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Commercial Space Actors: Disruptors or Solid Partners for National Security

A Virtual Think Tank (ViTTa)® Report

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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**

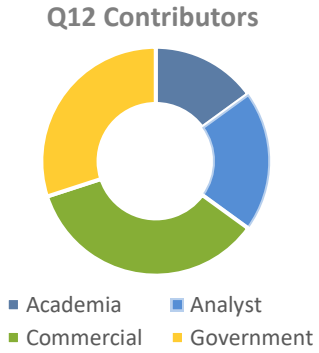
Cover Art: Orbital's Antares test flight: https://blogs.nasa.gov/bolden/2013/11/

Question of Focus

[Q12] Will major commercial space entities likely serve as disruptors or solid partners in terms of state national security interests? In the short-term (5-10 years), mid-term (15-20 years), and long-term (25+ years)?

Expert Contributors

Major General (USAF ret.) James B. Armor, Jr.[2] (Orbital ATK); **Marc Berkowitz** (Lockheed Martin); **Caelus Partners, LLC**; **Dr. Damon Coletta and Lieutenant Colonel (USAF ret.) Deron Jackson** (United States Air Force Academy); **Faulconer Consulting Group**; **Lieutenant Colonel Peter Garretson** (United States Air Force Air Command and Staff College); **Gilmour Space Technologies**, Australia; **Joshua Hampson** (Niskanen Center); **Harris Corporation**; **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); **Dr. George Nield** (Federal Aviation Administration); **Jim Norman** (NASA Headquarters); **Dr. Luca Rossettini** (D-Orbit, Italy.); **Dr. Patrick A. Stadter** (Johns Hopkins University Applied Physics Laboratory); **ViaSat, Inc.**; **Charity Weeden** (Satellite Industry Association, Canada); **Deborah Westphal** (Toffler Associates)



Summary Response

There was considerable variation in how the expert contributors interpreted this question, and in their assessments of the future relationship between commercial and government space enterprises. While the contributors who saw commercial entities as solid partners of the government were, with one exception, representatives of commercial space, respondents from think tank, commercial, and government communities tended to view commercial actors as potential disruptors (39%). However, the majority response among the expert contributors overall (44%) was that commercial entities might serve as *both* disruptors and partners.

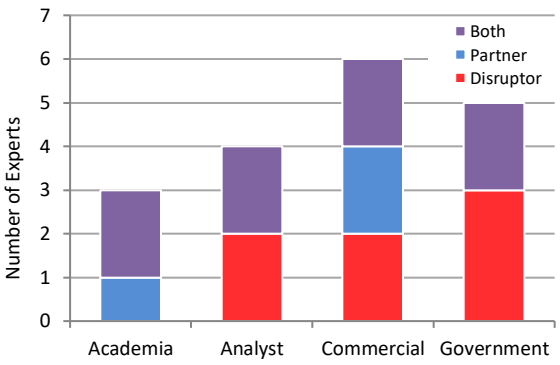


Figure 1: Distribution of contributors' overall assessment of potential for disruption and partnership

There are two lines of reasoning for this argument. First, based on the perspective that "disruptions" can have positive as well as negative consequences, some contributors saw disruptive actors as potentially valuable allies to government. Second, others argued that technologies or actions that may be disruptive in the short-term can evolve into ordinary or standard practices in the longer-term.[3] The contributors

[2] The subject matter expert's personal views, and not those of his organization, are represented in his contribution to this work.
[3] Berkowitz; Caelus Partners, LLC; Garretson; Hampson; Hitchens; Nield; and Rossettini.

also warn, however, that whether commercial space is ultimately a disruptor or a solid partner in space will in large part depend on how the United States government (USG) decides to respond.[4]

Furthermore, commercial actors' organizational advantages with respect to innovation make it likely that they will become the dominant actors in space in the medium- to long-term. The effect this will have on US national security interests will be largely determined by how the USG deals with these changes. There are significant potential security benefits to be gained by partnering with commercial actors. At the same time, encouraging the growth of the commercial space sector, and relying on its capabilities and services, reduces the USG's level of direct control. Regardless, the USG may not have much option—commercial space actors are here, and their relative capabilities are growing. If the USG attempts to limit or control commercial space actors to the point that they cannot meet their own objectives, there is nothing to prevent them from moving their endeavors to another country. This would effectively remove all but the most indirect or extreme forms of influence the USG has, and position commercial space actors to become a significant disruptor of US security interests.

Disruptors, Disruption, and Drivers

Contributors identified *disruptors* as actors whose behaviors and innovations trigger broad change in a system. In the context of this report's question of focus, a commercial disruptor is a company that significantly alters (for good or for bad) the ability of the US to achieve its national security space objectives. A *disruption* changes the nature of the relationship between the USG and commercial space actors. The potential for disruption is determined by the extent to which USG and commercial space are dependent on, or can determine, the activities of the other. Of course, the emergence of a commercial space sector is, in and of itself, a disruption to USG dominance in space activity and technology. The question is: to what effect?

The Impact of Private Capital

The nature of the relationship between the commercial sector and the US national security community is changing rapidly, and suggests that we may be on the cusp of a major disruption in the way US space has operated for the last 60 years. According to Dr. Moriba Jah of the University of Texas at Austin, the emergence of "angel investors and venture capitalists wanting to make huge profits" by investing in new commercial space activities has been a major driver of this change. Dr. Luca Rossettini of D-Orbit calls out "new space" start-ups, in particular, as potential disruptors as they both increase their capacities for rapid innovation and become less dependent on the USG for operating funds. It is interesting to note that this is happening at the same that the USG is increasingly looking to the commercial sector for services and innovation. As such, Joshua Hampson of the Niskanen Center believes that, 25+ years from now, the USG "may be more reliant on commercial providers for capabilities than those entities will be on the government for funding."

The availability of private capital to commercial space could spur additional disruptions in the space service provider-user relationship. Namely, if commercial entities rather than the USG are the ones developing and operating cutting-edge space capabilities, USG attempts to regulate the sale and transfer of those capabilities is likely to become both a more complex and more contentious issue than it is today. Simply put, the interests of commercial entities—in other words, their profitability-centric

[4] The recent release of the 2018 National Defense Strategy references the relationship between innovation and warfighting: "Success no longer goes to the country that develops a new technology first, but rather to the one that better integrates it and adapts its way of fighting."

business agendas—cannot be assumed to be in complete accord with the USG's national security objectives.

Table 1: Summary of Potential Areas of Disruption and Partnership by Contributor

Capability	Contributor Response: *When is the disruption likely to occur?* Now	5-10 years	15-20 years	25+ years
Commercial SSA	Westphal; Jah	Jackson; Karpiscak III		
Advanced maneuverability		Jackson		
Commercial remote sensing	Hitchens; Weeden; Garretson			
Satellites in large constellations	Hitchens; Nield			
Commercial space stations		Nield		
Availability of on-orbit servicing	Nield; Weeden		Nield	
		Weeden; Harris		
Space start-ups	Jah; Rossettini			
		Garretson; Jah		
Public access to high-resolution imagery		Coletta; Westphal		
		Harris		
Low cost access to space		Nield; Karpiscak III		
	Garretson			
Internet providers		Jah	Hitchens	
Resource extraction (including space mining)	Hitchens		Hitchens; Hampson	
				Garretson; Nield
Debris removal			Hitchens	
Communication satellites	Gilmour; Harris; Jah			
On-board quantum computing				Harris
PNT	Jah			

Solid Partner | Disruptor | Potential Partner

Regulation as Disruption

Several contributors comment on the impact of USG commercial regulations as a type of perennial disruptor,[5] which if lifted will increase innovativeness and growth in private space sector. The ViaSat, Inc. contributors note that while the USG has "directed" space innovation until recently, today more innovation is occurring in areas in which the government has had significantly less involvement (e.g., ground segments of space systems like ATMs, etc.). They make this point in reference to USG-controlled

[5] For a related discussion on the impact of regulation and other "hindrances" on commercial and government space sector relations, see the NSI Space ViTTa® Q9 report, "The Barriers to Successful Government-Commercial Relations".

GPS, arguing that, "since the start, the USG has gone through GPS-1 and now GPS-3. In a 35 [to] 40-year period, we've had three generations of space innovation. On the ground, we've had an infinite number of innovations." The contributors from ViaSat, Inc. do concede that some government direction is not a bad thing, but stress that there must be "a balance of the mix" between commercial requirements for profitability and USG concern with regulating access to high-tech capabilities.

Sources of Disruption in the Short-, Medium-, and Long-Term

In addition to discussing what might make an actor a potential disruptor, contributors emphasize the need to consider what is being disrupted, and how that disruption could affect US national security objectives. Table 1 above provides a summary of space-related capabilities in which disruption and/or private-government partnership is currently happening or expected to occur.

Short- to Medium-Term

Access to and Control of Information

Dr. John Karpiscak III of the United States Army Geospatial Center identifies information as one of the critical commodities that the US will struggle to control in the coming decades. Contributors highlight three particular struggles involving space: information ownership and control, data collection, and space situational awareness (SSA). Karpiscak III discusses the challenges with data ownership and management, in terms of the extent to which commercial space entities will maintain control over who accesses their data or whether they "can be coerced, manipulated, or incentivized [by the USG] to share data with friendlies and deny access to, say, gray or red forces." Several contributors[6] also identify advances in commercial information collection and processing, including remote sensing, as potential disruptors to current practices as they make what today may be considered classified information available in the public domain. Finally, Lieutenant Colonel (USAF ret.) Deron Jackson of the United States Air Force Academy notes that SSA capabilities operated and owned by private companies could transfer tracking of space objects from being done "largely by a government-heavy regime to being done by some regime that's now entirely private."

The contributors differ, however, in their assessments of the degree to which these developments will challenge or ease the ability of the US to achieve its national security objectives. Several contributors[7] see the improvements in commercial remote sensing as a potential solution to government needs. While Deborah Westphal of Toffler Associates and Karpiscak III acknowledge the potential benefit of this, they also raise concern about the loss of information control it implies. Finally, Dr. Damon Coletta of the United States Air Force Academy suggests that wider access to high-resolution imagery may "disrupt the safety of troops on the ground if suddenly a raft of competing state entities suddenly had access to levels of resolution that only the US government had beforehand."

Medium- to Long-Term

Infrastructure

In the medium- to long-term, contributors suggest that increases in the amount of infrastructure (both in space and on the ground) could serve as an additional source of disruption. Karpiscak III argues that developments in commercial launch capabilities could make it possible for nearly anyone to launch

[6] Coletta; Weeden; and Westphal.
[7] Weeden; Hitchens; and Jackson.

items into space, without necessarily having to gain "anyone's permission or consent." Inevitably, as more actors access space, the amount of infrastructure in space will increase as well (Hitchens; Nield). Increased infrastructure will in turn stimulate the development of space-based power and transportation for on-orbit servicing (Nield; Weeden), as well as increased maneuverability (Jackson). Finally, while expanded infrastructure in space is identified as a potential source of disruption, the implications for US national security are not always clear. This may be because many of the capabilities discussed by the contributors are dual-use technologies, which many of the contributors identify as posing challenges for national security.[8]

Long-Term

Harder to Tell

Perhaps not surprisingly, the contributors were less specific about potential sources of disruption beyond the next 25 years. Resource extraction and debris removal were the only specific capabilities mentioned in this timeframe (Hampson; Hitchens). As Karpiscak III points out: "If you look at rates of technological advance in a lot of the world economies and developments like cellphones and tablets, it's very difficult to predict a lot of this."[9]

Despite this uncertainty, many contributors expect time itself to have an effect on the potential for disruption. When considering the system change aspect of disruption,[10] most contributors believe that the sources and magnitude of disruptions will diminish over time as markets and commercial entities expand and mature. However, when focusing on the control aspect of disruption, Hampson sees the expansion of the commercial space sector as likely to increase disruption. He suggests that "a contemporary model exists in the computing/software industry today" where, although "companies cannot disregard US policy, [they] are large enough to…lobby against policies they disagree with and independent enough in funding to take their views to the public."

Building Solid Partnerships[11]

Table 1 above clearly demonstrates considerable variation in the contributors' evaluations of the potential for government-commercial partnerships across both time and specific capabilities. This variation relates closely to the idea that innovation is intrinsically linked to disruption. The USG benefits from the innovations produced by disruptors (Jah; Rossettini), yet the more successful these actors are, the less controllable they, and their capabilities, become.

Benefits of Collaboration

Strong partnerships and collaboration are built on mutual interest. A good percentage of USG objectives in space involve national security and defense, whereas for commercial actors a business and regulatory environment that allows profitability is critical (Hampson; Stadter). Looking further out into the future,

[8] For additional discussion on dual-use technologies, and the challenges they pose for national security, see the NSI Space ViTTa® Q2 report, "Ally, Adversary, and Partner Use of Space"; the NSI Space ViTTa® Q7 report, "Use of the Commercial Space Industry for Military Purposes by Non-Western States"; and the NSI Space ViTTa® Q11 report, "Leveraging Allied and Commercial Capabilities to Enhance Resilience".

[9] See also the contribution from Rossettini.

[10] See the contributions from Berkowitz; Caelus Partners, LLC; Garretson; Hitchens; Nield; and Rossettini.

[11] For more detailed discussion of the potential for collaboration between the USG and commercial space actors, see the NSI Space ViTTa® Q9 report, "The Barriers to Successful Government-Commercial Relations", and the NSI Space ViTTa® Q11 report, "Leveraging Allied and Commercial Capabilities to Enhance Resilience".

Marc Berkowitz of Lockheed Martin suggests that the near-term establishment of routine partnerships could help decrease the extent of disruption in the longer-term. Hampson predicts that, as the orbital environment becomes busier and riskier, commercial actors will be motivated to partner with the USG to reduce the risk of "being placed under burdensome restrictions by causing problems." Finally, Lieutenant Colonel Peter Garretson of the United States Air Force Air Command and Staff College posits that, as the value of economic activities such as space mining and the number of US citizens in space increase, "[t]here will be a very strong push for national security services to be extended toward US citizens and their property in space, and a push to make the independent space corps look more like the US Coast and US Navy, with a strong emphasis on safety of navigation for licit commerce."

Barriers to Collaboration

Several contributors[12] indicate that commercial actors want to partner with the USG, but that barriers to solid partnerships do exist. On the government side, contributors point to regulation and security concerns (Faulconer Consulting Group; Hitchens); organizational impediments (Garretson); and lack of outreach to, and communication with, the commercial sector (Weeden). The need for profitability, and the freedom to sell their technology (Armor; Stadter), are mentioned as disincentives for commercial actors to work with the USG. On top of this, the lines of communication between the USG and commercial space sector are weak, as is the understanding of the other's objectives and constraints (Garreston; Stadter).

Implications of Failure

If national security constraints impede the development of new technologies, as Theresa Hitchens of the Center for International and Security Studies at Maryland believes has already happened with remote sensing and SAR, innovative commercial actors may abandon the US. Dr. George Nield of the Federal Aviation Administration points out that this is something that "we ignore at our peril because, again, the capability is going to be out there in the rest of the world. If the US chooses not to take advantage of it, we're likely to be left behind," a view echoed by Jim Norman of NASA. Even if companies do not relocate out of the US, we should not forget Hampson's point that, over time, commercial space actors will likely become large enough to wield influence over policy and public opinion. Both of these outcomes would signal a loss of USG influence over some activities in the space domain.

The Verdict

Considering the contributors' responses as a whole, it appears that "disruption" is considered a necessary part of the development of space capabilities and activities. Commercial actors' organizational advantages with respect to innovation make it likely that they will become the dominant actors in space in the medium- to long-term. The effect this will have on US national security interests will be largely determined by how the USG deals with these changes. There are significant potential security benefits to be gained by partnering with commercial actors. At the same time, encouraging the growth of the commercial space sector, and relying on its capabilities and services, reduces the USG's level of direct control. Regardless, the USG may not have much option—commercial space actors are here, and their relative capabilities are growing. If the USG attempts to limit or control them to the point that they cannot meet their objectives, there is nothing to prevent them from moving their endeavors to another country. This would effectively remove all but the most indirect or extreme forms of influence the USG has, and position commercial space actors to become a significant disruptor of US security interests.

[12] Gilmour; Hampson; and Weeden.

Subject Matter Expert Contributions

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

Staff Vice President (Orbital ATK)
7 August 2017

WRITTEN RESPONSE

Commercial Space is no different and commercial air or commercial computers or commercial automobiles. They hopefully will be *both major disruptors and solid partners* of state national security.

In the long-term, commercial space will dominate. Like computers/IT industry – all started as government capabilities and now are virtually all commercial. Government R&D still pushes boundaries of capabilities, technology, science, but commercial dominates globally.

In the short-term, global commercial firms will tussle in the market to gain ascendancy/market share, including vs the USG. USG can help US space industry by incentivizing their global competitiveness. (tax, licensing, clarity of regulations/policy, purchasing of capabilities, transfer of technology, pressing forward with big science/manned missions, etc.)

Marc Berkowitz

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

WRITTEN RESPONSE

Yes, major commercial entities are likely to serve both as disruptors or partners on national security matters over each of the above time frames. Depending on the number, type, and success of partnerships established and routinely practiced, the extent of disruption could abate over the mid- and long-terms.

Caelus Partners, LLC

Jose Ocasio-Christian
Chief Executive Officer

24 August 2017

WRITTEN RESPONSE

Caelus Partners believes that the US government is at a critical point in addressing the space domain. If continuing on its current path, the US will likely lead the world in the space domain both from a nation-state interest and commercial competition perspective, but it may be at the cost of the rest of the planet perceiving us as adversaries. There is another option that Caelus Partners is leading in which the US can maintain a certain form of

[13] The responses here represent the sole views of Major General (USAF ret.) James Armor, and are not intended to represent the position of Orbital ATK.

leadership in the space domain, but as part of a greater community of commercial and nation-state partnerships. This option will not prevent conflict or reduce the need for security, but it may contain or minimize the amount of effort and expenditure of resources to sustain. The US has about 3-5 years to decide or the international community (nation-state, commercial, and 3rd party actors) may decide.

Dr. Damon Coletta and Lieutenant Colonel (USAF ret.) Deron Jackson

United States Air Force Academy

Damon Coletta
Professor of Political Science

Deron Jackson
Director, Eisenhower Center

8 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: So, you mentioned that competing interests could be a possible barrier to cooperation between the commercial space realm and government space realm, and I think that this ties nicely into the next question I was hoping to ask you. From your perspective, do you see major commercial space entities as likely serving as disruptors or solid partners, or maybe even both, in terms of state national security interests over the short-term (5-10 years), mid-term (15-20 years), and long-term (25+ years)?

D. Coletta: Well, that is a great question, but I think we are going to ask you to break this question down a little bit. This question also has another ambiguous term in it— "state national security interest." It may be one of those cases where a bit of ambiguity is necessary, but "state national security interest" is often used in different ways.

When you are talking about commercial entities being disruptors in space with respect to state national security interests, at some level the type of cooperation that we've been talking about is a state national security interest. But I suspect that you are thinking about something that is more narrowly defined, which is the safety of military satellites. Is that what you mean by "national security interest," the safety of these satellites?

Interviewer: Sure, let's think about "state national security interests" in space in the sense of US government assets and infrastructure that is up in space, as well as general US government space interests.

D. Coletta: Okay. So, could commercial entities be major disruptors to the safety of US government, especially military, space operations? Well, I don't personally see that happening. What do you think, Deron?

D. Jackson: Well, again thinking hypothetically here, for most of this space era, the security of assets has been dependent on not really knowing exactly when and where these assets are operating. A great disruption would be if private space satellites started developing their own positioning and situational awareness network, whereby they could identify with high fidelity anything that was in their area. This could then essentially result in the tracking of all space objects flipping from being done largely by a government-heavy regime to being done by some regime that's now entirely private. If this were to be approached over some period of years, it could create an almost perfect solution to tracking and identifying assets. However, that would be disruptive of the way things have been run over the first 50 years of the space era.

So, is that something that could be avoided if the US government wanted to avoid it? Or, is it just the natural direction of technology, and it is incumbent on people to figure out what to do when that day arrives? I guess the other disruptive element to this has to do with the response, which would naturally be to get more maneuverable, so you have to start planning for the day when greater maneuverability is something that is widely proliferated and spread amongst the commercial sector as well as a bunch of other actors. What kind of environment would you want to see then, and how would you want to try and keep tabs on it?

Overall, though, the removal of ambiguity as to 1) where and when things are in orbit, and 2) then the ability of maneuver, seem to be the two disruptive elements that will need to be contended with in the future.

D. Coletta: So, we're speculating here, but it sounds like if you are talking about the safety of space assets here, then those scenarios tend to push you into the longer-term.

Let me propose something that would be more medium-term or short-term focused. Though, to do that, I've got to change the definition of "state national security interest" from our space assets to the safety of our troops on the ground. So, let's imagine that foreign commercial space entities start to compete with American commercial space companies in terms of the level of resolution that they can have on their remote sensing satellites. My understanding is that American commercial space entities so far have cooperated with the government in terms of limiting what they provide with respect to high-resolution images. Foreign commercial entities might not be so cooperative, so you could imagine that this would disrupt the safety of troops on the ground if suddenly a raft of competing state entities suddenly had access to levels of resolution that only the US government had beforehand. Based on the unclassified rhetoric surrounding this, I would think that something like that can happen in the short- to medium-term.

Interviewer: So, it sounds like you think that the probability of disruption is probably increasing as we progress over time with more and more actors getting involved in this domain and having access to more and more evolved technologies in the domain. Is that a correct assessment?

D. Coletta: Also, when you ask this question, I think we must also consider what is being disrupted. Disrupting what? Are you talking about disrupting the satellites? Are you talking about the level of security for troops on the ground? When you ask, "is disruption likely in a certain timeframe," it really matters disruption of what.

Faulconer Consulting Group

Walt Faulconer
President

Mike Bowker
Associate

Mark Bitterman
Associate

Dan Dumbacher
Associate

15 August 2017

WRITTEN RESPONSE

Seems that this should be developed into the relationships, contractually, etc. Need to understand the motives and strategies of the respective companies engaged in the enterprise and implement appropriate relationships.

This depends solely on the government's approach to contracting and the requirements thereof. However it is folly for the government not to be able to control its launch vehicle capability for DoD missions. Does the government worry about procuring its nuclear triad capabilities from a “commercial” entity? To put the DoD in this posture is political nonsense.

- 5-10 years: This depends solely on the government's approach to contracting and the requirements thereof.
- 15-20 years: This depends solely on the government's approach to contracting and the requirements thereof.
- 25+ years: Unknown.

Lieutenant Colonel Peter Garretson

Lead, Space Horizons Research Group; Instructor of Joint Warfighting, Department of Research
(United States Air Force Air Command and Staff College)
10 August 2017

WRITTEN RESPONSE

Short-Term: The DoD will be unable to adapt and find business models to make use of extant capabilities, largely because it has not developed forward thinking requirements to make use of them. Already SpaceX is able to offer rapid turn around and low-cost launch on re-usable vehicles and the USAF cannot make use of it. Within 2 years there will be multiple launch companies that can provide launch-on-demand, but there is no formal JROC requirement for launch on demand. The ability to make use of the data analytic capabilities of remote sensing is already here, but we do not have people trained to make use of the data-analytics.

Mid-Term: These entities will evolve to be solid partners and an industry-first paradigm will begin to take over. The major partners will likely have seen significant change with older players being displaced. We are likely see initial introduction of commercial services for space-based video, space-based infrared, space-based SIGINT, on-orbit servicing, on-orbit refueling, manned & tele-operated on-orbit construction, purchase of time and space at private space stations, and possibly space-to-space power beaming.

Long-Term: Things will be completely different. In this time frame, we will be in the process of an expanding space economy that is no longer just about moving bits of data, but will include significant developing markets in material and energy. We will be seeing the first successful ventures of Lunar and Asteroid mining, of on-orbit propellant sales, of significant number of US citizens on orbit, and construction of prototype Space Solar Power satellites using on-orbit manufacturing from space-sourced materials. There will be a very strong push for national security services to be extended toward US citizens and their property in space, and a push to make the independent space corps look more like the US Coast and US Navy, with a strong emphasis on safety of navigation for licit commerce.

Gilmour Space Technologies

Adam Gilmour
Chief Executive Officer

James Gilmour
Director

13 July 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: I see. Okay. Now, I did notice when I was going over the Gilmour Space Technologies website. Forgive me, but I just have to ask this question. How do you 3D print rocket fuel?

J. Gilmour: Well, we have hybrid rockets and a hybrid rocket by having a liquid oxidizer and a solid fuel. It's the solid fuel that we 3D print.

Interviewer: I see.

J. Gilmour: We basically print a combination of materials. Then, our research indicates that we can get around a lot of the legacy issues of hybrid rockets with a 3D printed fuel. We tested the technology and it seems to work, and we're testing much larger engines in the third quarter of this year that we'll use for an orbital vehicle.

Interviewer: Wow. That is amazing. Okay. As far as disruptive innovations, and particularly the launch component of the space domain, how has that weighed in on a developing company like Gilmour Space Technologies? Is this something that is, not necessarily a worry, but is this… is R & D, in other words, a constant concern to an upcoming company?

A. Gilmour: Yes, absolutely. All the launch companies keep their technology very close to the chest. You almost have to start everything from scratch. We are hiring some people that have some experience in the space industry, but we think we're kind of pioneers in terms of what we're doing in our hybrid rocket motors. The next three and a half years of that company is all R & D. Now, we've got plenty of technology troubles to overcome.

Interviewer: That is how the biggest barrier entry for a new company in this landscape. Would you agree with that?

A. Gilmour: I think so.

J. Gilmour: Yes, I would agree with that.

Interviewer: Okay, great. Well, thank you both, gentlemen. This was a great interview. It's always really amazing when we get a nice commercial perspective that's international. Let me just end the interview by asking one more question that I will ask everyone. Is there anything, any question, you feel you would've liked to have answered that you think is important that I didn't ask? Anything in general you would just like to comment on further?

A. Gilmour: Well, I just want to say that we spend plenty of time talking to the US military about the risks of attack on space assets, and we agree with them, and that we think they're already looking at commercial partners to fulfill, the de-risking of that. I'm talking specifically about past technical launches of communication satellite. We think that's a very smart way to go and I encourage them to keep going in that format. We're not the only commercial company that can provide the service and they shouldn't only have one commercial company to provide the service. But it's definitely something that is a bit of a mind change from 20 years ago to use commercial operators with quick launching, small tech satellites. I think that's something I definitely would want to say that I agree with a lot of the people in the defense force, on the need to develop that capability.

WRITTEN RESPONSE

Think they will be great partners as interests are greatly aligned.

Joshua Hampson

Security Studies Fellow (Niskanen Center)
26 July 2017

WRITTEN RESPONSE

Short-Term (5-10 years): This depends on the type of business environment the U.S. government allows to exist. If the factors needed for a viable commercial market—transparent and consistent oversight, government purchasing capabilities as service, and international competitiveness—then the overall space sector will be a solid partner for national security interests. Even if specific companies come and go, the U.S. will be provided the capabilities it requires. However, if this environment does not exist, then there may be some initial disruption as new companies disrupt existing systems, and then the market will collapse back to providing what the government awards contracts for.

Mid-Term (15-20 years): If currently immature sectors of the space economy move out of the short-run into maturity (similar to the satellite communications market today), then the orbital environment at this point will be much busier. Mitigating the risks that come with this environment—debris, potential conjunctions, international tension—will require the United States government to be an active partner of America's major commercial space entities. A significant amount of international coordination will have to occur, which will at least require the United States government's participation, and companies will not wish to risk being placed under burdensome restrictions by causing problems. This means that, even though the orbital environment may have more risks, the commercial entities will likely strive to be solid partners.

Long-Term (25+ years): From the mid-term, if commercial markets continue to properly develop, major commercial space entities may start serving as disruptors in terms of state national security interests. The U.S. government may be more reliant on commercial providers for capabilities than those entities will be on the government for funding. This is particular true if space resource harvesting begins, which may be a multi-trillion-

dollar market.[14] A contemporary model exists in the computing/software industry today. Companies cannot disregard U.S. policy, but are large enough to both lobby against policies they disagree with and independent enough in funding to take their views to the public. This has been most visible in the ongoing debate over encryption.[15] Major commercial space entities in the long-term may similarly be involved in policy development and implementation.

However, in the long-run, the innovative capabilities that commercial space will bring to the United States will bolster national security in unpredictable ways.[16] On balance, a robust commercial space industry will bolster U.S. national security.

Harris Corporation

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

15 September 2017

WRITTEN RESPONSE

Absolutely, but within the US or Western commercial sector, any potential disruptive capabilities could also be used to build solid partnerships. These include capabilities in imagery, space lift and SATCOM in the short-term; on-orbit refueling and maintenance in the mid-term, and on-board quantum computing in the long term. We are unaware of any substantial commercial capabilities of our adversaries as most space efforts are funded and led by their governments.

INTERVIEW TRANSCRIPT EXCERPT

G. Klinger: Actually, although I didn't participate in those debates, I'm almost certain it was part of the debate when the government in the early '90's made the decision to allow export of high performance computing and the hot sections of high performance jet engines. Those two may actually be the best comparisons here to your point which is I think that government, the federal government, in my opinion in all those cases but almost astoundingly in the case of high performance computing and the hot sections of high performance jet engines, it's almost astounding to me to say that the government had the foresight to recognize that to try and restrict American companies from being able to compete internationally in those markets by continuing to have a presumption of "no" with regard to exports was a losing proposition. What ended up happening via the decisions to allow those exports, not unfettered exports [0:26:02 inaudible] with moderate applications of safeguards was that US compares really I think to this day in many ways although our production is up in many cases off shore but US companies cornered the market on high performance computing and Tom you would know better than I do

[14] Calandrelli, Emily "The Potential $100 Trillion Market for Space Mining," *Techcrunch*, July 9, 2015 [accessed July 17, 2017] https://techcrunch.com/2015/07/09/the-potential-100-trillion-market-for-space-mining/.
[15] Kharpal, Arjun, "Apple vs FBI: All you need to know," *CNBC*, March 29, 2016 [accessed July 18, 2017] http://www.cnbc.com/2016/03/29/apple-vs-fbi-all-you-need-to-know.html.
[16] Hampson, Joshua, "National Security Needs Robust Commercial Space," *Niskanen Center*, June 21, 2017 [accessed July 18, 2017] https://niskanencenter.org/blog/national-security-needs-robust-commercial-space/.

what place, you know, Pratt & Whitney and GE have in terms of, you know, commercial and military high performance jet engines. You know, I don't think there's a simple right or wrong answer but, you know, I tend to side with, you know, with former Secretary Gates whose admonition to the people about exporting administration control was "let us make sure we don't build higher walls around a castle that the Huns have already entered."

[…]

G. Klinger: I think there are a few things that in my experience when they occur they are automatically going to place the government in a very, very difficult position in terms of policy making. I think that when issues become politicized and I'll give you the example when Lorale… when we had the problem with Lorale's export violations in the late '90s to the PRC, the reaction, it become instantly politicized in the Congress. What we got for that was the better part of 15 years where virtually everything space related got put under the jurisdiction of the USML. What that did was engender more than a generation of foreign companies advertising satellites for sale and components for sale that were called Itar free. If you talk to almost any one of our commercial satellite component manufacturers, we paid a very high price due to the politicization that followed the Lorale… I'm not saying there shouldn't have been sanctions, there should have been but there are sanctions and then there's craziness and what we got was that issue was turned into a religious issue, it was tied to a larger issue of a missile proliferation. My point is, it is imperative within the executive branch that there be a tight configuration control over policy making and policy making in general needs to stay out in front or at least keep pace with technology because when we don't… and the other thing is you can't let the outliers beat the bases by making policy.

Theresa Hitchens

Senior Research Associate (Center for International and Security Studies at Maryland)
19 July 2017

WRITTEN RESPONSE

Depends on sector. Some are already disruptive and have potential negative consequences for space security: space mining folks, people pushing for end of OST. In near term, remote sensing and sat swarms likely to be disruptive, but perhaps largely in a beneficial way. Mid- to long-term, resource extraction and debris removal. Internet providers in space in mid-term also.

Dr. Moriba Jah

Associate Professor (University of Texas at Austin)
3 October 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: Okay. So, transitioning to another question from our list, do you see major commercial space entities likely serving as disruptors or solid partners, or maybe even both, in terms of state national security interests over the short-term (5-10 years), mid-term (15 to 20 years), and long-term (25+ years)?

M. Jah: I think some commercial space entities could serve as disruptors, especially like space startups out of Silicon Valley. The incumbent and more traditional commercial space entities, like the Boeings and Lockheeds of the world, have been historically a bit on the naysayer side when it comes to the new space factors like Planet, like One Web, like Blue Origin, like SpaceX. But, now these new space startups are getting huge government contracts, and so, yeah, they have been disruptors. So, there are a lot of naysayers from incumbent commercial space in the US, for instance, but as the new space actors started saying, "Yep, sounds good. You can laugh all you want, but I'm going to show you what I can do." Planet now has 200 satellites collecting Earth imagery 24/7. SpaceX now has this launch vehicle that takes off and can land, and it's totally reusable. Blue Origin is on the same lines. Historically, these other incumbent companies have always been waiting for the government to subsidize all that stuff. Now, though, you've got angel investors and venture capitalists wanting to make huge profits. So, that has been a disruptive element in the space sector, and now the government gets to capitalize on that initial investment.

I think that plays well to the government, and the government's hand, if the government leverages that to its own advantage. And these companies aren't averse to working with the government. I mean, they easily could have just said, "Yep, our investors said no. Your money is no good here," but they didn't. Other countries have done that—the space sector in Japan, for example, for the longest time was averse to getting any sort of military colored money for anything in terms of space research, but now they've slowly been changing that. Planet, when I was in the Air Force Research Lab and I visited them, they weren't necessarily on the up-and-up with working with defense, but now they have huge contracts with defense.

So, I see these companies as starting off kind of in a disruptive way. But, over the longer-term, I think it's a good thing for the space sector—it creates more competition and new ideas with risk retirement, and the government gets the benefit of an investment that it did not initially make.

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: So, this is a nice segue into that other question you mentioned. From your perspective, will major commercial space entities likely serve as disruptors or solid partners, or both, in terms of state national security interests in the short-term (5-10 years), mid-term (15-20 years), and long-term (25+ years)? It sounds like you're saying that maybe over the short-term we could predict things, but beyond that, like 5 or 10 years out for example, there is far too much uncertainty to be able to accurately predict things. Do I have this right?

J. Karpiscak III: We also have to look at what factors are involved here, and whether they will serve as disruptors or solid partners in terms of state or national security interests. The answer is yes, they will. I say that deliberately because it depends on who's launching, who owns, who's willing to work with us, etc.—commercial space will be used by third parties or shell companies to gain intelligence one way or the other. I think a lot of the success that we hope to achieve will depend on how many commercial space entities can be coerced, manipulated, or incentivized to share data with friendlies and deny access to, say, gray or red forces. That also depends on the region that's being assessed and how long the period of time is that you want to assess in particular area, because a lot of this stuff has a big temporal component these days. The faster you can look at something and the faster you can react, the better your chances are. That's been a truism since the year of God.

Commercial space entities that have their roots in the US will always be easier to influence than those that are not. Like I said, the short-term stuff is easy to predict to a large extent, and the mid-term stuff perhaps is also predictable to some extent (e.g., an intensification of capability as you can simply get more or a slightly better version of whatever it is that you have [or lost] in orbit, or you can find somebody to do feature extraction or some other kind of capabilities from space for you). But I think most would agree that long-term prediction is nearly impossible, and even then predictable only in general terms. If you look at rates of technological advance in a lot of the world economies and developments like cellphones and tablets, it's very difficult to predict a lot of this stuff.

Overall, though, certainly the short-term is a lot more predictable. In a lot of cases, it's like the weather, where you're dealing with essentially bounded chaos—you know what can happen in a little bit, but the further out you look, the wider the range of possibilities, and then it becomes a very cloudy murky swirl.

Interviewer: What are the national security implications of the uncertainty surrounding the longer-term future and the likelihood of commercial space actors of possibly serving as both solid partners and disruptors in the future? How does this impact US national security?

J. Karpiscak III: Well, I think the major implication we're dealing with is a loss of information control and information dominance, especially if you're dealing with small and regional conflicts. I think that over the next 20 years, information dominance will still remain an advantage of US and NATO partners, but that doesn't prevent other companies or other entities from having access to space. One thing I'm thinking of, more specifically, is that company in New Zealand, Rocket Lab, which is doing a lot of additive manufacturing to create boosters and so forth, and I'm sure those plans are going to get out, which would mean that anybody—doesn't even necessarily have to be

a nation state—that does this, can create a launcher undetected and be able to launch something without anyone's permission or consent.

Now, on the other hand, the complicated electronics for terminal guidance and other accuracy issues may still be a problem because that kind of technology may be more proprietary; you can't 3D print it. But when looking at things like SpaceX, where you have Elon Musk launching these rockets kind of like Model Ts one after another and then returning and refurbishing within a desired turnaround time to 24 hours, this is a rapid leap in technology that other countries may be able to mimic to some degree, certainly to be able to put together components via additive manufacturing to help shorten their development cycle from years to maybe a year or two.

A good analogy would be something like here in the US with gun control. That would be, we have to limit export, we have to limit manufacturing, we have to limit sales, and all that. Well, if you go to YouTube, you can see somebody who's 3D printed an M1911A1 45 caliber pistol and shot 5,000 rounds through it, and it was just printed out in the office. Well, there goes the whole concept of gun control. What you really need is morality, but that's a separate issue altogether. This just shows you how easy it is with today's technologies to go leaps and bounds beyond what was limited to other countries just a few years ago.

Dr. George Nield

Associate Administrator, Office of Commercial Space Transportation (Federal Aviation Administration)
1 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: Right. Okay. As far as the next question goes, you know, this can often be cited as a concern or a reason for government control in the space industry. So how would you respond to the concern that commercial space entities being a disrupter in terms of national security interests over these different time periods?

G. Nield: I say great. Will commercial entities be disrupters or solid partners? I would say absolutely. Commercial space entities will serve as disrupters of space national security interests. Whether they will also be solid partners really depends on the decisions made by the government. I view that as a positive thing that we ignore at our peril because, again, the capability is going to be out there in the rest of the world. If the US chooses not to take advantage of it, we're likely to be left behind.

I mean, it's hard to predict the future clearly. How do you pin down different time periods? But I would just across the board say the potential for disruption is huge. For the kinds of things we look at from our area, like commercial space transportation, I think in the short-term, five to ten years, we're going to see significant reductions in the cost of access to space, especially through the use of reusable launch vehicles, and regular and frequent suborbital space flights, both for tourism and other purposes. We'll see commercial space stations, we'll see satellite servicing, we'll see numerous large constellations of small sats that provide a wide range of terrestrial services. That is what is going to happen with or without the military in the next five to ten years, unquestionably, in my mind. Mid-term I think we could very well see things like space based solar power, propellant depots, space tugs, commercial lunar bases and high speed, long-distance point-to-point transportation through space.

In the long-term, 25 years or so, I would not be at all surprised to see what I would describe as a thriving, sustainable space economy that is going to include human missions to Mars, asteroid

mining, space resource extraction and that the like. A lot of the things that I've been talking about are not necessarily directly tied to national security, but if the capability really is there to do those things, the question is how could they be used for national security purposes. I think there are lots of ways -- just show us a new capability and we'll come up with ways that we could use that to our advantage from the national security point of view.

Interviewer: In other words, the sky is the limit in the commercial sector and the government as, currently, their best customer, would be a fool to not take advantage of that?

G. Nield: That's correct. They'd be foolish not to take advantage of it.

Jim Norman

Director, Launch Services, Human Exploration and Operations Mission Directorate
(NASA Headquarters, Washington DC)
27 September 2017

WRITTEN RESPONSE

If our view is that a "solid partner" is a commercial space entity that can be controlled by the National Security community, and that a "disrupter" is a commercial space entity that can't be controlled, then the "disrupter" category is probably the most likely outcome. To paraphrase a finding from a May 2017 paper titled A Global Space Assessment:

> *"The availability of private capital from information technology firms is such that they can acquire almost any space-based information technology they may require."*

If the U.S. tries to limit what they can do, what is to prevent them from moving their endeavor to another country? A better basis for a successful relationship between the private and government space sector might be for the U.S. government to sponsor, partner and facilitate the growth of the U.S. private space sector with the goal of growing the number of competitive providers, and creating a business environment that is better than any other location in the world in order to attract the best ideas and businesses to our shores.

Dr. Luca Rossettini

CEO and Founder (D-Orbit)
16 August 2017

WRITTEN RESPONSE

Disruption is typical of young and hungry new ventures proposing innovative solutions and technologies to the market. We are now experiencing the initial transient phase for the commercial space market. However, only sporadically new applications or solutions are originally designed for the national security market, unless driven directly by government requirement, hence no disruption.

On the other hand, new ventures in most cases do not have the pre-requirements to work with the government into national security applications, since the pre-requirements imply years of preparation and heavy expenditures (certifications, security of the production phase, procurement, etc.).

Existing well known space companies already meet all the requirements and usually are already active – at least most of them- in defense and the national security markets. However, they are more expensive and definitely less disruptive.

Eventually, the definition of short, medium and long-term here used rarely apply to the concept of disruptive technology. If we accept the concept of disruptive solutions associated with small, committed, privately funded new ventures, the concept of short-term usually means one to five years maximum. If the company is not able to enter the market, and to begin scaling, after such a period of time, either the technology is not working or the market is not ready. Once in the market, the temporary monopoly conferred by the competitive advantage of the disruptive technology will last only few years. Hence, the concept of "disruptive" will soon become "ordinary" or "standard". Medium-term is better defined as 5 to 10 years in the future. After ten years it becomes more difficult to forecast based on technology or solutions, since the rate of innovation and technology transformation is so high that we don't really know what to expect. The right approach would be a forecast via principles and not via technology: basically we want to design the long-term and not take as base the technology development, but use principles, "adjectives", to design it. For example, we want to see a commercial space functioning according to defined rules, preserving national security. As a sort of long-term objective, it will help designing the right technology to get there.

I believe the following:

- In the short-term, government should scout for innovative and disruptive technologies from the new ventures coming into the space market. Once identified a disruptive solution, a technology/service/solution adaptation plan should be prepared. Cooperation between these innovators and major commercial space entities already working with the government should be strongly encouraged.
- The more structured existing space entities will include disruption in their outcomes. A precise requirements statement from the government on the use of a particular type of disruptive solution is essential: commercial entities tend not to implement innovation and prefer, instead, to use and sell what they already have. Lack of confidence in young but innovative ventures, plus the lack of knowledge of the new, disruptive solutions may become an impenetrable barrier. As a consequence, after spending money on adaptation of the technology, the government will not be able to take advantage of it on the field if the main contractor decides not to implement it.
- A degraded version of the disruptive solution, should then be degraded and offered into the global commercial market: in this way, the US government will keep control of the evolution of the technology and especially avoid the raising of competitive and poorly controllable other solutions outside US.

Dr. Patrick A. Stadter

Principal Professional Staff, National Security Space Mission Area
Program Manager, Space-Based Kill Assessment Program
(Johns Hopkins University Applied Physics Laboratory)
9 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: Okay, great. So, let's transition into the next question that I was hoping to ask you. Given the increasing number of non-government actors getting involved in the space domain, plus the rapid advancement of technology available to these actors, I'm wondering, from your perspective, do you see major commercial space entities likely serving as disruptors or solid partners, or maybe both, in terms of state national security interests over the short-term (5-10 years), mid-term (15-20 years), and long-term (25+ years)?

P. Stadter: Okay. So, the general statement that I would have is kind of a hedge, which is: if they're going to be paid and it's easy to get paid, they will be your best partner—and that's perfectly fine because they're capitalists, and I think that's a good thing. Companies ought to make money, government ought to get services.

In the near-term, I am convinced that the government does not have a straightforward way to make that partnership easy. This doesn't mean that industry is going to run away, because they are hungry to survive and grow, but in the near term, it's going to be, I think, a contentious situation where the government wants more and industry wants more, but they're not sure how to get out of their own way—and this will come from primarily the government side, in my opinion, given some of the hurdles that we talked about before.

In the mid- and the long-term, one thing that I think we need to be aware of, and I know we've had these discussions among key National Security Space stakeholders, is: who protects commercial space assets? As it blurs, and you can talk about the difference between strategic and tactical, as we are riding government capability over commercial, who has responsibility for insuring their resilience (cyber, physical, the whole bit)? Right now, to some extent, commercial sort of says, "we're not bearing that burden, you guys are responsible for it."

As space becomes more of a commons, if we can make it that way effectively and we deal with the policy issues relative to that, this becomes an important question in the medium- and the long-term. Just to give you a practical sort of focusing example, we have the JSPOC, which essentially does our cataloging missions, and we have the National Space Defense Center (NSDC), which used to be the JICSPOC and will do more interesting things, but what is the burden on them to incorporate the dynamics of activity involving commercial in space, and what does it mean to an actual potential operation that is occurring on very, very short timelines? Those are very significant things that will affect how we are partnered between government and commercial. And this, again, is both Title 10 and Title 50, and in my opinion that has got to be a partnership and that's got to be addressed through both policy and activity.

Interviewer: Okay. So, what is the dynamic like between commercial and government with respect to something like monitoring for threats to space infrastructure, or monitoring for potential indicators and warnings of threats? Is it the case where the commercial entities are sort of dependent on government for providing those indicators or warnings? Or, is it the case where commercial entities are starting to more and more do that monitoring for themselves?

P. Stadter: Yeah. I think the answer is that industry does more and more of informing government, and being closer-tied to government (particularly through, for example the JSPOC), of what is happening. Both side are sharing more information, but it is not at the level, rate, dynamics, or level of sophistication that is needed. And that is an ongoing discussion.

Air Force Space Command, for example, is really reaching out to commercial industries to try to understand how to start to address that and how commercial can start to play in this arena. There has also been work that's been done in the assured space operations world, relative to the JICSPOC and now the NSDC, to try and understand what that functionality should be and needs to be, which I think is helping to drive that conversation, but that's something that in my opinion ought to be really worked in the near-term but I'm afraid the best we'd likely be able to do, other than some low hanging fruit, is the mid- to long-term. But, I think it is essential that it be a deep partnership, and at some point somebody is going to have to pay some bills relative to protecting not only Title 10/Title 50 assets but also commercial and allied assets.

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

15 August 2017

WRITTEN RESPONSE

The private sector satellite industry has taken notice of the advancing threats and has proactively begun adding threat defense capabilities. Since 2010, private sector Satcom service providers have invested significant capital to harden their satellites and networks against electromagnetic interference, cyber, and denied PNT threats in order to protect their service offerings, eliminate single points of failure in teleport and ground infrastructure, and to automate their operations, maintenance and overall security processes. They have improved hardening, security, and operating concepts based on advancing threats to their business and operational models.

Enhancing understanding, cooperation, and collaboration between the government and commercial or private sector companies will enable those companies to continue to operate as solid partners in support of the National Security Space. The 2018 National Defense Strategy summarizes this state of affairs best: "Success no longer goes to the country that develops a new technology first, but rather to the one that better integrates it and adapts its way of fighting."[17]

INTERVIEW TRANSCRIPT EXCERPT

VanderMeulen: Historically, the USG has been the space innovation leader and therefore they're used to directing. We think that there has been some leadership concepts from General Hyten and General McChrystal, who has written a book on how he had to essentially move from directing to encouraging innovation. We is a big theme of one of his books on how he had to become more innovative to fight ISIS. There's been a history and we think we're all starting to see a change. There's numerous examples, I think Fred commented on GPS at the start. The government still directs the GPS satellite.

Look at all the innovation that's happened on the ground segment side where they weren't directing at all. Private sector people decided, "Oh, well I'll put this in an ATM machine. No, I'll put it into an iPhone, I'll put it into a Samsung. I'll build Google maps and let people know where they are all the time. etc." All these things, all this innovation has occurred on the side that the government wasn't directing. Whereas on the side of directing there's been... and since the start we've gone through GPS-1 and now GPS-3. In a 35, 40-year period we've had three generations of space innovation. On the ground, we've had an infinite number of innovations. That's not to say that directing isn't bad, that's just saying that you just have to find a balance of the mix.

[17] https://www.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf

Charity Weeden

Senior Director of Policy (Satellite Industry Association)
Former Assistant Attaché, Air & Space Operations (Canadian Defence Liaison Staff, Washington, DC)
24 July 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: Okay. Thank you. I'll bundle the next two questions together sort of. Are there any innovations on the horizon or specific companies that are blazing the trail in space technology that are disrupters or either felt in the commercial sector and in respect to the national security domain, or are they more solid partners with more of a partnership role, and what are those technologies

C. Weeden: The commercial industry wants to be partners with the government. The extent of this relationship is quite good and increasing in the way that the US government is incorporating industry into federal advisory committees, or having industry input being brought in either ad hoc or more formally. The DoD is undergoing the Air Force analysis of alternatives on wideband satellite communications, where they have the commercial industry in talking to them in an open and transparent way.

In innovation, for the commercial remote sensing industry, we're not just talking about taking pictures anymore. We're talking about radar, infrared, hyper-spectral, frequency allocation services off of radio signals, and things that one wouldn't have thought is commercially possible five years ago happening. I think the remote sensing world is disrupting. I think a commercial space situational awareness could be a disruption in the next five to 10 years, but that has to do with partnership as well. On-orbit servicing is disruptive, but again it has to be in partnership with the US government to make sure security issues are taken care of. There are a couple disrupting innovations, but I see partnerships throughout as well.

Interviewer: I see, and could you speak specifically on to the topic of commercial launch services?

C. Weeden: Commercial launch is about being able to get to orbit all these great innovative capabilities that can only strengthen the national security posture. When it comes to enabling commercial satellite to get into orbit, the more launched the better.

Deborah Westphal

Chief Executive Officer (Toffler Associates)
17 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: Will commercial space entities likely serve as disruptors or solid partners in terms of state and national security interest in the short to long term?

D. Westphal: Some pretty exciting things are happening that will be very disruptive. There are exceptional intelligence gathering activities related to global challenges surrounding food and water, climate, human migration and poverty, and the emergent space capability in this regard can create a mini-intelligence community of its own. More than just communications and imagery, elite companies are emerging and evolving like a small commercial intelligence community that will be very, very

disruptive. Not only because the government could use or buy that capability as a service, but it will be disruptive in a sense that others will have access to it, too.

Will the world be totally transparent? I don't think so. But it will be more transparent than what it has been in the past as commercial space capabilities evolve. It's something that is emerging, and fairly rapidly, probably faster than what we realize.