain leads to an international set of commercial or publicly traded companies requiring the peaceful and safe usage of space for the continuity of their businesses and shareholder value. As the international commercial use of space grows, the disincentive for military action that could harm space also grows.

¹¹ For a related discussion, see NSI Space ViTTa® Q18 report on [Principles of Response to Space Aggression](#).

¹² As theorist Robert Powell points out, a minor accident might “set the dice rolling,” but for a crisis to escalate further, it must be “followed by a series of interacting decisions” that are deliberately aimed at escalation, invoking pre-planned response options to contingencies.

Increased Cooperation

Increased investment should also lead to increased cooperation, and cooperation would decrease the incentives for kinetic action, according to contributors. Phrased most simply, the view of these contributors is that the greater the number of actors invested in space, the larger the set of actors who have something to lose, such as services, capabilities, and assets, if there is kinetic action in space. The prospect of loss increases cooperation.

Theresa Hitchens of the Center for International and Security Studies at Maryland indicates that increased investment literally allows more actors to “buy into” concerns about space safety, sustainability, and security. Wes Brown and Todd May of NASA add that patterns of cooperative investment into the space domain, combining states in partnership with each other, as well as states in partnership with commercial entities, provide space-faring nations a “leveraging point for diplomatic resolution for issues in other areas,” and a way to increase inter-dependence within and on the space domain to “ensure partnership ensues over conflict.” Elliot Carol of Ripple Aerospace further posits that the greater the number of actors with assets in the space domain, the less appetite for “warfare” the space domain would face, since if “more people have more assets, [the] less likely they will [be to] want to destroy them.”

These actors should, as a result, experience an increased willingness to be willing to abide by what Hitchens identifies as “rules of the road” that guarantee free and safe access for all actors. Dr. Damon Coletta and Lieutenant Colonel (USAF ret.) Daron Jackson, both of the United States Air Force Academy, agree that *if* (and only if) “there were a rough consensus on [the] rules of the road” would “investment would actually be a positive for deterrence” of kinetic military action. For, Coletta Jackson, the effect of a greater number of actors involved in the space domain on cooperation is conditional on who those actors are. They warn that the hope that larger numbers leads to larger cooperative coalitions obscures an important determinant of the effect of rules on peaceful behavior: whether or not those rules lead to invested actors being in the “habit of cooperating with American oriented favored systems, rather than responding to, say, another big country (e.g., China) that would maybe want to set up its own set of rules.” Specifically, they indicate that it is crucial to “understand who writes those rules, who maintains them, and who sustains them with some level of coordination or information sharing” to determine whether these rules will result in a political contest, between say, Washington and Beijing, and whether the rules themselves are more or less “permissive of dangerous maneuvers or kinetic activity.”

Public-Private Partnership Restrain Incentives for Kinetic Activity

Although most contributors were silent on how the specific patterns of increased investment would have these positive effects on cooperation and restraint, a few specifically identify *public-private partnerships* as the most effective vehicle for security-increasing investments. Public-private partnerships not only increase the efficiency of investment for states, by providing cost savings, as Carol notes, but also by making investments appear less threatening to potential adversaries. According to contributors from Caelus Partners, LLC, the *optics of cooperation* through public-private ventures alone would make new investments appear less threatening and thereby enable “more room for international collaboration.” In contrast, if any actors (though especially state actors) were to invest more in the state domain *outside* of public-private partnerships, the increased investments would drive “other nations to consider [further] militarizing the space domain.” Similarly, ViaSat, Inc. predicts that public-private partnerships allow for “layering military/government and private sector systems,” which not only “can create significant improvement in space ‘security’” but also provide “a disincentive for kinetic or even non-kinetic adversarial actions.”

The cooperative optics and cooperation dynamics of public-private partnerships should provide these disincentives for kinetic activity even if actors in the space domain *did not* end up affirming common rules of the road, according to Pellegrino: joint ventures with commercial actors “require (and necessitate) that outer space be safe, sustainable, secure, stable, and predictable over the long-run.” Contributors from Faulconer Consulting Group agree: “When there exists a collective and mutual interest for commerce that all parties may partake of it disincentives actors from taking adverse actions.” In short, commercial actors’ interests in order and stability for profit-maximization opportunities itself alters the dynamics of the space domain away from kinetic military action and toward space security; state and commercial actors’ interests converge through cooperative public-private partnerships.

When Might Increased Investment Lead to Less Space Security or More Kinetic Action?

Although the overwhelming majority of the expert contributors argue in favor of a positive connection between security and investments, Dr. Henry Hertzfeld of George Washington University advances a cautionary view while Dean Cheng of the Heritage Foundation offers a countervailing one. According to Hertzfeld, one potential outcome of increased spending is simply more spending. Specifically, he warns that higher levels of spending could just mean greater wasteful spending: “More spending can be just replicating what we have as opposed to doing R&D and going forward.” For Hertzfeld, more important than levels of spending is what spending is allocated to; he favors investment in R&D as well as equipment for the purposes of staying ahead of adversaries as well as protecting space assets from other harm, including natural debris and interference.

Cheng surmises that just because many nations are performing the same action—adding assets to the space domain—does not mean that action has the same strategic benefits or risks for different actors. For example, he muses, China and Russia will never be as vulnerable as the US in the space domain, and therefore may pursue security-seeking motivates across domains differently: “Both of their primary strategic interests are offshore or in their near abroad—meaning, they can cover communications, ISR, PNT, etc. by using non-space-based capabilities. The US, though, is expeditionary. The US needs those space-based capabilities in order to communicate on the other side of the planet.”

Cheng proffers that the products of increased investment would just be new sets of targets for adversaries to target: “More investment gives the bad guys, whoever they may be, a new set of targets, and targets that by their physical nature are fragile.” While SSA *may* increase as a result of new investment, it also may not; and given the limited SSA we currently possess, the “actions to target these targets can be very ambiguous for attribution and the like.” Dr. Nancy Gallagher of the Center for International and Security Studies at Maryland notes this view was shared by the Bush Administration. She reminds our effort that the Bush II Administration explicitly rejected the view that increased investments and interdependence—“e.g., greater economic activity and the greater amounts of money involved would generate a harmony of interests”—would create pathways for space security. Instead, that Administration’s view was closer to Cheng’s view: “all of that investment is vulnerable and, therefore, we need to build up the ability to basically control space and to take kinetic military action if we need to in order to protect our own assets.” In Gallagher’s telling, that perspective on risk in the space domain influenced foreign policy ameliorated the potential pacific effects of investment, to the extent that worldview guided American space security policy.

Conclusion

The expert contributors exhibit a durable consensus in answering this question. Most agree that substantial investment would provide an avenue of approach for space security and disincentive for kinetic military action, especially if those investments took the form of public-private partnerships. Almost every contributors supporting increased spending as a disincentive for kinetic military action argues that spending from *both* commercial and government actors would have the predicted positive effects, and that neither type of actors' spending would be more efficacious. The few contributors who deviate from the consensus raise important concerns about a few key issues: the potential for wasteful spending, adversaries that are less invested in the space domain, increasing the number of targets for the United States to defend, and political conflict over the rules of the road governing space cooperation.

Subject Matter Expert Contributions

Major General (USAF ret.) James B. Armor, Jr.¹³

Staff Vice President, Washington Operations (Orbital ATK)
4 August 2017

WRITTEN RESPONSE

YES. But it will not eliminate it any more than terrestrial investment will deter terrestrial kinetic conflict. (Aside: Nuclear is a class by itself. DO NOT confuse space and nuclear deterrence: it is a false analogy.) [My point is, there is an intellectual thread that deterrence of space conflict is equivalent to deterrence of nuclear conflict. There is no equivalent "MAD" strategy that will prevent a conflict extending to space. Space is another conventional medium of conflict.]

Dr. Daniel N. Baker

Director and Distinguished Professor of Planetary and Space Physics
(University of Colorado-Boulder)
28 July 2017

WRITTEN RESPONSE

The overwhelmingly clear answer to this question is "yes". The larger the investment by government and commercial organization in space "situational awareness", the more everyone can be confident that mistakes will not be made in delicate situations. In many foreseeable circumstances, space weather events could be taken as hostile attacks on a nation's space assets. It is crucial that the space faring nations have as much knowledge as possible about the Sun and disturbances from the Sun that can disrupt near-space, atmospheric, and surface technological systems.

The security of all players is increased when complete and transparent knowledge of what is happening (or is about to happen) in space is provided. It is crucial that we have more available "eyes in the sky". This will only be possible with more government and private investment.

Marc Berkowitz

Vice President, Space Security (Lockheed Martin)
25 August 2017

WRITTEN RESPONSE

Yes, of course. The complex challenges of space security can only be addressed by establishing the priority and commitment — reflected among other things by allocating sufficient resources to address the problems the US must now confront. The US has incentivized potential adversaries to develop the means to hold space assets at risk by demonstrating their political, economic, and military value to the nation. Concurrently, the US traded off

¹³ Armor's personal views, and not those of his organization, are represented in his contributions to this work.

resilience for capability and affordability in the post-Cold War period when that there was an expectation that space would remain a sanctuary from armed conflict and continued to have cognitive dissonance when the threat reemerged. Remaining reliant or dependent upon vulnerable space capabilities for mission critical functions is provocative and provides incentives for (kinetic or other forms of) aggression in crisis and conflict.

It would be infeasible and imprudent, however, to attempt to turn back the clock and eliminate reliance on space capabilities. Consequently, the only practical alternative is to create disincentives through deterrent threats of denial and/or punishment. Denial threats of course will only be credible and effective if the US demonstrates the political will and capabilities systematically to reduce or eliminate provocative vulnerabilities and improve the survivability, endurance, operational continuity, protection, defense, resilience, etc., of its national security space architecture. Deterrence by denial also has the benefit of safeguarding the means of retaliation. Similarly, deterrence by punishment requires that the US demonstrates the political will and capabilities to hold at risk and inflict unacceptable costs on what the adversary values to be effective. This may or may not include responses involving space control operations depending on the adversary's values and reliance on space capabilities.

Wes Brown & Todd May

NASA's Marshall Space Flight Center

Wes Brown

Manager of the Office of Strategy

Todd May

Center Director

27 September 2017

WRITTEN RESPONSE

Substantial investment and heavier commitment by both government and commercial interests can serve to provide a message of the strength and breadth of America's capability in space. A similar message was sent to Russia during the Cold War when the U.S. put boots on the moon, demonstrating the nation's capability without military action. Today we are looking to put boots on Mars via the government, in partnership with commercial, that will show the sheer strength and magnitude of U.S. capability in space. Put simply, the rise of commercial industry shows the breadth of the U.S. industrial base.

Substantial investment in commercial interests has brought about the emergence of new private actors in space launch services, to the benefit of national security, to mitigate singularity in access to space and promote competitive pricing, irrespective of investment funds. This has not come without its challenges though. Lower cost has meant increased domestic competition and in some cases workforce reduction for traditional providers who, for certain national security payloads, remain the only viable service provider. Provided the government can subsidize for the maintenance of those payload classes, that same competition could work to the nation's advantage from a security standpoint. Even with the emergence of new actors, assured access to space and the capability to lift large, national security payloads to high-earth orbit and beyond demands a government-based launch solution.

The same substantial investment in commercial interests has led to the oversaturation of the launch service market. This too can be utilized to the nation's advantage from a national security viewpoint as there is greater supply than demand. It has been publically stated that this additional supply can be used to reconstitute space assets if need be.

The oversaturation of the launch market has not been contained to the domestic launch market, but has had an impact on the global market to effectively remove market share from other nation state-funded launch providers. This may prove to have an effect to slow the progression of other nation states capabilities in space who have limited funding to invest in space. It may not be as effective for other nation states who are investing in space aggressively without seeking economic gains. Perhaps a different approach for those nations is re-direction of technology. This worked with Russia after the Cold War in that they spent resources and energy developing what the U.S. developed and it has been suggested that they didn't know why. Choosing what programs are publicized may indicate not only technology capability, but could re-direct our adversaries to prioritize technologies that don't complement one another, creating a highly valuable time gap.

Investment in commercial interests has brought about actors who have the agility to move within the aerospace industry. With technology and overall capability in the space domain developing at a rapid pace, and those of our adversaries at an alarmingly rapid pace, the need for agility is vital for success. Commercial industry is poised, with fewer stakeholders directing its actions, to bring agility into the equation. The same rational of fewer stakeholders also introduces risk as the commercial strategic decision-making philosophy is based on sustainability as a "going concern." If the government has a need but is not able to provide a strong enough customer base to support the desired business case, a launch service provider may choose to remove that capability from service (Falcon 1). This inherent risk is one reason that investment in government interests and maintaining a government launch solution still has its place in meeting the needs of the nation in space.

The civil space program is in position to outpace our adversaries in terms of mission and technology to demonstrate the full scope of the nation's capabilities in space. The civil space program also houses the expertise of generations in space in areas where commercial space is still formulating and even non-existent. The challenge to this is maintaining purpose and course. If the U.S. is going to outpace our adversaries, we need a constancy of purpose and adequate funding in our civil space program. Proper funding in a timely manner will accelerate technology development for the benefit of the nation as a whole and reduce the overall timeline for mission success by eliminating the need for an evolvable path.

Technology is advancing at a rapid pace in many different disciplines. While commercial entities provide technology investment and advancement, it is typically tied to what is needed to increase profit. Government can afford a different economic risk posture and is poised for research and development work in many strategic areas to ensure the expertise to match or beat that of our adversaries. Technologies that can be developed for national security needs can also be transferred to the commercial sector for national economic gains. The two technologies that civil space can aid in developing are launch vehicle technologies and non-traditional communications technology. This, along with the current experience base, provides at a minimum access and operations at any destination our adversaries would desire to be.

Even so, the programs currently in development offer national security benefits. When considering reconstitution of space assets, the SLS can provide reconstitution of a fleet of space-based assets in a single and perhaps co-manifested launch, as opposed to multiple launches in a short frame, so as not to trigger the attention of adversaries. Potentially unrealized margin in SLS can also serve to provide covert delivery of defense assets.

Our adversaries have developed their strategy for war in space. The current actions of USAF are not based on a desire for conflict in space but a reaction to a known threat. History shows that the path of our adversaries is rarely impacted by other nations as they do what is necessary to see their long-term plan come to fruition and say what is necessary to get the support of other nations in doing so. This is particularly true with China who has organized around the obtaining of data based on the philosophy of the state with the most information wins the war. Currently, it can be concluded from international agreements in space exploration that their strategy incorporates international partnership in civil space as an avenue to gain such information. In order for this strategy to continue to be successful they need more partnerships. The most recent white paper released by the Chinese government utilizes messaging in alignment with the outer space treaty to attract such partnerships. All of this points to the fact that international perception and political capital is key to their plan. Any strategy which costs them political

capital or changes the view of the nation, as seen by others in the international arenas, may be avoided. This fact can be used against them to deter them from kinetic military action. Decoy space assets would increase the financial and political resources spent by our adversary without guarantee of the desired outcome. If the decoys are monitored, it is likely that those responsible for kinetic action could be determined, either by the U.S. or our allies. The political expenditure for kinetic action without the guarantee of success may be enough to dissuade such action. For other nations whose strategy does not include international relations nor values the view of their nation by the international community, this strategy may not prove as effective but could open an avenue for highly useful insight into their response.

Investment by the government also provides an avenue for peaceful international partnerships and a leveraging point for diplomatic resolution for issues in other areas. Dependence on other nations in space and their dependence on the U.S. is a strategy to ensure partnership ensues over conflict. This can be done by investing in common in-space infrastructure, a role of government actors for civil and commercial benefit. It is perceived to be advantageous to have international partnerships in areas of militaristic advantage such as the lunar and Martian surface.

There are distinct advantages to having a commercial space flight industry as well as distinct advantages to investing in government space activities. With the current budget and an emerging market that is not yet independent from government as a customer, public private partnerships offer an advantage to maintaining the health of the both commercial and government programs for the realization of the totality of the nation's goals in space including national security.

Robert D. Cabana

Center Director (NASA's Kennedy Space Center)

27 September 2017

WRITTEN RESPONSE

NASA is leading an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system. The new Exploration Campaign initiated by the President and his new Space Policy Directive intends to lead missions beyond Low-Earth Orbit (LEO) and eventually return humans to the Moon for long-term exploration and utilization. That effort will be broadened to robotic and human missions to Mars and other destinations. The John F. Kennedy Space Center (KSC) remains committed to meeting our nation's goals in deep space human exploration with careful stewardship of our critical resources and wise investment of taxpayer dollars. With KSC's transformation into a multi-user spaceport of the future, where both Government and commercial space operations are being conducted and supporting one another, NASA's deep space exploration missions catalyze the continued growth and development of a comprehensive space industry. As NASA and KSC continue to advance and evolve the multi-user spaceport initiative, next steps to operate at a high velocity with multiple concurrent operations are being formulated. In order for us as a nation to be successful, we need both Government and commercial space exploration. NASA can invest in the uncharted territories of deep-space exploration, while industry plays a vital role in transportation within LEO, as well as partnering with NASA in the exploration program. The work we do together and the lessons learned that we share are essential for the U.S. space economy's continued growth.

The Commercial Space Launch Act of 1984, opened the door for commercial companies to meet NASA and Department of Defense (DOD) launch services needs resulting in an economic benefit to both NASA and DOD. This law was the platform needed to give rise to an emerging Commercial Space Market. Since 2004, there has been significant market growth with entrants such as SpaceX, United Launch Alliance, Orbital ATK, and Boeing becoming household names and winning major Government operations and support contracts to include commercial cargo

missions to the International Space Station following retirement of the Space Shuttle. Since then, these companies have contributed to an overall increase in the global market share for U.S. launch operations.

New space actors are entering the U.S. market with the intention of becoming a major disruptor within the defense, civil and commercial trade space. There is a misconception that being an industry disruptor is bad thing, when in fact, it can significantly benefit the government. For example, SpaceX has incorporated major cost reductions into the manufacturing process and the reusability of its launch vehicles, allowing the company to pass on the savings to its government customers. This disruption has forced other launch providers to look to cost saving measures in order to compete with the new low-cost competition. Other companies are disrupting the industry through the use of innovative technologies to streamline improvements to their manufacturing process, by incorporating automation and 3D printing to drive down costs and decrease their “time to market”. In addition to launch vehicle-related disruptive capabilities, small and nano-satellites are proving to be a common disruptive trend that is being used in Counterspace. No longer are NASA and DoD restricted to the use of large costly satellites for national security uses. Now they can partner or contract with commercial companies to develop and launch these satellites through ride sharing or as a secondary payload on launch vehicles.

These new commercial companies are solidifying their position in the space industry and proving to be trusted partners for NASA and DOD both now and in the future.

Caelus Partners, LLC

Jose Ocasio-Christian
Chief Executive Officer

24 August 2017

WRITTEN RESPONSE

Caelus Partners believes that substantial commitments by government and commercial ventures / partners (also known as public-private partnerships or PPP) are a necessity for the US to be considered as non-adversarial to the rest of the planet as it relates to space. We believe that growth in US space security assets without international collaboration will cause reciprocal effects and other nations will consider militarizing the space domain.

Elliot Carol¹⁴

Chief Financial Officer (Ripple Aerospace)
7 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: Okay, great and then as far as this last question goes I think you’ll be able to provide a rather unique perspective on this. We have been talking to a few different launch companies; some small, some large, but I have yet to interview someone from a Sea Launch company, so I think the last question you’ll have a particular insight on. What are the national security implications of increasingly successful and affordable commercial launch services?

E. Carol: Number one probably a low probability of warfare in space. If more people have more assets less likely they will want to destroy them, probably is the most important. Number two obviously, the

¹⁴ Carol’s personal views, and not those of his organization, are represented in his contributions to this work.

military budget goes a lot further if you're not paying ULA a couple hundred million dollars for the next launch, but paying SpaceX \$62 million a launch. Number three, just creating a lasting demand. If launch costs are lower, satellite costs will be lower, and satellite operations costs will be lower as well as communication channels. Right now you have in space you have what's called an "inefficient market". The more efficient you can get... you actually get launch costs to, based on our models, about \$1500 to \$1200 per kilo, you can then start to create real demand, organic demand for a different type of space ventures; going to the moon, which sounds a lot less ambitious, or just having constellations in the sky for Internet and 24/7 video of the Earth. I think a lot lower reduction in probability of threat a lot higher impact, positive impact on space assets in regards to budgetary constraints.

Dean Cheng

Senior Research Fellow (The Heritage Foundation)

2 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: Do you think substantial investment and heavier commitment by both governments and commercial interests provide an avenue of approach for space 'security' and disincentive for kinetic military action?

D. Cheng: No, I think it does the opposite. All of this investment doesn't make a disincentive for military action, it makes it more useful. More investment gives the bad guys, whoever they may be, a new set of targets, and targets that by their physical nature are fragile. And, because of the nature of space situational awareness and the like, actions to target these targets can be very ambiguous for attribution and the like.

There is a growing divergence between the space security community, which does see these threats, and the academic and parts of the space policy community, which see all of this as somehow creating security. The latter, in my opinion, almost defies the laws of physics, and seems to be a desire to return to sanctuary.

Interviewer: So, what about the argument that heavier investment and increased infrastructure in space might disincentive space actors from aggression and conflict? The idea is, I guess, that by putting more of their own things into space and advancing their interests in space, actors would be disincentivized from creating a conflict because they have more and more to lose.

D. Cheng: Well, first off, let's go over who exactly is doing all of the "investment" in outer space? Who exactly is dependent on space, aside from the United States and the West?

I have a sneaky suspicion that part of this argument is coming from...because some folks keep insisting that, for example, China will become as dependent on space as the US is. If you ask them why that is, the answer seems to be that apparently there's some unidentified law of physics that says this will be true. However, the reality is that when you look at Russia and you look at China, both of their primary strategic interests are offshore or in their near abroad—meaning, they can cover communications, ISR, PNT, etc. by using non-space-based capabilities. The US, though, is expeditionary. The US needs those space-based capabilities in order to communicate on the other side of the planet. Now, maybe we're going to see Russia becoming Soviet Union again with interests in the Indian Ocean and South America, but that's going to require a whole lot of other changes. We might see China become not strategically committed to

Djibouti, but, again, where is the evidence of this? What we see with “One Belt, One Road,” which is probably the single most massive Chinese investment, is that it is primarily focused in Central Asia, and, to a lesser extent, port facilities in the Indian Ocean—not defensive facilities. No one that I know of really seriously thinks that the Chinese are going to start doing expeditionary operations in western hemisphere, or even in Africa, and even that is different than fighting a war against an adversary who can access space and where China would need the space capability.

So, then we get to, “Yes, but you would foul the nest.” Why would China go to war? The answer almost always comes back to issues of regime survival. And if you have a regime survival issue, are you willing to foul the nest? Absolutely.

Interviewer: Okay. How would the Chinese define “space security” or “a secure space domain?” Does the Chinese definition and perspective on this differ from, say, that of the US or the EU?

D. Cheng: Well, to begin with, the Chinese are not that interested in space security. This is part of what we are getting at here. The Chinese focus is on national security, which is defined by core interest, which begins with territorial integrity and sovereignty, the preservation of the Chinese Communist Party’s rule, and the preservation of economic development. Space is a tool to obtain that, but there is not “space security,” per se, any more than there is “oil security.” When you talk about “oil security,” you are not talking about preserving oil rigs in Libya—you are saying, “Can I, country X, get enough oil to keep my economy running?” So, the Chinese, if they are going to define “space security,” are going to say, “First off, what do I need space for?” (note that those requirements for China are very different than those requirements for the US) and then, “What do I need to do to make sure that those missions are fulfilled, which may not have to be by space?”

So, consider that China does not at the present time have any space-based missile early warning capability. That was one of the first things the United States developed. That was one of the first things the Soviet Union developed. But the Chinese, 47 years after going to space, have yet to deploy space-based missile early warning. That should tell us that the Chinese has a very different view of the strategic role of space, and, therefore, how they think about something like “space security.”

Dr. Damon Coletta & Lieutenant Colonel (USAF ret.) Daron Jackson

United States Air Force Academy

Damon Coletta
Professor of Political Science

Deron Jackson
Director, Eisenhower Center

8 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: Does substantial investment and heavier commitment by both government and commercial interests provide an avenue of approach for space security and disincentive for kinetic military action?

D. Jackson: Well, I think it can. Whether we can deterministically say it does, depends on the actors and the contested relationship. If the level of investment and the timescale replenishing that investment were lost, the environmental conditions would make it even more challenging if you went kinetic. Furthermore, if you are looking at this with respect to certain global regimes, there may be certain constraints that apply to certain actors but maybe not all. As we watch certain players around the world, like North Korea, start to demonstrate greater missile capability, if they are not as equally invested then they are in a disproportionate part of that relationship to cause trouble in the space domain. The fact that you have considerable investment by some players gives them a certain shared interest, but it may also heighten the disparity of interest amongst other emerging actors.

D. Coletta: Again, what I'm hearing from Deron is consistent with what I've seen. Ultimately, it depends. Thinking about this in terms of political science, one of the variables it depends on is the asymmetry of investment.

Another variable that I've heard that might matter is the existence of common rules of the road. We are aware of efforts, some of which involve DoD and others not necessarily involving DoD but maybe just industry, are trying to come up with rules of the road. The idea is that if there were a rough consensus on such rules of the road, that commercial investment would actually be a positive for deterrence. Even if you had, say, asymmetric skin in the game, having rules of the road that were generally agreed upon would help strengthen the relationship between commercial investment and successful deterrence.

Interviewer: Okay. So, could you maybe provide or play out a scenario with a specific actor that you might have in mind and a specific type of investment that you might have in mind, which you think might be a good example of a scenario in which increased investment and commitment provides an avenue for increased space security?

D. Coletta: I don't have a historical scenario, but let me just give you a preliminary answer. If we approached this question, what we would do is we would say, well, have there been situations where a foreign satellite, maybe a military satellite, has maneuvered in a way that wasn't expected or has maneuvered close to a non-military satellite in low Earth orbit? That can be seen as a threat to space security, and it could be seen as a bad precedent, so we would want to know if this scenario is the type of situation where rules of the road would help reduce the ambiguity of these types of incidents or reduce the sort of testing of the waters through satellite maneuvers—let's say, reduce this testing of the waters that generally leads to less space security.

Then, we would scour the unclassified sources for situations that fit this scenario and make arguments about what sort of rules, whether those rules are being worked on right now or not, would make this type of insecurity less of an issue.

Overall, though, we'd start out with a scenario, a hypothetical scenario, and then we'd see if there's anything in the unclassified record that backs that up. But, unusual satellite maneuvers would be a place to start.

I'm sorry that doesn't answer your question about investment. I'm thinking more in terms of where rules of the road could come in, but, obviously, in this scenario there was an initial investment from the commercial sector to put the satellite up there in the first place. As you get more satellites in orbit, and that's certainly expected to increase, so it seems like this sort of scenario would be more likely.

D. Jackson: Let me make up a scenario on the fly. For your purposes, if we take a state that's just going to be an operator, so we don't presume launching space capabilities. There is a proliferation of states that can be operators, so the chosen state would need to conform to a rules of the road type of approach. Let's take Nigeria for example. If Nigeria contracts with somebody, then they are now a space faring state because they got a satellite in orbit. Then, going back to the idea of contesting regimes or contesting international institutions, the challenge there is to have a set of rules or relationships (e.g., an agreement to share some level of situational awareness data), so that they then have a habit of cooperating with American oriented favored systems, rather than responding to, say, another big country (e.g., China) that would maybe want to set up its own set of rules that are maybe more lax or generous or in some way more favorable to the Chinese interests.

So, what they are contesting is: *Who do you work with? What norms and what traditions get established that suggest what the international community's preferred options are for doing maneuvers and the like? Who do you know and who do you trust?* So, as you are theorizing about a country—whatever one it might be—that is trying to build towards that greater level of investment, they can be doing it under a certain set of rules. So, it is crucial to understand who writes those rules, who maintains them, and who sustains them with some level of coordination or information sharing? Is it going to be the United States, or is the contest going to be something less kinetic but more political so that another center of power, Beijing for example, sets those rules and helps to enforce those rules, which may or may not be more permissive of dangerous maneuvers or kinetic activity.

D. Coletta: There's another scenario that could be interesting—that is, the idea of as investment increases, perhaps the chance of collision increases. We've heard a lot about the concern of collision forensics. If something were to happen and a satellite were to go out of operation, how long would it take US authorities to figure out what happened (i.e., if it was an attack, or if it was an accident)?

As investment goes up, the chances for that kind of problem probably increase. Then, to bring in that second variable, could a more elaborate crash protocol—and I gather, for insurance reasons, there are already some protocols out there in terms of what's supposed to happen after a collision—that could assist multiple countries in their forensics were in place, would that improve space security from what it otherwise would be if these collisions just simply became more frequent under the current arrangement? This is a scenario that relates to increased investments and the importance of let's call it a collision protocol.

Colonel Dr. Timothy Cullen¹⁵

Commandant and Dean, School of Advanced Air and Space Studies
(Air University, Maxwell Air Force Base)
15 August 2017

WRITTEN RESPONSE

Yes. The US government should encourage commercial entities to continue to invest in the peaceful access to and use of space for economic and informational purposes. The US government should employ diplomatic and international measures to discourage the employment of kinetic or destructive actions in space, and the relative

¹⁵ The views expressed in Cullen's answer to this question do not reflect the official policy or position of the United States Air Force, Department of Defense, or United States Government.

peaceful existence of the international community in the space domain is the status quo and prevailing perception of the international community. Due to the dominant position of the US and its allies in space and the regime of relative and prevailing peace in the domain, the US continues to reap enormous access to and dominance of its adversaries, to include observations and communications from directly above enemy territory, if desired. It is in the US interests, above all, to maintain the status quo and the current use of the space domain for relatively peaceful purposes. Intuitively, space will have a greater potential to remain a relatively peaceful domain when countries, to include the US, choose not to deploy weapons—or unambiguous military targets—in space. In parallel, the US government must ensure its military and its allied forces are sufficiently redundant to employ lethal and decisive force independent of space assets, if required. With this redundancy, there is little reason to deploy exquisite, complex, and eternally vulnerable kinetic or directed-energy weapons in orbit around the globe. There are no people in space to defend, other than the odd explorer or two, who for generations will be more concerned with the unforgiving environment of space than human aggressors. Not unlike explorers before them, they should and will be responsible for their own safety from the elements—not the US government or the international community. After decades of financial success of the communications and other commercial sectors in space, the international community has also proven that a continuous security presence in space is not necessary to shape behavioral norms in the domain.

Faulconer Consulting Group

Walt Faulconer
President

Mike Bowker
Associate

Mark Bitterman
Associate

Dan Dumbacher
Associate

15 August 2017

WRITTEN RESPONSE

Yes, as long as it is integrated and works to maintain high levels of resilience at an affordable cost. When there exists a collective and mutual interest for commerce that all parties may partake of it disincentives actors from taking adverse actions. Commercial shipping lanes in the world's oceans are one corollary. All countries of the world are free to use this environment for their own commercial reasons with very little risk of adverse action.

Dr. Nancy Gallagher

Director (The Center for International and Security Studies at Maryland)
10 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: Does substantial investment and heavier commitment by both governments and commercial interests provide an avenue of approach for space 'security' and disincentive for kinetic military action?

N. Gallagher: My answer to almost all of these questions is going to be, “it depends.”

For this particular question, I would say that this is exactly what many people expected would happen in the 1990s—that the sheer fact that you had substantial investment, particularly since there was so much more investment by commercial actors in total terms and relative to government investment, would become a major disincentive for any sort of conflict in space, both because of the unpredictability that a conflict would generate and also because of the potential for something like debris generation for example. That was one perspective—basically that greater economic activity and the greater amounts of money involved would generate a harmony of interests, and that you might end up with a lot of coordination problems but everybody would be highly motivated to solve the coordination problems through some type of peaceful, political means.

However, that wasn’t at all how the Bush administration looked at space. In effect, the Bush administration said that more and more of our economic activity on Earth and our military activity on Earth depends on space assets, and we’re investing more and more money—both our own money and the money of our commercial actors—in space, so all of that investment is vulnerable and, therefore, we need to build up the ability to basically control space and to take kinetic military action if we need to in order to protect our own assets.

So, as you can see, you’ve got two different interpretations of the security consequences of the same types of trends.

Interviewer: Okay. So, if you think about the space domain in comparison to some of the other domains (e.g., the maritime domain, land domain, etc.), do you see space as being secure in terms of how we would typically think about defining other domains as secure? And, in comparison to some of the other domains, do you see the space domain as being more secure or less secure?

N. Gallagher: It depends on how you define “security.” I think it is pretty amazing that we’ve never actually had a kinetic attack on a satellite in space ever. There have been tests, but nobody’s ever destructively attacked another country’s satellite. So, at that level, that’s quite secure—you can’t say that about any other domain on Earth.

On the other hand, there are all kinds of actual threats that exist in space because of the simple fact that space is a really harsh environment that is unlike any of the environments that exist on Earth, so that creates natural sources of insecurity. Then, also, there is obviously a lot of activity that’s going on in space that’s very poorly regulated, which creates lots of opportunities for inadvertent interference and inadvertent collisions that can generate unintentional insecurity. And, also, I think that there are clearly a number of countries that are thinking about space as a venue where they can perhaps get some leverage, and therefore are likely to either make overt threats or just demonstrate capabilities, but haven’t actually done much of anything with it yet. For some of these countries, I don’t think their objective really is in space at all—rather, it’s to influence and send a message on Earth that the United States may be much stronger than us overall, but it is vulnerable in important ways, so it might want to think twice about some of its actions.

You could call that a foremost deterrent, and you could say “Well, chances are good that the Russians or the Chinese won’t actually act on a lot of what they are capable of doing,” but it’s very, very hard for me to think of scenarios where the Russians or the Chinese would actually decide that it’s in their interest to deliberately go and attack one of our satellites. People come up with scenarios on a regular basis, but when you push very hard and say, “Well, why would they do that in the first place, what would they think they would gain by it, why would they think

that whatever they gain in the short-term would be worth the long-term bad consequences, etc.,” the scenarios get harder and harder to sustain.

But, I think that there is a lot of room for people to feel insecure because of both the uncoordinated activity and the posturing that goes on.

Gilmour Space Technologies

Adam Gilmour
Chief Executive Officer

James Gilmour
Director

13 July 2017

WRITTEN RESPONSE

I think security can be addressed with investments that don't have to be substantial, that's what new space is all about.

Mike Gold

Vice President of Washington Operations and Business Development
(Space Systems Loral)
4 September 2017

WRITTEN RESPONSE

Additional investment and commitments by both government and commercial interests is a vital means of bolstering space security and preventing kinetic military actions.

A key example of this are the public-private partnerships in support of satellite servicing. Satellite hardware is usually very reliable and more often than not geosynchronous satellites are taken out of service due to a lack of fuel for maneuvering. Via public-private partnerships such as DARPA's Robotic Servicing of Geosynchronous Satellites ("RSGS") program, and NASA's Restore-L mission, robotic servicing vehicles will be able to refuel satellites, extending their operational lifetime and greatly enhancing a satellite's ability to maneuver and support evolving mission parameters. Moreover, a robotic servicing vehicle will be capable of actually repairing a satellite that has been damaged due to an attack, a debris strike, or mechanical failure. The ability to repair a broken satellite will help to deter kinetic action by reducing the potential efficacy of a physical attack. Robotic servicers will also be able to add or replace components on a satellite.

In addition to satellite servicing systems, smallsats and cubesats also have a critical role to play by providing a disaggregated array of spacecraft that can be leveraged during both peacetime and during periods of conflict. Specifically, after an attack, smallsats could be deployed from space stations or other forms of orbiting depots to compensate for any lost capabilities.

Although the private sector has interests in satellite servicing systems and smallsats/cubesats, substantial support from the U.S. Government is still required to bring these technologies to fruition in an expeditious fashion that supports both national security and commercial needs. In the case of satellite servicing, DARPA is taking such

action via an innovative public-private partnership. While there is certainly a potential commercial market for satellite servicing, it remains unproven, and government support for sophisticated capabilities such as robotic repair and the addition and/or replacement of components, remains necessary. Similarly, in low Earth orbit where, in stark contrast to GEO, there is a dearth of commercial satellites large enough to require servicing, the government has an important role to play in creating and demonstrating satellite servicing capabilities, and is currently doing so via NASA's Restore-L mission. Beyond RSGS and Restore-L, the U.S. Government should sponsor additional programs and public-private partnerships to generate and enhance domestic expertise in satellite servicing. The U.S. cannot afford to fall behind in satellite servicing technology and the best path forward is to increase the amount of public and private sector investments for such activities.

The U.S. Government should also support continued innovation in smallsats and cubesats. Since the ability to manufacture smallsats/cubesats is already relatively mature, the government can bolster their national security relevance by purchasing services, and leveraging such systems in innovative ways. For example, as described previously, smallsats could be stored in orbital space stations or depots, and then released after an attack to replace lost capabilities.

If the U.S. Government and American private sector increases its investments in and commitment to space security, it will substantially lower the potential for kinetic military action. Again, by utilizing satellite servicing systems to repair, refuel, and replace components on satellites, and constellations of smallsats/cubesats to bolster lost capabilities, the impact of and need for kinetic military action will be dramatically reduced.

Harris Corporation, LLC

Brigadier General (USAF ret.) Thomas F. Gould

Vice President, Business Development, Air Force Programs

Colonel (USAF ret.) Jennifer L. Moore

Senior Manager, Strategy and Business Development, Space Superiority

Gil Klinger

Vice President; Senior Executive Account Manager for National Security Future Architectures

21 August 2017

INTERVIEW TRANSCRIPT EXCERPT

J. Moore: When you ask the question, the first thing that came to my mind is those that have the greatest strategic risk beyond the United States would be our allies, who are as dependent on our state's capabilities as we are. And also consider our extensive joint war-fighting capabilities. Maybe that's part of our deterrent policy or our strategy deterrent and some more we can get... the more we get our allies and our friends cooperating with us and dependent on space capabilities that we all share, the less likely an adversary will be on that larger international community versus just in United States.

WRITTEN RESPONSE

Certainly, commitments to field more resilient space capabilities, build military/commercial partnerships, and encourage more international teaming would complicate an adversary's decision-making. However, the core of any strategy must be tied to our ability to sense the environment (space situational awareness, including an ability to identify and attribute attacks) in accordance with COCOM requirements and our ability to carry out credible offensive and defensive space operations should attacks occur against U.S. space capabilities.

Key foundational elements to any deterrence strategy is to make an attack by an adversary cost prohibitive, ineffectual, and put their own space capabilities at risk. Any attack should be expensive economically, relative to the effect being achieved, or politically unpalatable, based on collateral damage incurred. In addition, it should be clear to the adversary that we have the ability to fight thru any attack with a graceful degradation to our space capabilities, versus complete failure. This could be achieved by utilizing other platforms, partners or domains to pick up the slack...or other capabilities to rapidly replenish critical space services. U.S. declaratory policies and capabilities also should clearly demonstrate that the US possesses the will and means to deny any adversary's use of space.

Dr. Henry Hertzfeld

Research Professor of Space Policy and International Affairs
(George Washington University)
17 July 2017

INTERVIEW TRANSCRIPT EXCERPT

- Interviewer:** Does substantial investment and heavier commitment by both governments and commercial interests provide an avenue of approach for space 'security' and disincentive for kinetic military action?
- H. Hertzfeld:** What type of connection are you looking for here? I mean, everything...space is expensive, period. It's not getting cheaper because any technology as you move on gets more complex, and things get more expensive. It's not a question so much of how substantial an investment as it is...that is sort of a given. We're talking about ways of change and priorities of how it's invested. It's like how just spending money is not an incentive for war fighting or warfare. It could be an incentive for preventing it just as much.
- Interviewer:** So, would an order of magnitude higher, a NASA budget, for instance, this wouldn't be a viable strategy for increasing space security in terms of industry?
- H. Hertzfeld:** Yes. Again, spend more money, people will come, jobs will get formed. In some ways, but in other ways, are you spending it wisely? It's how you spend it as much as it is more spending. More spending can be just replicating what we have as opposed to doing R&D and going forward. It's a question I can't really wrap my arms around because it's too general and too vague.
- Interviewer:** Okay, I understand. So, how should we be spending the money? If that makes sense. In other words, how should we be allocating resources in the public domain to increase space security and disincentivize kinetic military action?
- H. Hertzfeld:** Again, there are many ways, I haven't thought this through, truthfully, but clearly, in most cases, the best offense is probably a defense, and that is making sure that you are aggressive enough in your R&D that nobody can technically match what you're doing. We've been there in space. We pretty much still are, but of course as we move along, other nations are spending a lot of money and catching up to us in some ways. We're not the leader in everything even though we are, I think, generally the leader in space. You want to make sure that you're ahead of the game. In terms of how much money that costs, I have no idea because there are so many different things that are involved in space from better ground equipment to better satellites. On the other hand, the other side of the security also involves knowing everything that is going on up there too,

what is a weapon or if it's more of a knowledge-based research space asset. Then, there's diplomacy involved., That's important. It's not just metal, machines, and their hardware. It's software, it's diplomatic relations, and it's a whole host of effects.

Theresa Hitchens

Senior Research Scholar (Center for International and Security Studies at Maryland)

19 July 2017

WRITTEN RESPONSE

Yes. The more actors involved, the more “buy in” to concerns about space safety, sustainability and security. This is important in thinking about security as more than just “national security” or “security of military systems.” As more nations become invested in space, they have fewer incentives to harm the space environment through kinetic operations that create debris, for example. They also have more incentives to be willing to abide by “rules of the road” that guarantee free and safe access for all actors. There are possibilities for restraining behavior in space based on “rules” (whether voluntary or legal) breakage of which could result in some sort of sanctioning activity, such as trade restrictions. This is a little explored area, sadly, that could result in some big payoffs in security if developed.

Dr. Moriba Jah

Associate Professor, Department of Aerospace Engineering and Engineering Mechanics
(University of Texas at Austin)

3 October 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: How do commercial ventures think about the security of their space assets or in peacetime, crisis, and conflict? Do industry leaders think about warfare in or through space differently than military leaders do?

M. Jah: By and large military leaders tend to think of this as problems that they have to deal with. They view things like “threat” and “conflict” as being very defense-centric, and think that commercial operators don't necessarily have these same kinds of concern. However, after speaking to quite a few commercial operators, I beg to differ. Moreover, right now, given that there's a growing number of actors in space, I'd say that commercial operators, more so than ever, are worried about people affecting their bottom lines, tampering with their systems, space piracy, etc.—not necessarily somebody taking over their satellite, although that is probably one concern, but more of somebody interfering with their space services and capabilities, because they have a profit to make and customers and stakeholders to report to.

In general, the commercial community is very intolerant to anything that's less than perfection. If their customers are watching TV and all of a sudden the signal starts degrading once an hour, then these customers might start thinking about changing to another provider. People in the commercial sector are worried about these kinds of things.

[...]

Interviewer: Okay. That's interesting. We haven't heard too much about the idea of commercial entities self-regulating themselves. But to transition to the next question, and you have touched upon this a little bit, does substantial investment and heavier commitment by both governments and commercial interests provide an avenue of approach for space security and disincentive for kinetic military action?

M. Jah: I think so. The thing that disincentivizes any sort of military action is transparency, and I think that's where the space community wants to go. Right now, only a few countries monitor stuff and the data aren't shared, so a lot of the times you run in to a "he said, she said" kind of situation.

I think a good example is what happened with the AMC-9 satellite. What happened was ExoAnalytic posted a video online in which they were tracking AMC-9. The video seems to show—let me underscore "seems to show"—what appears to be pieces separating from the satellite. ExoAnalytic said that there was some sort of explosion or a collision or something like that, which resulted in what appeared in the video; however, the AMC-9 operators claimed that they remained in full control of the satellite and that there were no indications that anything anomalous happened. Because data isn't appropriately shared and there isn't full transparency or ubiquity, these types of situations basically become a "he said, she said" situation. Even though ExoAnalytic might have video evidence, the AMC-9 operators say, "Well, who cares about the video. That's just one piece of data. There could have been clouds or other things that influenced the video. We didn't collect the data. Who verified and validated that that's actually true? Somebody could have doctored this stuff up."

So, as long as there's uncertainty, ambiguity, and a lack of transparency, it's an environment that's rife for some sort of military action. However, if data is shared more ubiquitously (i.e., creating a global system of globally-shared data that can be accessed throughout the globe) and things become more transparent, then I think that military conflict behavior in space will be disincentivized.

Interviewer: So, is the idea that as more actors get more infrastructure in space they'll be less likely to be aggressive because of that investment? Or, is the idea that as more actors have more infrastructure in space there will be better monitoring and awareness of activity and potential aggression, which will help decrease the likelihood of unintended conflictual action? Or, is it a little bit of both of those?

M. Jah: I'd go more towards the latter.

Interviewer: Okay. So, let's jump to one of our other questions. What are the national security implications of increasingly accessible and affordable commercial launch services?

M. Jah: Well, I think in terms of getting things on orbit and that sort of stuff, in times past, government actors had very specific kind of providers and launch opportunities, whereas now, with cheaper access to space and more launch providers, governments can take multiple rides and have many choices. To me, this serves as part of the confusion factor. And, to me, it seems risky to have very expensive systems that go on very predictable rides. If the governments blends more with the commercial, not just in the US but worldwide, to me, that helps reduce risk and actually raises resiliency because adversaries have a larger calculus to compute in order to affect government space activities.

Interviewer: Is there a specific space sector or space activity where you think the government commercial partnership is most well-suited to work together in the interest of space national security interests from the US perspective?

M. Jah: Yeah. I mean, right now the partnership that the government has with Planet for intelligence, surveillance, and reconnaissance is an example of a great partnership that serves national security needs. If the government also leveraged commercial entities to do space situational awareness, instead of just looking down but also looking sideways and up, then I think that would be a huge capability in terms of national security. Also, resilient communications and position, navigation, and timing kinds of services present an excellent opportunity—instead of just relying on GPS and these other global navigation satellite systems and some of their traditional communications like MILSATCOM, etc., if they worked with commercial entities launching some of these communications satellites, commercial services, and global Internet types of things, then I think the government could definitely be well served in terms of its national security interests, and this presents a great opportunity for a very nice partnership with industry.

Dr. John Karpiscak III

Physical Scientist (United States Army Geospatial Center)
2 October 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: Does substantial investment and heavier commitment by both governments and commercial interests provide an avenue of approach for space security and disincentive for kinetic military action?

J. Karpiscak III: That's a very good question. If we're talking about a disincentive for kinetic military action on the part of an adversary, then the answer is perhaps. But as you know, that depends on the nature of the enemy and the threat they pose. So, I guess what I need is a bit more of a definition and a bit more clarification on what you are getting at here with the term "disincentive."

Interviewer: For the kinetic military action, is that what you meant?

J. Karpiscak III: Yes, I'm wondering if we are talking about a disincentive for kinetic military action on our part or on the part of an adversary?

Interviewer: I believe the question is focused on the potential for providing a disincentive for kinetic military action on the part of the adversary.

J. Karpiscak III: Okay. So, again, that will depend on the nature of the threat. If we're talking about a classical Warsaw Pact type of thing, then perhaps yes. If we're talking about something a bit more up-to-date with regards to terrorist or asymmetrical activity, then perhaps not. Ultimately, it depends on the size of the force and what it is they propose to do, because today you don't really need much to create quite a threat. We hear a lot of talk about one EMP burst over the center of United States or cyber attacks and so forth. Very little of that would be detectable via space assets in one sort or another. Then it also depends on whether or not this potential threat has very much to lose (i.e., are they living in seclusion, are they some kind of fringe group that really doesn't have its head in reality). It's difficult to really say, but if we're talking about this from a classical nation-on-nation type of situation, then I'd say yes almost to the point where, "Why bother?"—we see what they're going to do and perhaps we can intervene before things get out of hand.

Group Captain (Indian Air Force ret.) Ajey Lele¹⁶

Senior Fellow (Institute for Defense Studies and Analyses)

9 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: Does substantial investment and heavier commitment by both government and commercial interests provide an avenue of approach for space security and disincentive for kinetic military action?

A. Lele: As far as investments by the state actors, there are a lot of emerging players who are also now making a significant amount of investments. I think these types of investments, and other kinds of investments that are directly related to space, will definitely put pressure on the nation-states to ensure that the space security maintains.

To just give a broad example, I think the best example in current time could be Russia and United States of America. There are currently sanctions on Russia because of its actions regarding the recent US election and its earlier actions in Crimea. But, the point I'm trying to make is that in spite of having those sanctions and other issues, neither side has brought those issues to the level of space, which is very praiseworthy. There is a business as usual between Russia and NASA. Otherwise, what would happen if this were not the case, is that investments in space would be at jeopardy if major countries like US and Russia started fighting with each other.

So, from that point of view, I think this particular incident between the US and Russia should be seen as an eye-opener and lesson for everybody—you may have problems and challenges on the surface of the Earth, but you shouldn't let those challenges spill into outer space because of 3 primary reasons. The first reason is the nature of investments. The investments are so big, so you just cannot afford to do that. The second reason is that if security is not maintained, then everybody's assets are going to be under threat. I think that is a major issue because space debris is very easy to create, and you just don't know what debris will affect what satellite systems. The third reason, and the most important reason in my opinion, is that we are so dependent on space today for our day-to-day survival and for most of the activities which we are doing—both at the nation-state and individual level, we are heavily dependent on space.

So, people have seemed to understand that you may get into a certain amount of issues on the Earth—there could be differences, there could be sanctions, there could even be some sort of skirmishes or military interventions or wars—but those sorts of interventions should not spread in to space. I will go the extent of saying that if one of these types of on-Earth issues were to spread in to space, and if the things quickly were to get out of hand, then the survival of a mankind would be at stake. And I think that is what Russians and Americans have understood—in spite of having challenges on the Earth, the relationship between NASA and Russia has been business as usual.

Interviewer: Okay. So, there are clearly more and more actors, both government actors and non-governmental actors, getting involved in space, and technology also continues to develop so that more and more actors can have access to it.

¹⁶ The responses here represent the sole views of Lele, and are not intended to represent the position of the Indian Air Force, Indian Space Research Organization, or Government of India.

A. Lele: Right now, if you consider this pattern that is emerging, I think there is a significant amount of hand-holding by the government because commercial actors are, particularly in the part of the world in which I belong to, are just making entry into the market. Even if you look at the commercial space actors that have been around for the last couple of decades, they also have been significantly dependent on government funding. Even with the giant commercial organizations like Lockheed Martin and Boeing, there is still a good amount of government hand-holding that is being done by NASA. A newer company like SpaceX may be saying that it is not interested in having large amounts of government funding, but there are still a good amount of projects in which they will be working with NASA.

So, with respect to investments in space, I think the major actors are still the state actors, even though there are more and more commercial actors getting involved. So, from that point of view, both state and commercial actors understand that maintaining security in space is very important.

Interviewer: Okay. Great. So, I have just one last general question that we always conclude these interviews with. Is there anything that I haven't asked you that I should have, or is there any final point that you would like to conclude with?

A. Lele: I think there has to be a certain amount of global acceptance for the space security architecture, and, from that point of view, one has to look at issues like SSA. I think there's an opportunity and need for countries like the US and India and a few other like-minded players to join hands together and cooperate on this because managing future space security will be quite difficult if you don't have good SSA available to you. So, ultimately, I think it is important to look at all cooperative and collaborative mechanisms for the space domain.

Massimo Pellegrino

Space and Security Policy Advisor

31 August 2017

WRITTEN RESPONSE

Several avenues can be pursued in order to ensure space security. While technical activities (e.g. the development of Space Situational Awareness capabilities), diplomatic initiatives at both the bilateral and multilateral level (e.g. PPWT, NFP, ICoC, GGE on TCBMs), and doctrinal aspects (e.g. space deterrence) are some of the options that can be taken into account in order to enhance the security and stability of outer space, the emergence of commercial actors and growing investments by both established and aspiring space nations offer an additional avenue for space security.

While actions by states suggest that a certain order in space will not be easily rationalized soon, commercial operators have come to understand that outer space is a domain in which the actions of few affect (the interest of) many. Intensification of private sector exploitation of space, including for tasks traditionally done by governments (e.g. military intelligence), can contribute to stability and predictability, as commercial actors themselves require (and necessitate) that outer space be safe, sustainable, secure, stable and predictable over the long run. In this regard, "new space" actors can be seen as a boost for space security and stability. While space will most likely continue to be exploited for military purposes, there might be increased emphasis on stability and predictability. More specifically, the proliferation of space debris, increased crowding of strategic earth orbits, competition for orbital slots, increased demand for and saturation of the radio-frequency spectrum resulting from this intensification of both commercial and governmental space activities could increase incentives

for regulatory measures and push commercial actors themselves to have a leading role in establishing specific forms of regulation, for which different options can be concluded and agreed upon.

Should these trends continue, one could argue that¹⁷:

1. low cost access to space – a reality by now – may increase congestion of strategic orbits as well as competition for frequency assignments and orbital slots to the point that this would not increase incentives for regulatory measures, but could rather become a source of instability or even conflict. In this scenario, it would be difficult, but not impossible, to see how such (hypothetical) conflicts could be resolved, especially because they may involve exclusively commercial actors;
2. a nation wishing to destabilize the (future) *status quo* in space might play on the role that private actors will likely have by disrupting commercial satellites, which may still have less effective means of protection;
3. but the opposite (to the point 2) may also be true; should commercial companies grow and become so important, they can provide a stabilizing influence on the policies and doctrines of potential space adversaries.

In sum, commercial companies have pushed forward with a more regulated and transparent space environment. While transparency in space does not directly ensure space security, it can be an aid to the maintenance of norms and disincentive for kinetic military action. The problem for space security is then twofold: on the one hand, commercial actors can provide an avenue for space security. On the other hand, commercial actors could ignite new hostilities in orbit and bring additional instability, not to mention that they could offer adversaries weaknesses to be exploited, as commercial systems (including those which are likely to become part of the national security infrastructure) are not as much hardened against attack as governmental and military satellites.

Dr. Luca Rossetini

CEO & Founder (D-Orbit)
16 August 2017

WRITTEN RESPONSE

I believe a joint commercial-government approach is mandatory for ensuring space security hence US and other nations security on ground. A common misunderstanding is considering space as a different and “far away” location: space is no more than another element or environment in which human are doing their activities, either in business, research, security, safety, entertainment. We started thousands of years ago “using” land, then water, eventually air. Now we started “using space”.

1. Clear regulations depicting what cannot be done in space. This is a pretty common approach in any other industrial and non-industrial sector on earth; why not in space? For example, driving rules are pretty much standard all over the planet and cover speed limits, yield rights, emergency situations. Similar space regulations should be put in place. We do not need to start from scratch – several attempts have been made already – however, legally binding rules and stronger enforcement is needed. The Outer Space Treaty¹⁸ has been ratified by more than 100 nations and is a good start. Other rules have been issued at the national level. Still, the majority of space missions request and receive waivers to existing guidelines... and governments grant waivers. New regulations should clarify aspects now under discussion in the scientific community under the rubric “space traffic control”, covering aspects such as littering

¹⁷ See Harrison, R., ‘The Role of Space in Deterrence’ in Kai-Uwe Schrogl et al. (eds.), Handbook of Space Security, New York: Springer-Verlag, 2015.

¹⁸ Formally the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies.

(space debris), end-of-life decommissioning of space asset, emergency situations, rights to use orbits, safety and security restrictions, etc. For example, in my field of expertise, a clear commitment to keep space as a viable environment is mandatory. Today, the situation in space is already critical¹⁹ and we need to act now to avoid catastrophic losses of our space asset in the near future. A common misunderstanding persists that the total average space debris density in the entire space volume is non-critical. However, this analytical model and approach is contradicted by recent studies presented at the University of Maryland's Center for Orbital Debris Education and Remediation conference in Washington in Nov. 2016. In sum, studies and experts emphasize the fact we do not use the entirety of space around the earth, but are confined to specific orbits, and the collision probability in those restricted areas is already critical. A malicious intent to create one or two more collisions in an already debris-dense orbital area could start the collision chain reaction I mentioned before. An immediate analogy with highways and cars is straightforward: the US has a vast area, but we drive only on a very limited area, roads. In space we are acting like: my car stopped working, I leave it in the third lane and walk away. The car behind me runs out of fuel, the driver stops the car in the second lane and walks away. And so on. Very soon the chance of accidents skyrockets and congestion by cars will make that particular highway unusable. Every satellite at the end of its mission should be properly disposed of via an independent propulsion system: independent in such a way that the satellite can be removed even if it is not functioning. Satellites in LEO orbits should be removed in the least possible time: permitting junk satellites to remain in orbit generates a dangerous situation and requires costly monitoring – today paid by the US Airforce – and, incidentally, may constitute the perfect situation to hide dormant weapons to activated by an enemy when needed. A clear space is easier to keep under control. Furthermore, high-value military space assets should be equipped with special fast collision avoidance systems, able to react independent of the satellite, to keep its functionalities even in case of hacker or kinetic attack. These regulations and space traffic management frameworks have to be agreed at international level and we need a leader promoting such actions. US has been, historically, a strong motivator and first mover. I am expecting US will lead this change strongly required for our national and global security.

2. Commercial entities have to be invited to the round table: we want to have them on our side while proposing actions that, at first sight, may appear to restrict their operating freedom. They have to be educated showing the benefit emerging from a clear rules framework. Also, some of the companies involved – like for example D-Orbit – may have good pieces of innovative technology that can help match their objectives.
3. Once a general set of rules with governments and commercial entities is agreed, a clear and fast technology development path should be implemented. Starting from technology that is ready and just needs to be adapted, while in parallel investments have to be made into future technologies.
4. Control, reward, and punishment actions should be put in place; “demonstrating before launch my satellite is not harming anyone” is not enough. A regular check on a yearly basis should be made by space asset operators to assess the status of their asset. Once the satellite is not performing over a minimum functionality range – for example cannot guarantee a minimum 90% decommissioning success rate – it should be disposed of immediately. Again, this is quite a common practice with cars: they have to be checked and if the car is polluting too much or posing a risk to society it is forbidden to be used anymore. Littering tax or waste tax should be imposed: why should the US Air Force spend money to monitor satellites' waste resulting from bad commercial operator behavior? The more a satellite remains in orbit as a hazard, the more the operators should be taxed. This will stimulate quick removal of non-functioning or dangerous satellites. We should remember that the fewer “inactive” objects there are in space, the higher the chance to guarantee a minimum level of security for ground assets and people.

¹⁹ This is an impressive video recorded by ESA: http://www.esa.int/spaceinvideos/Videos/2017/04/Space_debris_2017_-_a_journey_to_Earth

5. Although this roadmap may strongly decrease the need of kinetic military actions in space, we want to make sure to be ready if needed. Special “police cars” in space should be maintained in order to monitor and quickly intervene in case of malicious actions, going after, docking and removing the menace. This can be done via “active debris removal” technologies and rented as a service from commercial companies planning to offer satellite servicing and active debris removal to other satellite operators.

Brent Sherwood

Program Manager (NASA Jet Propulsion Lab, Solar System Mission Formulation)

13 July 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: Does substantial investment and heavier commitment by both governments and commercial interests provide an avenue of approach for space security and disincentive for kinetic military action?

B. Sherwood: I need to ask you first, I’ve not seen the term “kinetic military action” before. So, I’m not sure what that means, so can you define this a bit for me?

Interviewer: I think by “kinetic military action” we are thinking about some of the traditional types of on-the-ground military versus military actions and conflicts possibly being applied to or taking place in the space domain. More specifically, thinking about the types of direct military actions that could be taken against an adversary within the space domain. For example, some things that come to mind might include missile or laser strikes on space infrastructure, or other types of aggressive physical military actions along these lines in space.

B. Sherwood: Well, because I’m not a military guy, I guess I could think of this as something that's tangible and offensive. Is that correct?

Interviewer: Sure.

B. Sherwood: Then the question basically is, does the increasing investment by both governments and commercial interests provide a disincentive for military action? Well, the answer to that is obviously yes, because nobody wants to be aggressed upon. However, I don't know what it means to say an avenue of approach for space security. What does “avenue of approach” mean?

Interviewer: Well, how would you define “space security?” Do you consider space to be secure currently?

B. Sherwood: No. Again, so let me dissociate a couple of domains. For what I do in planetary science, space is essentially secure by default, because the barrier to entry to doing planetary missions is so high. So, I give zero thought to somebody interfering with my planetary mission.

If I back up a half-step to something that is closer to Earth, for human spaceflight missions—depending on the nature of the mission—again, the barrier to entry is extremely high, so I don't worry about that in deep space.

For any asset in Earth orbit, which I guess would include geo, but certainly in low Earth orbits, you have to worry about something like somebody launching a bucket of nails in a retrograde orbit, right? So, in that sense, space is not secure. Everything up there is vulnerable. So, is it secure? No, and I would say that the barriers to entry for what you guys are calling kinetic

military action are lowering as more people get access to ballistic missile technology. I mean, that's the problem with 7 kilometers per second, right? You don't even have to have very much of a sophisticated interceptor because you've got all that kinetic energy working for you. So, you could cause somebody a bad day if you can get yourself into an offensive orbit.

Interviewer: Okay. So, you mentioned that barriers to entry are decreasing and technology is rapidly advancing, which is giving more people access to new areas of space. You'd think that this increases the likelihood of security threats in the lower orbital area, so what sort of things do you think could be done to maybe deter or help maybe minimize these threats that one would think have the potential to rapidly increase?

B. Sherwood: Yeah, so that's actually out of my area of expertise. I don't know how to solve that problem. If somebody has a big enough rocket with a payload that's just a bucket of nails, I don't know what you do. I guess you can identify it or track it in boost phase and then shoot it down, but I don't know what you do. This is a problem that I have seen mentioned in the literature, but people don't seem to dwell on it very much maybe because there is no obvious answer. I don't know though, so I don't really have anything of value to add to this question.

Interviewer: Okay. So, stepping back a little bit, part of the question talks about substantial investments and heavier commitment. I'm just sort of wondering, when you look at the terminology "substantial investment" and "heavier commitment" what would personally consider substantial investment and heavier commitment in space? For example, in your opinion is the US, both in terms of the government and commercial sectors, substantially investing in the space realm? Are there other countries that you might consider to be substantially investing in the space realm as well?

B. Sherwood: Well, again, I would partition it by domains. I would say that the visible expenses and openly funded stuff is in the human spaceflight domain, which accounts for nations participating in the international space station project. So, nations participating in the international space station project is an example of heavy investment that is clearly visible, and also vulnerable to the types of threats we were talking about. Yeah, so these countries are invested and committed.

I don't know the specific numbers, but it seems to me that the total investment that's in space now is far, far higher than what for example NASA has spent. The other domains are defense, which I know nothing about, and commercial. There are a whole lot of telecom operators who own assets in geo, for example. These telecom operators are heavily invested. There are transnational companies and there is a lot of collective investment, and through these transnational companies in particular, society is heavily invested in space in ways that people don't even think about. You know, we can turn on the weather channel and we can use our cell phones for GPS—everybody depends on space today, all of the technological societies depend on space. So, therefore, by definition, they are heavily invested in space.

Interviewer: The question also mentions "heavier commitment." So, beyond what we are currently doing in space, what types of things would you consider to be significantly heavier commitment in space? What types of activities and investments would you consider as being classified as heavier commitment?

B. Sherwood: Okay, so again my expertise is pretty limited here. But, the House markup of the NASA budget right now somewhere around \$19.8 billion. So, if you just assume that the NASA budget on an annual basis is about \$20 billion, it might go up or down a little but it isn't going to double or isn't going to get cut in half. So, I don't foresee a dramatic increase in the commitment or investment on the part of civil space by the US government (i.e., through NASA).

I can't speak at all to the potential for increased investment by the military or by reconnaissance agencies because it's not my field.

The new domain, it seems to me, is commercial. Again, the telecom market is what it is—it may be growing, I don't even know because I don't track the numbers, but it's probably pretty predictable. But, the new domain is really the human spaceflight market on the commercial side, which is still in the very early stages—no one is flying paying passengers yet, but eventually they will and when that becomes more routine, then I would imagine the growth of what I call a “destination systems market” (i.e., people building privately developed space stations on which governments may be tenants or users but are not the owners). This creates a situation where you have private capital committed to large infrastructure in these vulnerable orbits close to Earth. That's a new regime.

With respect to all of these kinds of future-oriented potential markets, it's almost always the case that it takes much longer to actually get going than people want to believe. So, you can't know ahead of time whether it's going to stay that way, or whether it's going to take off as a market. The analogy I use when I give talks about this is: back when airplanes crashed a lot and when air travel was new, it took things like the anchored tenancy of the mail delivery contract even for airplane manufacturers to be able to build next generation airplanes. But, once that happened, all kinds of other markets opened up (i.e., cargo delivery, passenger travel), and now we have commercial air travel). A century later, we've got 747s and other aircraft flying hundreds of people around constantly. Nobody really predicted that back in 1916. So, this same kind of thing could happen with passenger travel in low Earth orbits. It's just unknown.

Interviewer: You mentioned earlier that with respect to the planetary exploration sector, there are not really any perceived threats because the barrier to entry is so high and no one else is really operating in this domain.

B. Sherwood: Well, let me interject here. It's not that nobody is operating in the planetary exploration domain besides the US; there are multiple players in this domain. Europe, India, Russia, China, and Japan are all players in the planetary exploration domain, but the number of players in this domain is relatively small, and because of scientific exploration and the Outer Space Treaty, it's a collegial group. For example, nobody is going to land next to the Curiosity Rover on Mars and try to damage it. So, it's not just the US in this domain; but the focus of the domain is really about science so it's not the same type of environment as I think we consider lower Earth orbit to be.

Interviewer: Okay. So, if you were to look at the actors operating in the planetary exploration sector on a spectrum, you'd think that the US is pretty far ahead of everybody else, right?

B. Sherwood: Well, technologically the US is further ahead and does more missions than anybody else, so both of those things are factually true.

Interviewer: Okay. So, who are the other key actors in the planetary exploration and mission domain, and would they fall along this spectrum in comparison to the US?

B. Sherwood: So, there is the US, with NASA. There is Europe, which predominantly consists of the European Space Agency, although there are multiple national space agencies in Europe as well. As far as planetary missions, there is also Russia, although not so much anymore because Russia has encountered a number of failures and doesn't have as much as in the past to spend on these activities. There is also China, which has already been operating on the surface of the Moon. There are also India and Japan. Japan has done multiple deep space missions. India has already gotten an orbiter to Mars.

So, the next countries up will be South Korea, which is actually working on 2 lunar missions, and the United Arab Emirates, which has a Mars orbiter mission that's in development. Brazil also has a Space Agency and a Scientific Agency. Brazil has mostly been focused on space physics and heliophysics missions, and that is about the extent of what Brazil does here, which is not really planetary.

The countries that been to the moon, for example, include the US, Russia, Europe, Japan, China, and India. The countries that have been to Mars include the US, Russia (though Russia has never actually had a success at Mars), Europe, and India. The countries that have been to Venus are the US, Russia (which was actually the first to Venus), Europe, and Japan.

Interviewer: Okay. So, you mentioned that Russia is sort of dropping off because of some resource constraints and also some failures, but do you see a situation where maybe some of the bigger actors that you mentioned, like maybe China or India, start to sort of close the gap with the US in terms of planetary mission capabilities? And, if so, as this gap starts closing, could there be a situation where some points of conflict or aggression begin to arise between the US and say a more empowered China in the planetary missions and exploration domain?

B. Sherwood: Well, I think that's a stretch. I don't want to be naïve, but that's kind of a stretch.

I'll tell you what I think is maybe a more reasonable way to view threat in the planetary missions and exploration sector. It's not somebody going up to your spacecraft and compromising it. It's not somebody trying to interfere with your process to conduct a mission. What could happen though, for example, is an accidental damaging of the potential for scientific research. The case in point would be Mars or the ocean worlds of the outer solar system, like Europa or Enceladus. An apt analogy here is Lake Vostok in Antarctica. Lake Vostok is the largest subglacial lake, it's under a 4,000-year record of ice, and the water in it is thought to have been isolated from Earth's biosphere for between 5 and 20 million years. So, biologically, that's an extremely interesting and important place to do scientific research. Well, the Russians were the first to drill into it, and they penetrated it in 2012 and did some biological work in which one of the findings was an announcement of a new organisms that had never been seen before. But, there is a problem, which is also in the water that they sampled, that their sample was clearly contaminated with drilling fluids from the drilling operation. Because of this, Russia has taken multiple measures since then, but to this day there is a scientific argument about the validity of their results.

So, the analogy for Mars exploration, is what we call forward contamination—bringing something with you and then making a discovery, but you don't know if you've discovered something you brought with you or if you've discovered something that was actually there. So, the way that frames up as conflict is if somebody's urgency outstrips their care, and then by rushing in they compromise the ability for genuine science to be done. It's not intentionally meant to screw up the science of others; it's more meant to be a desire to get there first and in such a hurry that an actor is willing to take shortcuts that maybe make their science less valid. And in the case of forward contamination of Mars, if there are potential habitats in the deep subsurface for example, and we contaminate them with Earth life, then that has more consequences than just complicating scientific research, which is why forward contamination planetary protection is governed by treaty.

Interviewer: So, it sounds like some unintended consequences could arise?

B. Sherwood: Yeah, you could kind of put it in that category. It's certainly not the kind of typically thought of security threat. Normally, if you are thinking about a security threat, people think you mean somebody is taking some aggressive action on purpose, some kind of offensive action, but that's

not what this is. But, this is just the kind of threat that we think about in the scientific field (i.e., some damaging of future science, or some abrogation of an ethical commitment to not screw up an alien ecosystem, or those kinds of things).

Dr. Patrick A. Stadter

Program Area Manager - Assured Space Operations Programs
(Johns Hopkins University Applied Physics Laboratory)
9 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: So, we always conclude these interviews with a general question, which I will ask you as well. Is there anything that I haven't asked you that I should have, or is there any final point that you would like to conclude with?

P. Stadter: Sure. So, let me give you a couple more comments regarding some of your other questions real quick. One of your questions was, does substantial investment and heavier commitment by both governments and commercial interests provide an avenue of approach for space 'security' and disincentive for kinetic military? So, there is a very nice discussion to be had about deeply thinking about how to turn space into a commons (i.e., as per maritime commons, etc.), but each domain is distinctly different. The cyber and electromagnetic domains, these are evolving commons as well. Space is a commons, both technically, operationally, and from a policy perspective. That helps you a lot to potentially deal with some of those national security issues. And the space domain is different—it is probably closer to the electromagnetic and cyber domains as a commons. But this is just something to think about.

ViaSat, Inc.

Richard A. VanderMeulen
Vice President of Space and Satellite Broadband

Ken Peterman
President, Government Systems

Shannon O'Meara Smith
Executive Director of Strategic Initiatives

Fred Taylor
Vice President, Space and Cyber Applications

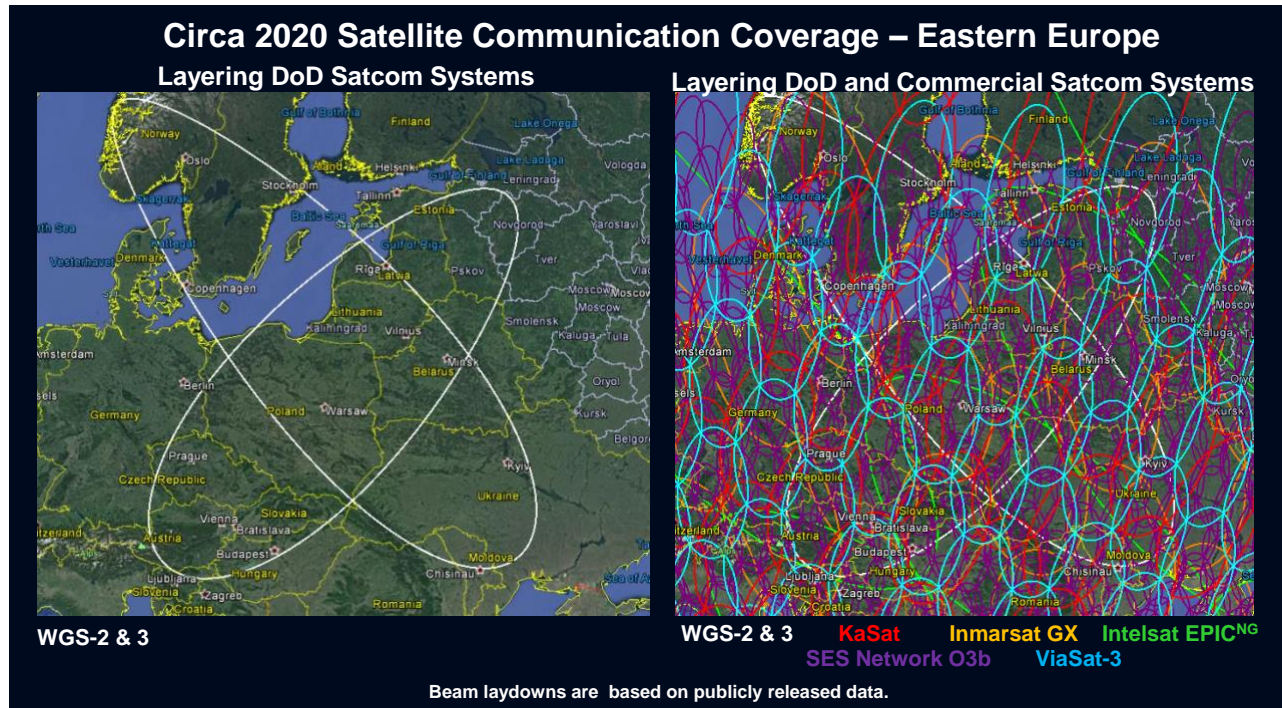
Bruce Cathell
Vice President of Government Operations

21 August 2017

WRITTEN RESPONSE

Yes, and the investment necessary for governments to leverage commercial space capabilities might not be that significant. In the first figure below, we show a potential method to serve government ground and air based forces in the eastern European theater. This is a simple use case applying spot beams from WGS flights 2 and 3 to a

potential area of deployment. In the second figure below, we add beams from commercial or private sector Satcom providers including Eutelsat’s KASAT, Inmarsat’s IOR GX, Intelsat’s 33e EPIC, SES Networks O3b constellation, and ViaSat’s forthcoming ViaSat-3B satellites. These commercial Satcom services serve commercial markets and as such are available for government use.



Government use of both government and commercial Satcom solutions provides an approach for space ‘security’ and disincentive for kinetic military response against the full layered enterprise of solutions serving primarily commercial markets. Space is becoming a growing international “business” domain.

In the first case, the investment is in the WGS compatible end-user terminals and the attack vectors potentially include the two WGS flights and associated ground segment. In the second case, the investment would be in the form of a multi-mode end-user terminals, service level agreements (SLAs) enabling pay- for-usage models and roaming, and the attack vectors potentially include over 20 satellites in multiple orbital regimes and multiple independent ground segments. Even more the increase in the potential for multi-path or network routing complicates or confuses targeting of the communication service. It could become very difficult to determine which service is being used at any given time.

We believe that the concept of layering military/government and private sector systems can create significant improvement in space ‘security’ and a disincentive for kinetic or even non-kinetic adversarial actions. The principles of this approach were outlined by the prior Deputy Assistant Secretary of Defense for Space, Douglas Loverro. He outlined an approach of using disaggregation, diversity, distribution, deception, protection, and proliferation or what he dubbed D4P2.

In this approach, investments would need to not just focus on the infrastructure but also on how the infrastructure is deployed or used. Specifically, the space networks or ecosystems, including SSA, EO, PNT, and Satcom, would need to consider how they could apply:

- Disaggregation – Separating the high value missions across multiple protected networks
- Diversity – Using multiple networks, frequencies, operators, and surrogate capabilities for SA, C2, PNT, BFT, etc.

- Distribution - Routing on dozens of government and hundreds of commercial networks creating essential no single point of failure
- Deception – Operating missions overtly, covertly, or even with wartime reserve modes across multiple networks
- Protection – Applying hardened and heterogeneous networks that are rapidly evolving to threats and market demands
- Proliferation – Spanning the missions on multiple government and commercial networks

This approach would strive to create a National Security Space construct that would deter attacks by demonstrating that an attack on space, or any of the domains that these ecosystems operate in, would not benefit the attacker.