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National Security Implications of Space-Launch Innovation

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**.

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Question of Focus

[Q13] What are the national security implications of increasingly accessible and affordable commercial launch services? Are these the same for the US and near-peers or states with emergent space capabilities?

Expert Contributors

Roberto Aceti (OHB Italia S.p.A, Italy); **Adranos Energetics; Brett Alexander** (Blue Origin); **Major General (USAF ret.) James B. Armor, Jr.**[2] (Orbital ATK); **Mark Berkowitz** (Lockheed Martin); **Dr. Riccardo Bevilacqua**[3] (University of Florida); **Caelus Partners, LLC**; **Elliot Carol**[4] (Ripple Aerospace, Norway); **Dean Cheng** (Heritage Foundation); **Dr. Damon Coletta and Lieutenant Colonel (USAF ret.) Deron Jackson** (United States Air Force Academy); **Dr. Malcolm Ronald Davis** (Australian Strategic Policy Institute, Australia); **Faulconer Consulting Group**; **Lieutenant Colonel Peter Garretson** (United States Air Force Air Command and Staff College); **Gilmour Space Technologies**, Australia; **Harris Corporation, LLC**; **Theresa Hitchens** (Center for International and Security Studies at Maryland, University of 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 Lele**[5] (Institute for Defense Studies and Analyses, India); **Dr. Martin Lindsey** (United States Pacific Command); **Dr. George C. Nield** (Federal Aviation Administration); **Jim Norman** (NASA); **Dr. Deganit Paikowsky** (Tel Aviv University, Israel); **Dr. Luca Rossettini** (D-Orbit, Italy); **Dr. Patrick A. Stadter** (Johns Hopkins University Applied Physics Laboratory); **Stratolaunch Systems Corporation**; **John Thornton** (Astrobotic Technology); **ViaSat, Inc.**

Summary Response

The experts solicited in this effort agree that there will be wide-ranging national security challenges and a few benefits arising from decreased launch costs. The challenges are largely derived from two *structural* changes to the space domain: more actors and a wider diversity of payloads. The subject matter experts indicate that changing commercial launch technology alters the monetary costs of the types and timing of deliverables national space programs can produce. These potential transformations of national space programs affect: military procurement patterns, environmental destruction, informational supply chains, and military space operations.

Less is More: More Actors and More Junk

The diversity and number of actors accessing space and the types of objects in space is increasing over time, seemingly exponentially. According to Dr. Malcolm Davis of the Australian Strategic Policy Institute, a suite of commercial entities, "SpaceX, Blue Origin, Virgin Galactic, and Stratolaunch, amongst others," are "either launching payloads or soon will be, in new ways that opens up access to space to a

[2] The subject matter expert's personal views, and not those of his organization, are represented in his contributions to this work.
[3] Ibid.
[4] Ibid.
[5] Ibid.

broader customer base and at a lower cost and with greater responsiveness."[6] Dr. Deganit Paikowsky of Tel Aviv University observes that commercial entities are one of the "two new types of players [that] joined global space activity" due to decreased costs to launch. Historically, larger incumbent companies, such as Boeing and Lockheed Martin, have used government corporate subsidies to drive their product cycles. Lowered costs to launch have added "(a) small and developing countries [and] (b) private sector players" to the mix of actors in space.

More actors with access to space has led, unsurprisingly, to more material in space of varying quality. Dr. Damon Coletta of the United States Air Force Academy incisively notes that what "looks like a change in launch services" and costs is actually "an advancement and diffusion of technology for building small, lightweight, highly capable payloads." Marc Berkowitz of Lockheed Martin maintains that

> further increasing the number of nation-state and sub-national actors able to access space…risks continuing to make the space domain more congested and complex. Such increased congestion and complexity will impose additional resource burdens on space domain awareness capabilities and could create additional debris or other hazardous operating conditions that pose risks of mishaps.

The diversity of payloads, Dr. Luca Rossettini of D-Orbit postulates, creates physical danger from an atmosphere of cheap objects threatening the integrity of government-sponsored space systems:

> The increasing and unregulated launch of satellites—23,000 satellites have been forecasted for the next ten years, and this estimate grows every three months—may pose several risks. In fact, most of these satellites are designed to be manufactured using COTS (commercial off-the-shelf) components. Hence, they are less reliable than government-type satellites, and their death rate will be higher than the current average.

How the Implications Differ (or Not) Across the International System

The national security implications that the subject matter experts identify are best categorized into four baskets: military procurement deliverables, environmental destruction, informational supply chains, and military space operations.

One implication of increasingly affordable launch services that the experts consistently identify is how launch services shift the *military procurement deliverables* of national space programs. Nations with advanced commercial space sectors would gain more value for their spending and allowing for new timelines of development within both emerging and legacy national space programs, experts postulate. Elliot Carol of Ripple Aerospace observes that any country's "military budget goes a lot further," including the United States, if those countries are no longer "paying ULA a couple hundred million dollars for the next launch, but are paying SpaceX $62 million a launch."

Although saving money in space programs appears to be primarily an economic benefit, these cost savings yield steep national security implications. Shifting the necessary allocation of resources affects the whole of countries' defense industries and the distribution of capabilities across the international system to those countries whose responses to these changes are strategic and forward-thinking. Berkowitz argues in this vein: "An advantage should accrue to the side that mitigates the risks and takes

[6] Please note that responses from Blue Origin and Stratolauch are included in the Subject Matter Expert Contributions Section of this report.

advantage of the opportunities created by accessible and affordable commercial launch services with the greatest speed, agility, and consistency."

Other exerts concur with Berkowitz that cheaper, changing procurement options shape space program management and initiatives. Lieutenant Colonel Peter Garretson of the United States Air Force Air Command and Staff College points out that lowered costs allow the United States to "affordably field entirely new military capabilities (Space-Based Radar/MTI, Space-Based Missile Defense, Space-Based Terrestrial Strike)." This innovation, Dr. Moriba Jah of the University of Texas posits, stems from the commercial competitiveness of a larger market to win government contracts, which in turn gives public sector procurement managers increased program design options. He states: "In times past, government actors had very specific kinds 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."

Some experts also agree with Berkowitz that only countries that move quickly will gain advantage, but argue that the United States has been slow to capitalize[7] on these transformations, reducing the relative competitiveness of the American space program. Dr. Davis warns that "ironically, large, expensive, fully expendable rockets, which take months to prepare for launch and cannot be reused, are still the focus of NASA with its 'Space Launch System' (SLS) and United Launch Alliance (ULA) with the Atlas and Delta family of vehicles." Experts from Harris Corporation, LLC urge American policymakers to "rethink 'how we do space,' writ large. The legacy requirements for large, highly sophisticated, redundant systems with lots of fuel, multiple backups, and long service lives may no longer be required to the same extent as today." The national security implications of these changing options for procurement pushed Dr. Davis to raise a key question: "How will these traditional launch vehicle technologies compete with reusable rockets, airborne launch, and, ultimately, spaceplanes in terms of cost competitiveness, efficiency, and responsiveness in the next two decades, particularly as reusable launch systems mature over time?"

The second implication of these commercial technologies is the environmental destruction from so many actors' increasing ability to place more materials of varying quality into orbit and potentially affect all states equally. Dr. Riccardo Bevilacqua of the University of Florida cautions that

> actors in the space field are approaching access to space as if it were an infinite resource, and reduced prices are enabling operators to reduce the quality of their satellites and to launch more, relying on redundancy of poor hardware. Low quality hardware's behavior is more difficult to predict and control. This is obviously a non-sustainable and wild approach but, unfortunately, there are no global regulations and no enforceable actions that can prevent these behaviors.

Third, some of the experts argue that, although many actors can access space and place their objects into space due to the lowered cost to launch, only a select few actors—those with superior information processing capability—will see any benefit from more affordable access to the space domain. Dean Cheng of the Heritage Foundation suggests that when "anyone on the planet with a few dollars will be able to get raw data" from space-based assets, the key "differentiation then is going to be in analysis," and the benefits of affordable launch services will mostly accrue to those actors who will be able to "look at that data and say, 'That is a T-72, and that is an M-1 Abrams' or 'That is an American AEGIS destroyer, and that is a South Korean or Chinese destroyer.'"

[7] No pun intended.

Fourth, and finally, Dr. Davis hypothesizes that a critical national implication of affordable launch capabilities will emerge with the "development of reusable launch capabilities—reusable rockets, airborne launch, and, on the horizon, aerospace planes," because these technological developments could "improve responsiveness and boost cost efficiencies in accessing and exploiting space" in ways that could "fundamentally transform military space operations."

Conclusion

In conclusion, the main national security effect of reduced cost to launch is that cheaper launches enable a greater number of actors to send a wider range of payloads—some of which will, quite frankly, be junk—into space. Cheaper costs to launch also shape how countries leverage (and build) their national space programs by shifting available procurement patterns.

Subject Matter Expert Contributions

Roberto Aceti

Managing Director (OHB Italia S.p.A. a Subsidiary of OHB)
9 September 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: Okay. Thank you, Roberto. So last question here. What are the national security implications of increasingly accessible and affordable commercial launch services? Are these the same for the US and near-peers or states with emergent space capabilities?

R. Aceti: I think there are two sides. So**,** inclusively accessible and affordable commercial loan services on one end; this is because now you see a number of even small companies, that are developing launchers which are supposed to bring down the cost of a simple launch. So including an affordable commercial loan services, they are coming out because there are so many initiatives or a new launchers or new mini launchers and this in itself is initial from the security point of view, a national security point of view, because at the end of the day, this technology could serve many purposes. Also, could be a threat because at the end you can deliver a satellite, but you can also deliver other things with the same technology. So, that's an issue and on the other end, yes, you could imagine that lowering the launch cost would enable almost anybody to put a satellite into orbit. Also, people which do not have a very benign intention. But I'm more worried actually about the first thing. So, I'm more worried about the fact that what before was an endeavor for governments and large companies. Now, I see that it is at reach for people are there reaching a certain level of success even with this kind of new project they are developing. So, yes, it's an issue that should be somehow (from my personal view) should be monitored and controlled. There is a very well and capsular system to control which technology is going where in every country in US, in Europe, in Italy and so on. This should be something to be monitored very carefully. It is an issue. I think certainly this issue is there for US, an issue there for western country, for Italy, for other western countries. Obviously, this require attention. That's what I can say.

Adranos Energetics

Chris Stoker
Chief Executive Officer

Brandon Terry
Founder and Chief Technology Officer

11 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: So we'll move to the last question here. So what are the national security implications that's increasingly accessible in affordable commercial launch services? If you could tailor your response a bit to give your insight as a company that works with propellant and fuel… would you

say government has more to gain or more to lose from attempting to mitigate the proliferation of launch services and anything that is subsequently attached to that domain?

C. Stoker: A couple of different questions in there. So I'll try and answer… I'm not sure I understand the more to gain or more to lose question but national security implications, anybody being able to have a satellite and look at anything in the world anywhere. I'm not a national security expert but my guess is that just the whole big brother is watching concern. Whether it's big brother or some private organization, I don't know if there's a difference. So I don't know. I don't know how to answer your question frankly. Brandon?

B. Terry: I mean yeah there's three downsides that I can immediately see. One would be as we already touched, if you have a massive proliferation of satellites up there, space debris and space junk has been kind of a huge issue. So that's one. Number two is what Chris touched on and that is if you have all of these satellites up there with cameras talking to each other, it could become a national security issue in terms of if there are areas in the US used to operate in and not have everybody watching, that could be an issue. Then three would be that if you have a very easy way for private parties to get into space very easily, you then start to worry about what they are putting in that and what's the regulation for what they put up. I mean speaking outside the box here, say I am a terrorist. It becomes suddenly very cheap for me if I can hitch a ride off into space easily to put an object up on the space, it is literally nothing more than a frag device. It gets engine orbit, you detonate it and now you have objects smaller than 10 centimeters which are as you know very hard to track. You now have a shock in effect in space which would be a massive cascading terrorist attack. If those fragments then hit other satellites, you'll have a cascading effect of debris. So that would be my other concern would be space-based terrorism.

C. Stoker: Good point.

B. Terry: Right there. I feel like there does need to be some way for the government to regulate what can go up on these satellites. If I am a private individual or a company and I want put it in the space, someone needs to validate that what I'm putting in space meets a number of criteria. One, it is not a terrorist device. Two, it is actually in fact operational. It's not going to go in there and start shifting to a different orbit. Three, what is my exit plan for de-orbiting after the lifetime of my mission.

Interviewer: So, these are all valid concerns of the government and you would say that enforcing these concerns wouldn't be necessarily overbearing or overreaching on the part of the government, correct?

B. Terry: No but the government would not like me driving around a car with a bomb in it. So they should be caring about what we put in space as well.

[…]

Interviewer: Okay, great. Then lastly, I'll ask if companies in your space that you're familiar with as far as their threat priorities, this is clearly not the question. They did something that enters the business calculus from day to day or it's just simply not a daily concern of the commercial, on to you?

C. Stoker: I think it's a huge concern. I mean for us, I'll take IP for example. I mean IP trade secrets like we have… we're basically trying to play certain strategies to keep our IP safe even though we're following some pattern. We're highly sensitive to even nations in our own competition taking advantage of our IP and that's a huge issue. We don't do much about security in space but we would have… we do a lot of cyber security concerns, we have a lot of those. We just don't as a small company have the money to really put into practice cyber security controls. So all we do is all our sensitive stuff is basically left on computers or drives that aren't connected to anything. So yeah, we're really sensitive to that. Brandon, anything else do you think?

B. Terry: No. That's about covers it. Another thing that I think we worry about, especially probably even more during peacetime is always the fear and I've been seeing this as we go to some of these conferences especially in the small sat community, is as this micro-sat community enlarges and get more and more launches up there. This concept of I don't know if you want to call it orbital responsibility or whatnot, but I a big peacetime threat is what happens if somebody messes up and started getting space debris problems, collisions, inadvertent mishaps in space. Again, down the road, it's going to have to be something that's more strictly managed by either a government entity or a commercial group that comes in, just because the amount of objects that are 10 cm and above are going to be rapidly expanding here in the next couple of years.

[…]

Interviewer: Right, okay. So if we can speak a little bit more specifically in terms of the commercial sector. Is there a specific nation which like I said, is excelling at a sector of the commercial industry? To give an example, let's say Australia in particular producing a lot of launch companies or cube-sat startups or anything like that. Is there a specific sector of the commercial industry that seems to be focusing not only in the West but outside of the US in particular?

C. Stoker: Well, I mean we could say New Zealand, but that's not because New Zealand pushed it. It's because Rocket Lab is started by a guy from New Zealand. So that's one. I don't know. I can't think of anything that comes in mind although I'm sure there is an answer.

B. Terry: We have a lot of stuff going on in Norway but I don't particularly know Norway is part of the West.

C. Stoker: Sure. Norway is in particular trying to come up with a launch vehicle that they can launch from the ocean. I don't know. All of the small sat groups there in the US that I know of.

Interviewer: Right, but would you say that that is likely to continue or is there a movement or a shift to other nations outside the US.

C. Stoker: I don't know. Brandon, correct me if you disagree with me. But even Rocket Labs in New Zealand, they are moving to the US and they establish all of the available launch companies that have all the money that you could take to succeed, they're all US based. Unless there can be stuff out there that I don't know about.

B. Terry: I think the main reason for that is the eccentric VC realm that is funding this currently are all here domestic in the US. Even Rocket Lab in New Zealand, it's main backers are still domestic here in the US. Until that changes to where you have these pocket investors, eccentric investors outside of the US starting to fund this, I don't think you're going to see the commercial market start to expand elsewhere, until you get those VCs elsewhere backing you.

C. Stoker: I mean, obviously NASA has their kind of SVAR program that we're kind of trying to get to use it but I don't… I'm not aware of other sovereign nations that funds space nearly as much as the US. That's maybe your little point on here.

[…]

Interviewer: Okay. So the issue of government funding, specific sectors, little commercial industries, is the biggest concern, is that what you're saying?

C. Stoker: Not necessarily government but really any government or private. So we're going to fund our company in one of a few different ways. One, the government gives us money to develop our technology which that's happening. The US government is doing that for us. You get a private sector to fund which we're also doing.

B. Terry: We are also doing.

C. Stoker: Yes, which we're also doing, and using these investors or you're selling your product. The buyers of our products are primarily going to be US. So our product is launch systems for small sat and launch systems for missiles. Biggest market by far is the US for both of them. Then you go back to well who's going to fund it? Well, just like Brandon said, by far the most money is coming out of US privately. Then I don't know the details on this. I know the Europeans fund a lot of space launch and I don't know much money they likely put into it but I'd be shocked if they put in nearly as much as the US does. So when you're looking at those three sources of cash which is the life blood of the organization, by far that you're going to come out of the US. There're some monumental thing happened which will take a long time to occur.

Interviewer: Right. Okay. Now as far as a shift in the politics, you can be speaking specifically about the Executive branch but Congress as well. Is there a concern among commercial actors over the stability of, let's say long term funding or long term interest in space, or if it's just accepted that the investment will continue, and that the interest will continue and that it doesn't necessarily enter into the decision making, it's commercial act or is it a particular concern?

B. Terry: I would say for the small sat community it's probably less concerned about the particular current administration than you would for your large satellite launches. I think the reason why the customers for the small satellite launches are not primarily government. Your primary customers are going to be B2B, business to business. So you're going to have businesses that want to pull up these small satellites. I think for them the business model doesn't really change as much based on what one administration versus another whereas with the large satellite launches there's not as much private demand for the large satellites as there are government demand. It a lot will be heavily depending on what the current funding scheme looks like in the current administration budget. So I'd take the small satellite is probably in my opinion less moved by current administration in the large satellite industry.

C. Stoker: I agree with that. I mean, there's always macro concerns and government classes or something crazy like that but it must have happened. I think people view space as the competition. Now the next frontier, who's going to conquer the next frontier and take their biggest share as they can and control as much as they can? Who's going to win the potential war in space? If there is a country who can take out all of the US satellites without the US being able to do anything about it, that would be a huge, huge, huge problem. So because of that, I think you're going to see a bunch of money from the government and see go into the space sector. Whether because they want to compete and they want to beat other countries or want to just protect themselves. I don't know… it's just something that I worry about right now.

Brett Alexander

Director of Business Development and Strategy (Blue Origin)
14 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: Okay, great. We'll move on to the last question here. What are the national security implications of an increasingly accessible, affordable commercial launch services?

B. Alexander: You know, I think there's a positive impact. I there's a positive impact if those commercial launch services are US. And the more things going from the US I think is positive. Now, the proliferation of space capability maybe, you know, around the world but it means US can control the launching capabilities and in general means US industry dominating the launch sector. This is

related very much to those nations interested in the future of human space flight. I happen to believe that the proliferation of human space flight capability from that perspective will be a big advantage for leadership in space going forward rather than letting somebody else try to take over spaceflight or the Russians. I think that controlling the means of accessing space and what is done in space is more effective by US leadership.

Yeah, bottom line saying that I think that having US leadership and access to space hand in glove in space capability is overall important to leadership in space and beneficial to US leadership overall, rather than letting other countries do it.

Interviewer: Right. This is a sentiment we've heard very often in the course of this initiative but I'm just wondering from your perspective in Blue Origin what is the biggest obstacle from the US assuming and maintaining that leadership you just mentioned.

B. Alexander: That is a good question. Well, I think a large part of US funding on several space capabilities has not been effective in maintaining leadership in human space flight. Because we really don't launch people from the US anymore and the NASA program over 30 years of the space shuttle was not one that was innovative that led to increase in space flight, it led to less. You know, to me it's a national policy-level decision about whether the US is willing to lead and bring the commercial sector along with it. Other than that, the commercial crew program, for example, is a positive thing even though it may not make economic sense in term of price, perhaps in that kind of metric, it developed private capabilities that can be used elsewhere and so that is an example of US leadership that can leap-frog what other countries are doing. We have private people developing space trips and can fly in to space for the government and for the private sector that develop our capability beyond what anybody else is doing. So, you know, I think from a government standpoint working public private partnerships with industries is better than just doing, you know, costly programs that are only for the government. I believe the public private partnerships here are still a buoy to trade, commercial, and government where we do that.

[…]

Interviewer: Okay. Good. All right, then we'll move on to the first question from the commercial list and I'll just go ahead and read through the questions and queue you off of that. The first question here is, how do commercial ventures think about the security of this state's assets during peace time, crisis and conflict? Do industry leaders think about warfare and our current space differently than military leaders? What are their main concerns? How reliant are they on governmental warning or protection of space and what are their threat priorities?

B. Alexander: Yeah, I think from a Blue Origin perspective, you know, we are a launch company first and foremost and that's what we've been working on. My broader experience has been with commercial satellite companies and operators as well as [with] the government-hat on [there has been] increased awareness over the last 20 years about, you know, unfriendly actors doing jamming and other things as well as things that can happen to your spacecraft in space without being able to be able to tell exactly what happened to it. There is increased awareness about that—about the need for situational awareness as well as possibly protection for assets.

Interviewer: Speaking specifically more the nature of Blue Origin as a launch company, would you say that your counterparts in the military and the government are aware of the specific concerns that a launch service may have and is there a miscommunication between Blue Origin and the government, specifically on this issue?

B. Alexander: I don’t think there's been lot of conversation between Blue Origin and the government about the security aspect for launch. I know that from a, on the government side, that there's, you know, there is concern or, you know, awareness of the single-point failure nature of launch. You know,

of having fixed assets in a few locations that are vulnerable or at least could be vulnerable but that is not a conversation Blue Origin's had very much with the government.

Interviewer: Are other nations outside the west poised to tap into their own commercial space industry for military purposes in the next five to ten years?

B. Alexander: Yeah, I think most other non-Western countries, they are, their space industry really is not commercial, it's state run. Those [state-run] enterprises do both government, civil government, national security and what we would call commercial missions, particularly on the launching and the communication satellite side. So those industrial actors, you know, act in multiple capacities and are fully coordinated with their government in that respect.

Interviewer: Okay. I think it's pretty well known AND pretty well agreed upon that the US is dominating commercial launch services now but you see a possible way this is changing or shifting to another part of the world and the medium to long-term?

B. Alexander: I think the Russians still have quite a bit of [the] launch market as well as Europe so, you know, the US is not really dominating that and SpaceX has done some. ULA doesn't do any and so there's still a non-US -- a large Non-US component of the launch industry for commercial. The Chinese have been prevented from launching US-manufactured satellites and now they are manufacturing their own satellites and selling both the satellite spacecraft and then the launch; and they're financing it on very good financing terms. A lot of third-world countries are buying directly from the Chinese so we're, in that respect, helping the Chinese build up their capacity because we have pushed everybody -- not pushed everybody, but pushed them to have their own spacecrafts that are…since they cannot launch US spacecraft or components…they use that money to improve their own capabilities.

Interviewer: Okay. We'll go then to the next question a little bit. The next question is, how are the components of the commercial space industry allocated outside of the US? Which countries have which type of market interest on the commercial end, for example, tourism, Imagery, PNT, etc.?

B. Alexander: Yeah, that's a fairly long question, you know. If you look at the launch sector you [have] the Europeans, the Russians, the Chinese, the Indians all with capabilities. The Indians and the Chinese, in particular, want to get, you know, more of the business whereas the others all pretty much stay back; the Japanese as well. The other sectors, communication as I mentioned, the Chinese are building up [their] communication satellite capability selling in particular [to] African countries coupled with the launch and the services for that. Remote sensing in India and in Europe… the Russians also have some remote sensing but as far as I know have enough good market penetration, you know, and I don't know what the Chinese are doing in that sector in terms of commercially marketing [their] capability. But actually, yeah, they were working with others for a while on electro-optical remote sensing so yeah, China, India, you know, have been active in promoting their commercial capability.

Interviewer: And would you say that commercial actors in the launch industry look at these other nations as, you know, potential opportunities for growth?

B. Alexander: I don't think so. I don't think so. I mean, India, for example, the communication satellite industry, the satellite industry concept. They looked at India as an opportunity -- as a market opportunity, maybe 15, 10 to 15 years ago. But the Indians chose to keep their market closed. But that the old communication companies that could broadcast to India were Indian manufactured, Indian-owned, Indian capabilities so that market remained closed, they had the state department overseeing India for a long time on a market access agreement that did not work. I don't know if they were negotiating, but they were talking about it.

Major General (USAF ret.) James B. Armor, Jr.[8]

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

WRITTEN RESPONSE

- Space is normalizing. More players will have more access to space and space capabilities. This is a fact of life. NSS community should embrace it
- Space medium stability is in the interest of the US and West.
- New electronic and additive manufacturing technology is moving advanced capabilities to more players.

Marc Berkowitz

Vice President, Space Security (Lockheed Martin)
12 June 2017

WRITTEN RESPONSE

What are the national security implications of increasingly accessible and affordable commercial launch services?

The national security implications of further increasing the number of nation-state and sub-national actors able to access space are twofold. First, it risks continuing to make the space domain more congested and complex. Such increased congestion and complexity will impose additional resource burdens on space domain awareness capabilities and could create additional debris or other hazardous operating conditions that pose risks of mishaps. Second, conversely, more affordable access to space holds open the promise of igniting further innovation in space technology development and applications that could reduce the cost of national security space activities and increase their operational utility.

Are these the same for the US and near-peers or states with emergent space capabilities?

Yes, in general. An advantage should accrue to the side that mitigates the risks and takes advantage of the opportunities created by accessible and affordable commercial launch services with the greatest speed, agility, and consistency.

[8] 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.

Dr. Riccardo Bevilacqua[9]

Associate Professor
(University of Florida, Department of Mechanical and Aerospace Engineering)

14 August 2017

WRITTEN RESPONSE

The most general implication of accessible and increasing space services is the creation of additional space debris. In the long term, the ability for humans to continue exploiting space flight may become limited. In particular, both defense and civilian/commercial activities in space are increasingly threatened by the tens of thousands of objects that are either active artificial satellites, defunct spacecraft, or the product of past in-flight collisions. More than 20,000 objects are known to orbit our planet, only half of them are matched by a name (i.e., we know what they are and who launched the satellite), while only about 1,000 are active assets we can control. Human use of Earth orbits has clearly been abused, and an uncontrolled, unregulated growth of accessible and affordable launch services may very well lead to the point of no return. Spending less per satellite is already leading to a philosophy of "the more the better". India has recently injected more than 100 CubeSats into low Earth orbit, with a single launch. Actors in the space field are approaching access to space as if it were an infinite resource, and reduced prices are enabling operators to reduce the quality of their satellites and to launch more, relying on redundancy of poor hardware. Low quality hardware's behavior is more difficult to predict and control. This is obviously a non-sustainable and wild approach but, unfortunately, there are no global regulations, and no enforceable actions, that can prevent these behaviors. At least at this point in history.

The majority of these debris objects are affected by dynamics that are not well understood, making their tracking and possible removal one of the biggest challenges of today's and tomorrow's generations. The cost of permanently removing a defunct spacecraft is comparable to the cost of its original orbital injection, with current technology, thus impractical and not part of a satellite's life plans. If we do not succeed in inverting the trend and eventually solving the space debris problem, future generations may not be able to enjoy space-based services that today we give for granted, such as GPS and weather forecasting.

From a US national security perspective, the concerns should be on guaranteeing the safety of our most expensive space assets, from the shared ISS (international property) to GPS spacecraft, from geostationary communication spacecraft to agile spy satellites. The United States and the former Soviet Union set a bad example of uncontrolled orbital injections, especially during the Cold War, and now emerging countries are leveraging on decades of technology development, to behave in the same reckless manner. Collisions in space are already a reality (first one documented dates back to 2009), and the Kessler syndrome predicts that, even stopping orbital injections entirely, current space debris will increasingly collide with each other, creating more particles, with an exponential trend.

In conclusion, affordable and increasing launch services will affect not only US national security, but also the ability of all nations to use Earth orbits. The US should take the lead in solving the space debris problem and regulating future access to space, setting now a good example. This should be achieved by developing breakthrough technology to invert and resolve the issue, leading to a series of enforceable space access and space utilization regulations.

[9] The responses here represent the sole views of Dr. Riccardo Bevilacqua, and are not intended to represent the position of the University of Florida.

Caelus Partners, LLC

Jose Ocasio-Christian
Chief Executive Officer

24 August 2017

WRITTEN RESPONSE

At this time, we see that there are limited implications to national security as a result of affordable launch, and we believe it is equally applicable to other nations. Launch affordability is an issue for gaining access to space. However, there are other hurdles that are of greater importance; if these are overcome by inexpensive technology then the national security concerns increase exponentially around the planet.

Elliot Carol[10]

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 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 costs, 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.

Interviewer: Now, would you say there is any particular national security concern given the rise of Sea Launch services, or can they be treated much in the same way as land services from land.

E. Carol: No, there are significant… when we're talking about sea launch services there's really two companies. There is Sea Launch, which is owned by S7 which is a Russian group. They are developing an idea where you put a large oil platform in the middle of the equator to get the extra speed via the rotation of the Earth; and you launch from the ocean. In my opinion there is limited, additional threat. Basically because you will know when a massive oil platform is being

[10] The responses here represent the sole views of Elliot Carol, and are not intended to represent the position of Ripple Aerospace.

pushed along closer to the US. You will know where it is launched from. With regard to our technologies and this has been a major concern within Ripple. We've done our best to alert the 45th space wing as well as other military resources to what we're doing is developing a system that is 100 percent mobile. We are developing a mobile launcher that will be very hard to track and very hard to see before we launch it, and we can launch from anywhere with little preparation. I would love it if someone could connect us to somebody that might take this concern seriously… and tell us what to do about this. Our system can be connected to almost any type of rocket and any type of missile and tow it into the ocean and flip it up and launch within 60 minutes. And, quite frankly we would love some direction about how to deal with this threat, because I think it should be taken serious.

Interviewer: I was just going to add is the pay load of the launch vehicle, can it be increased from a Sea Launch service or is there any other unique attributes to what Ripple Aerospace is designing?

E. Carol: Number one, low cost. Our small sea vehicle will capable of lifting about seven metric tons to low Earth orbit from Kennedy Space Center longitudes. We're looking at launch prices below SpaceX, Falcon 9 even though they're five times larger than us. Number one, low cost, number two our vehicles are actually assembled in ship yards. You don't need a specialized VAB building or specialized mobile collar. You literally put it together in a ship yard; in the dry dock, then you flood the dry dock and you just tow it right on a boat. I mean I'm sure the military knows where every potential dry dock could be, but we really only need a small dry dock and this enables us to do this in the dry dock and enables mass production. We can theoretically, based on the current design make a vehicle in a week if we needed to. On top of that, both the first and second stages are reusable because they are made to be launched from the ocean. They are also made to be recovered from the ocean and the last one of course; we can launch in almost any maritime condition for a larger rocket. Our limitations I believe is four meters swells.

[…]

E. Carol: Regarding security of our space assets, when we're assessing the risk of putting satellites into space or launching them, we're more concerned about natural threats. Threats such as meteors, asteroids, space junk, solar flares and not so much kinetic warfare. I have yet to experience either, through internal meetings or external meetings, a commercial company developing systems - at least a new space commercial company developing systems - specifically for space warfare, but with that said it's an easy way to justify a business model. I think a lot of new space startups, Ripple Aerospace included, see a potential market through military acquisition of our technology, in addition to development funding as well. What do we see as the biggest threat during peace time? Space Junk. I think the biggest threat without a doubt would be the aftermath of space junk flying in space and causing major damages to the satellites already up there and future satellites, in addition to the launch vehicles that we'll have to bring them up into space with.

Regarding the next question, do industry leaders think about warfare in or through space differently than most military leaders? Commercial space leaders, I do not think so.

Most of the people that I work with do not deal with the military and are focused on the commercial aspect of space. And I believe, based on my experiences, it is fair to say commercial space does not think about military conflict. So what are our main concerns? Personally, during conflict and or crisis, one of my biggest concerns is if satellites are taken out or damaged during a military warfare, what's the plan to get them back up there? Because, at least where I'm sitting, probably one of the most important assets for our nation is launch pads and yet, they're probably one of the most difficult to protect. I've asked this question with military officials. What is the plan if during warfare if the launch pads get bombed or taken out for any reason? I have tried to have those conversations because the technology at Ripple Aerospace is developing is a

launch vehicle which is launched, semi-submerged from the ocean. We see our technology as a potential solution. I have yet to hear a convincing argument what the plan is. Any questions so far?

Dean Cheng

Senior Research Fellow
(The Heritage Foundation, Asian Studies Center, Davis Institute for National Security and Foreign Policy)
2 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: Okay. So, what are the national security implications of increasingly accessible and affordable commercial launch services?

D. Cheng: Well, the more you have launch services, what happens is you move away from military-to-military as being the purview of major powers, which is what we are now, and you will see that move downward to the point where people will have the ability to put commercial observation satellites that have military-level resolution into space to serve a wide range of both national and private customers.

That in turn means that more and more the real differentiation among space powers is not going to be, "Can I access raw data?" Rather, more and more the real differentiation is going to be two things.

One, what is the frequency that I can access that data for a given site (i.e., what is the refresh capacity)? And that's going to drop as launch services drives down the cost of orbiting commercial satellites of that nature.

Two, then, as with other things, the real differentiation then is going to be in analysis. Anyone on the planet with a few dollars will be able to get raw data. Now, the question is, who is going to be able to look at that data and say, "That is a T-72 and that is an M-1 Abrams" or "that is an American AEGIS destroyer and that is a South Korean or Chinese destroyer."

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

United States Air Force Academy

Dr. Damon Coletta
Professor of Political Science

Lieutenant Colonel (USAF ret.) Deron Jackson
Director, Eisenhower Center

8 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: Okay. So, I think that segues nicely into the next question I have, which is a more specific example. What are the national security implications of increasingly accessible and affordable commercial launch services, and are these the same for the US and near-peers or states with emergent space capabilities?

D. Jackson: This shifts the dynamic out of the realm of managing relationships primarily between state actors and governments. If you have easier and lower costs for any number of smaller groups or individuals of interest to put something in space, then to what extent does that degrade the arrangement whereby states are supposed to regulate everything that gets launched out of their own territory? If that fundamental principal of the system is eroded because now a company can just do sea launches to launch from international waters, then who's going to regulate that and how many different types of actors might avail themselves to it so they become independent and unregulated?

The whole space regime has thus far has been state-based, and while we may have issues with certain state actors, we can deal with them as state actors. If some level of technology dropped to the point where space access slips the bonds of a state-based control of launch, then I think that would be a truly disruptive game-changer because that would be undoing the international regime that's based on nation state control. Though, I don't know that that's really practical, but if it happened, that would be an example of undermining the ability of the international system at that level.

Is that something that you're actually speculating on in terms of lower costs to orbit-types of issues that would truly get out of the hands of state-based actors or companies?

D. Coletta: Let me take a different approach to that question. When we had these discussions 7 to 10 years ago, most of the experts were saying that launch costs were going to be relatively stable. They couldn't see much change in the physical principles for launching certain payloads, so they felt that launch costs were going to stabilize. But your question is premised on dramatic change in launch costs, so why are both of those things true? I think one of the reasons why that happened—why we failed to anticipate the change in launch costs—is because of the change in payloads. Today, you can do a lot more with a lot less weight, and when you start to drop payload weight while also being able to still increase capability, then you can have more players come into the launch market. However, while I think that's true, I don't expect to see a bunch of commercial players coming in to serve as launch suppliers because I think the barriers to entry are still very high.

I think the poster child for this would be SpaceX. It's hard for any of us to imagine SpaceX being competitive without a lot of support and sponsorship from the government, at least in the form

of contracts. Also, in terms of human capital, I think there was quite a bit of support there to make it possible for SpaceX.

So, I don't see a multitude of foreign companies, or even American companies, that are very independent of some government entity being able to compete in this market, even if it does involve smaller payloads.

The other thing that this says to me is that you can't really ask the launch question or talk about the idea of competitive launch services without dealing with the payload question. It is possible that commercial entities are going to be able to put together small, low weight, highly capable payloads in the future, which could be disruptive; however, while this looks like a change in launch services and it looks like a drop in the cost of launch services, what's really happening is an advancement and diffusion of technology for building small, light-weight, highly capable payloads.

Interviewer: Deron, you mentioned the evolving sea launch capability, which I think adds an interesting wrinkle to things.

D. Jackson: I was pursuing an example trying to figure my way from the surface of the Earth to orbit, which is why I ran down the sea launch rabbit hole.

Damon brings up a really good point. If you work your problem/question back from orbit, which is really your concern here—is somebody going to do something in orbit that would be disadvantageous for the US?—then you'd want to start chasing the idea of what kind of payloads would be up there that would be disruptive. So, as an example, let's use the Earth observation piece, because that's something that's already out there. If you put an ever smaller, lighter, and cheaper Earth observation package in orbit, and assuming that the rate of technology remains the same in terms of countries that may start joining the launching state crowd, then an actor or entity that has a package that they want to put up in orbit, because it's lighter, now can choose from a wider variety of potential launching space. So, if there aren't certain standards or rules about what you're going to launch and what you're going to do with it once it gets into orbit, then that's your bottleneck—that's your choke point at which you can exercise influence over what gets in orbit.

But if that number goes up, not because the technology but because everyone can start putting stuff onto lighter weight rockets because they made payload lighter, then now you have to worry about who's in your gentlemen's club of practicing and believing in adherence to the international standard code of conduct.

Again, looking at the map and recent headlines, let's just hypothesize that North Korea puts itself in this category. What if North Korea became that rogue actor, an equivalent of the "dark net" (i.e., we don't care what you have; we'll launch it as long as your money is good)? What would that do for disruption of the international order if you had an actor that you could not easily coerce that was willing to put anything and everything into orbit in exchange for hard currency?

D. Coletta: That's disruption.

D. Jackson: That's disruption, and that's possible. What are the North Koreans going to do with their rocket technology once it is good and reliable enough? They could hold the US at bay, and maybe that's the one thing they use to make money.

If you develop the payload technology to the point where something very capable could be designed for not a lot of money and not a lot of mass, then there's a lot of entities—I won't say states or countries or whatever—that might want to put something up in orbit, and the lowest common denominator (i.e., the most rogue actor out there) might just be bold enough to

provide the vehicle to do that. Unfortunately, at that point, our options for stopping it, having lost control of that choke point of launch, would be minimal.

Dr. Malcolm Ronald Davis

Senior Analyst, Defense Strategy and Capability (The Australian Strategic Policy Institute)
21 August 2017

WRITTEN RESPONSE

Key Findings

- Space is becoming both contested and congested. The development of adversary 'counter-space capabilities' (kinetic and 'soft-kill' ASATs) threatens US Space Assurance.
- Although adversaries would have to consider the implications of US retaliation in the event of ASAT use, they are under less constraint in terms of introducing operational space weapons capabilities than the US and its allies in western liberal democratic states.
- Commercial space, and 'Space 2.0' open up both risks and opportunities. Space 2.0 technologies in particular make it easier to exploit space for military purposes in innovative new ways, but also see broader access to Space for a wider range of state and non-state actors including those who are unfriendly to the US.
- A key transformation to watch is the development of reusable launch capabilities – reusable rockets, airborne launch, and on the horizon, aerospace planes – which could dramatically lower cost, improve responsiveness and boost cost efficiencies in accessing and exploiting space. These potentially represent disruptive innovation that could fundamentally transform military space operations.
- The US needs to formulate an effective deterrence policy for space to dissuade adversary use of counter-space capabilities. This should be based around a combination of strengthened resilience, and rapid reconstitution of capabilities, the use where appropriate of terrestrial and 'near space' capabilities to fill gaps, and perhaps most controversially, the ability to undertake deterrence by punishment against an opponent's satellites using non-kinetic 'soft kill' ASAT capabilities.
- The loss of space capabilities – a 'day without space' – would force the US and its allies back to an older, less precise and more costly form of warfare. We would not be able to fight a 'western way of war' which emphasizes, speed, precision effect and gaining and sustaining a knowledge edge over an opponent. Instead, the playing field would be levelled to an extent where an adversary could better exploit asymmetric capabilities more effectively.

Introduction

Humanity is approaching the 60th anniversary of the launch of Sputnik 1 (4th October, 1957) and with it, the beginning of the 'Space Age'. The last sixty years of Space activities has seen some key milestones. The most prominent of course was the first manned landing on the Moon on July 20th, 1969 with the crew of Apollo 11. Amazing achievements have been made exploring the Solar System with unmanned space probes to all the major planets. Our progress in undertaking space science has been matched by the widespread growth of networks of satellites that have played a fundamental role in transforming human society and enabling globalisation in the latter decades of the 20th Century and into the 21st Century. The development of satellite technology is underpinned by global norms of behaviour in space, with key legal documents such as the 1967 Outer Space Treaty seeking to reduce the risk of an 'arms race in space' in what has traditionally been seen as a 'global commons' akin to Earth's oceans, or the advent of cyberspace.

However as is the case with the oceans and cyberspace, Space is not free of military activities and its perceived status as a global commons is being challenged. Since the 1960s Space has been 'militarised' with satellites used

for a broad range of military purposes, including intelligence, surveillance and reconnaissance (ISR), communications, missile early warning and nuclear detection, meteorology and geodesy, and precision-navigation and timing (PNT) through systems like the US Global Positioning System (GPS) network. The growth of other states' military space capabilities continues to gather pace, providing similar capabilities for US allies and foes alike. Space has become a vital 'centre of gravity' because access to space is essential in ensuring an ability to wage modern network-centric information-based warfare. In 2014, Brian Weeden of the Secure World Foundation published a seminal report, 'Through a Glass, Darkly – Chinese, American and Russian Anti-Satellite Testing in Space', which highlighted Chinese and Russian development of anti-satellite (ASAT) weapons. There is broad consensus that traditional view of Space as a global commons is increasingly challenged. Space is becoming 'contested and congested', as space transitions from militarisation to 'weaponisation'. The Obama Administration's policy which emphasized promoting legal norms against space weaponisation, backed by greater space situational awareness capability, has not prevented the development of increasingly sophisticated space weapons capabilities by China and Russia in particular. The growing risk of space debris further adds to a complex and challenging operational environment.

The US and its allies must respond to dramatic change in the Space domain, and deal decisively with the threat posed by adversaries which seek to challenge US and allied access to space. The notion of a 'Pearl Harbour in Space' at the outset of a military conflict could deal a decisive blow to US military power, and allow an adversary to level the playing field, then bring their asymmetric terrestrial military capabilities to bear in a much more effective manner. In the absence of space support, the US (and its key allies which also depend on US Space systems) would be forced back to an older and cruder approach to the use of force that is more costly in lives and platforms, is based on attrition, and is likely to be prolonged and with little certainty of military success.

This paper will explore some key issues related to Space as a contested domain. These include: what are the motivations and impacts of an opponent contesting space access; the implications of commercial space for US and allied space security; the role of Space in US deterrence strategy; and, lessons emerging from other domains in terms of 'C4ISR-PNT' capabilities. It seeks to inform discussion and debate on the implications of Contested Space Operations as part of a Strategic Multi-Layer Assessment on this issue for US Air Force Space Command (AFSPC) in cooperation with US Strategic Command (USSTRATCOM) and Headquarters Air Force.

What are the national security implications of increasingly accessible and affordable commercial launch services? Are these the same for the US and near-peers or states with emergent space capabilities?

Space launch is undergoing a transformation in technology and capability with the emergence of commercial space launch companies. No longer only the domain of nation-states, space launch is flourishing under commercial actors. Companies like SpaceX, Blue Origin, Virgin Galactic, and Stratolaunch, amongst others, are either launching payloads or soon will be, in new ways that opens up access to space to a broader customer base and at lower cost and with greater responsiveness. SpaceX is notable with its Falcon 9 booster. The Falcon 9 has a reusable first stage which returns to the launch site, or a robotic recovery vessel off-shore, where it is refurbished, and subsequently launched again. SpaceX is looking at re-using the Falcon 9's payload fairing in the future, and ultimately, the entire booster (i.e. first stage, second stage and payload fairing). Another objective sought by SpaceX CEO Elon Musk is rapid refurbishment of first stage with an objective of a 24 hour turnaround. Falcon 9 is designed to place a 22,800kg payload into LEO (8,300kg to GEO) at a current cost of $62m per launch. Complete reusability, combined with rapid turnaround and re-flight, would fundamentally transform the paradigm for space access, providing low cost, regular launch capability, with the customer ultimately paying only for fuel and use of a launch site. Likewise, SpaceX's primary competitor, Blue Origin is developing the New Glenn reusable launch vehicle which, like SpaceX's Falcon 9 (and the more powerful Falcon 9 Heavy to be launched in 2018) aims to dramatically cut the cost of launching payload into space through reusability.

The key implication of reusable rocket technology like Falcon 9, Falcon Heavy and New Glenn, and in the future, Elon Musk's proposed 'BFR' super-heavy reusable booster, is that these launch vehicles could lead to fundamental transformation in space launch and represent true disruptive innovation. The emphasis for commercial space launch companies is on lowering cost per kg to orbit by exploiting innovative approaches and technologies and minimizing waste. The lower the cost, and the more responsive launch capabilities can be, the more space can be

utilised for a variety of tasks, including by a broader range of actors. Space ceases to be dominated purely by superpower or major state actors – the proliferation of access at lower cost makes space open to all. Small expendable rockets also tap into a growing market (particularly in relation to launching small payloads). Commercial companies such as New Zealand's 'Rocketlab' with their Electron booster; Arca Space Corporation's development of its Haas 2CA Single Stage to Orbit powered by an Aerospike engine and Vector Space Systems with its Vector-R that employs a mobile launch system, emphasize innovation in their approach to space access.

Airborne launch systems such as Scaled Composites Stratolaunch and Virgin Galactic's Virgin Orbit provide another path into orbit. On the horizon, hypersonic propulsion technologies suggest the prospect of single stage to orbit aerospace planes that are fully reusable, and provide airline-style efficiencies for low-cost space access. Britain's Reaction Engines is developing the 'SABRE' (Synergetic Air Breathing Rocket Engine) that could power a future manned or unmanned fully reusable aerospace plane suitable for space launch. Research into supersonic combustion ramjets and combined cycle engines for hypersonic flight also suggest that aerospace planes are the most likely path to the next generation fully reusable space-shuttle type vehicles which can take off under their own power on a regular runway, transition to hypersonic flight, and then boost into orbit on rockets, deliver a payload, and then re-enter and land under their own power. This would represent a highly flexible, responsive and totally reusable space transportation system for personnel and payload, and mark a capability that the original space shuttle could never have matched, but which originally drove its conceptual development.

Ironically, large, expensive fully expendable rockets, which take months to prepare for launch, and cannot be reused, are still the focus of NASA with its 'Space Launch System' (SLS) and United Launch Alliance (ULA) with the Atlas and Delta family of vehicles. A key question is how these traditional launch vehicle technologies will compete with reusable rockets, airborne launch, and ultimately spaceplanes in terms of cost competitiveness, efficiency and responsiveness in the next two decades, particularly as reusable launch systems mature over time? It is this transition from an old paradigm to a new one – from Space 1.0 to Space 2.0 – that marks the most visible transformation of the space sector, and makes the rise of commercial space launch so important.

At the moment, developments in reusable launch, and more broadly, commercial launch services, are concentrated in western liberal democracies, notably with the United States leading, followed by France's Arianespace. Russia and China still rely on state-run space launch services, using traditional expendable rockets. Russia is developing and promoting is Angara booster, produced by Khrunichev that will replace the Proton rocket by 2025. The Angara 1.2 is the light booster than can launch satellites up to 3 tons in weight, whilst the heavy Angara A5 will be capable of launching 25 tons from 2021. Given the growth in the light satellite market, Angara 1.2 is designed to compete with Arianespace's Vega booster, and with SpaceX, as well as Chinese, Indian and Japanese launch vehicles. However, Russia's space launch industry are beset with reliability issues and poor production quality, resulting in a string of launch failures for Proton, so its ability to successfully market Angara is questionable. The 2017 Space Report (paywall), produced by the Space Foundation suggests China may be the state to watch in terms of future space launch competition. China's share of the global orbital launch market for 2016 matched that of the US, and excelled all other launch providers. China's launch systems are predominantly produced by state-owned enterprises, rather than commercial companies, but China appears to be set to move towards a commercial space capability designed to compete with counterparts in the West. China's Kuaizhou-1A commercial space launcher is designed to carry small satellites up to 300kg in weight, with high reliability and short preparation.

It's clear that the US and Europe have an established lead in commercial space launch technology, and are moving forward with new approaches to getting payload into orbit, but the prospect for China in particular to challenge US and European respective market shares should be taken seriously. So what are the national security implications of growing competition for market share in commercial space launch between US and Europe against China, and perhaps Russia, particularly if this leads to reductions in cost for accessing space?

Commercial space launch, and particularly, reusable launch systems means that peer adversaries can do more in space if they develop these types of capabilities. Lower launch costs means greater development of space capabilities, higher frequency of space launches, and more comprehensive space-based systems for C4ISR and PNT, as well as for other roles. Low-cost reusable rockets may enable easier access to Space for the deployment of

space weaponisation. A CSIS Report 'Implications of Ultra-Low-Cost Access to Space' (2017) highlights a number of potential space weapons applications (Chapter 4) – Space-based kinetic strike against terrestrial targets; Space-based missile defence; Space-based ASATs; and Space-based directed energy weapons – that could be enabled by significant reduction in launch costs. The CSIS report also raises the prospect that low-cost space access would enable innovative uses of space transportation for projection of military power and logistic support.

In considering these missions, and their prospective procurement costs, a Chinese development of low-cost reusable space launch, building on efforts with Kuaizhou-1A, as well as larger expendable boosters in the Long March series, would enable China to begin developing serious space weapons capabilities for projecting force from Space against other targets in Space (i.e. satellites and spacecraft), as well as against the Earth. China is also pursuing the development of aerospace plane technology, with a number of projects underway. For example, the Chinese Aerospace Science and Industry Corporation (CASIC) is developing a spaceplane, with the project seeking to emulate the UK's Reaction Engines SABRE type technology. This is a step forward from China's earlier efforts with its Shenlong experimental spaceplane that was considerably smaller, and less capable than the much more sophisticated US X-37B.

It is important to understand that the US will not be able to maintain a monopoly on the technologies and capabilities associated with low-cost commercial space access, such as reusable rockets, air-launched space capabilities and ultimately, aerospace-planes indefinitely. In the same way that commercial jets took over from propeller driven airliners in the 1960s and the technological rapidly proliferated, reusable launch systems will proliferate in the 2020s and beyond. The days of large, expensive and fully expendable boosters (like 'SLS') are numbered – they represent yesterday's approach of getting payload into orbit.

Were a country like China to develop modern reusable launch capabilities, either with its own reusable rockets, airborne launch, or aerospace planes, it would place severe pressure on the US and its allies to respond in kind, or in a manner that countered any Chinese advantage gained from large-scale space weaponisation. The potential for an action-reaction 'arms race in space' would become very real, in a manner that was highly destabilising and ultimately costly. Such a development would mandate a requirement for the US and its allies to deter Chinese space weaponisation. The policy challenge of developing 'space deterrence' should be a key objective for the Trump Administration, and for US allies which support the US in space security endeavours.

Faulconer Consulting Group

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15 August 2017

WRITTEN RESPONSE

If the per launch cost actually did come down, more frequent launches and launch on demand is needed. DARPA's XS-1 can be a model, meeting National Security needs and also being built to a business case.

The utility of smaller space systems in the form of cubesats and smallsats has grown dramatically over the past

decade. The national security community (to include intelligence) is increasingly able to make use of these systems across the spectrum – remote sensing, PNT, weather, space situational awareness, counter-space, targeting. Companies like Planet have actually produced capabilities of tremendous interest to the IC, for example. The Director of the National Geospatial Intelligence Agency (NGA) has been very vocal about the utility of the spacecraft being put up by Planet. India, has been a major enabler of Planet's (and, by extension, the IC's) success by launch multiple spacecraft (as many as 88 thus far) on one rocket. Will US firms also be enablers? Firms like RocketLab, Vector Space Systems and Stratolaunch are jockeying for position to do just that. While the question posed by the national security community in the 1990's was "what relevant capability can we possibly launch with small rockets anyway?" the question now is "how quickly can we get you on contract and when can you launch?" If one accepts that increased resilience is a key goal of the national security community, current and planned more affordable and flexible launch systems fall directly into that sweet spot.

For decades the United States has had a single provider of heavy launch services – United Launch Alliance and its predecessor companies, Lockheed and Boeing. SpaceX may very well change the game if the Falcon Heavy can launch successfully and offer the government a lower price point. Disaggregation of space systems is indeed a laudable goal but there are certainly capabilities that, for the foreseeable future, will require larger launch systems.

Companies like Blue Origin, financed by billionaire Jeff Bezos, are developing engine technologies for commercial purposes with spin-offs that are directly relevant to national security. Testing with the BE-3 engine for space tourism have led to development of the BE-4, potentially powering the new ULA Vulcan and other launch vehicles. Likewise, Virgin Galactic Launcher One and Stratolaunch, funded by Richard Branson and Paul Allen, respectively, could become enablers for cheap and resilient space launch.

Congress has also taken steps to direct the DoD and the IC to look at allied country launch systems to augment our domestic capabilities on more than a no-exchange-of-funds basis. Current US national space transportation policy requires USG payloads to fly on US launch vehicles with the exception of international cooperative missions. The European Vega launch vehicle just put into space two high-resolution payloads for Israel. Arianespace has this capability to launch for many emerging space-faring nations where US systems may still find themselves restricted based on ITAR controls. Vega, a launch vehicle long-in-coming to market, is situated to provide significant lower cost opportunities to many emerging nations. China has suffered some launch setbacks but that nation remains highly capable as a low-cost launch provider. Russia has also encountered a series of launch challenges but also remains unencumbered by export restrictions and high labor costs.

Reusability is being addressed by a number of US launch companies. SpaceX has demonstrated re- use of the Falcon 1st stage and other companies are also looking carefully at reusable systems. One can certainly envision commercial investment in reusability enabling a range of military and intelligence missions.

Since we're talking more about commercial launch systems that must perform successfully in supporting government and commercial customers alike, near-peers and states with emerging capabilities may be able to reap national security benefit from these new systems. SpaceX, for example, has demonstrated a capability that is reliably servicing USG, US commercial and international customers. Even the heritage provider, United Launch Alliance, has had to invest in a new launch system, the Vulcan, to remain competitive across the commercial-government spectrum.

Some threat countries may herald satellite launches on vehicles actually intended for ballistic missile use. In the case of countries like Iran, space launch capabilities can be dual use. The recent launch of a satellite on Iran's Simorgh space launch vehicle may bear more significance for ballistic missile capabilities than in-space capabilities.

Lieutenant Colonel Peter Garretson

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

WRITTEN RESPONSE

Well, if we don't lead, we are screwed. We have a brief window where we our nation has a definite lead in re-usable launch vehicles, and where a public private partnership could consolidate our lead. The implications of increased access are that whoever has cheap, abundant launch services can: 1) Capture market share 2) Enable new markets (broadband, propellant depots, space tourism, space resource mining) 3) Affordably field entirely new military capabilities (Space-Based Radar/MTI, space-based Missile Defense, Space-Based Terrestrial strike) 4) Global sub-orbital ISR and strike.

Yes, if we can do it, so can they. The PRC in particular is already giving thought to this.

Gilmour Space Technologies

Adam Gilmour
Chief Executive Officer

James Gilmour
Director

13 July 2017

WRITTEN RESPONSE

Potential for commercial space launch services to launch assets for other governments. Doesn't appear to be any formal rules of the road for what non-weaponized satellites are allowed to be launched for any particular country.

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

15 August 2017

WRITTEN RESPONSE

If access to space becomes more affordable to other nations, it could fundamentally change the way space capabilities are designed, built and operated. However, low cost access to space is just one variable that affects the

cost of space. If we consider the potential for on-orbit servicing, to include fuel and hardware updates; software defined capabilities, and on-orbit quantum computing, everything changes and the US will be forced to rethink just about every aspect of how we operate in space. We will need to take a comprehensive look across the enterprise to determine what is still relevant and can still be utilized and what is no longer relevant and needs to be addressed.

The U.S. may have to rethink "how we do space" writ large. The legacy requirements for large, highly sophisticated, redundant systems, with lots of fuel, multiple backups, and long service lives may no longer be required to the same extent as today.

Theresa Hitchens

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

WRITTEN RESPONSE

More actors in space. Good and bad both for U.S. national security; better for international security and world economic development. Cheaper launch is good for U.S. too. In all, this is a positive development for space sustainability and security, and should be encouraged.

Dr. Moriba Jah

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

INTERVIEW TRANSCRIPT EXCERPT

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: Do you see the US as being more impacted by this increase in accessibility and affordability of commercial launch services, or do you think it's sort of universal across the board for all international actors?

M. Jah: I think the US is a little bit behind the ball compared to other countries like India, etc. I think the US has an opportunity to catch up and actually be the leader in exploiting all these capabilities, but I think right now they are definitely behind other countries.

[…]

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-terms (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.

Dr. John Karpiscak III

Physical Scientist (United States Army Geospatial Center)
26 June 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: So, digging a little deeper with respect to the idea of space security, how would you define space security or a secure space domain? And do you think space is secure currently?

J. Karpiscak III: I see it as somewhat secure, being that it's very difficult to reach out and impact space systems that are in orbit, particularly in MEO and GEO orbits. With respect to space systems that are in LEO orbits, this is a different case where you can have lasers effectively blind optical systems of one sort or another.

But the question that you originally asked got me thinking. The more the world becomes integrated economically and electronically, the more difficult it is to really predict this stuff anymore. For example, if you're a second or third world country, why loft a satellite when you can launch a stealthy UAV and achieve a lot of the same effect.

So, we're looking at alternatives to space. While space may be secure, the object that you are trying to achieve (i.e., the protection of your own forces at the point of exploiting other forces) may not be as achievable as it used to be years ago because the entire situation that we face is highly dynamic, with a lot of technologies, and in a state of rapid advancement. This gets to one of your later questions where you can probably predict the state of being over a 1-5 year range, but beyond that, you might be better off pulling out your dart board because there are a lot of things that we didn't think were possible that are now coming to fruition.

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 issues 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.

Interviewer: Given all of this rapidly developing technology, plus the increasing number of actors that are getting involved in the space domain, how should space feature in US deterrence strategy? And what kind of changes to US deterrence strategy might be needed to account for a rapidly evolving space domain?

J. Karpiscak III: That is probably the most important question on your list. I think you can look at this a couple different ways. Overall, I think there are 3 key factors: preemption, integration of thought, and monopolization.

By preemption I mean getting people to work with us and to expose the fact that we can see things in country X and elicit a worldwide response. We can do that via continual monitoring of certain areas and sharing the data. This is not just from a military weapon standpoint (i.e., monitoring for new missiles new launch complexes) but also to reveal things like the extent of resource depletion in a country that might be going to war with another country. From space, we can monitor all sorts of resources to identify indicators and warnings of resource depletion—for example, we can monitor many important factors regarding water, minerals, and forests. Resource depletion has always been a historical reason of going to war, for one reason or another, so the more we can share or understand the extent of those resources and how they're being depleted, the better the likelihood that would be able to intervene and step in and address the issue before it escalates into a war between the two countries. I think this is probably—the deterrence—the biggest thing that we can do—something in the form of preemption.

Another important factor is the integration of thoughts, especially for the active military or as a reserve officer, to avoid two-dimensional thinking and have an integrated approach to deterrence in whatever you do rather than making space some kind of an afterthought.

With respect to the third factor, monopolization, the way to maintain multi-domain deterrence is simply to be the best at it and have everybody come to you. To do so, you have to make space access more affordable to people and provide more incentive to partner with the US and other countries and organizations. But we also have to understand that the big caveat here is: regardless of what you do, you'll never ever be able to prevent a bad actor from getting access to space—you only may be able to limit their access for time or limit their access through another party. Like I said earlier, the gun control example is probably the best one. I think with the rate of technological change coupled with other things like additive manufacturing, the game has changed permanently with regards to launch and other things.

But along those lines too, I would think that still the most important need that we have at this point is probably detection and warning. Not limited to ICBMs or spikes in EM transmissions prior to the start of aggressive actions, but also with regard to space debris and the occasional asteroid impact. I like looking at the things like the Chelyabinsk meteorite. How did that get through? Well, it was too small for survey telescopes and it "came out of the sun." Nobody found it. But this kind of thing is going to happen again. So, detection and warning really needs to be rolled in to our overall space strategy.

Group Captain (Indian Air Force ret.) Ajey Lele[11]

Senior Fellow (Institute for Defence Studies and Analyses Centre on Strategic Technologies)
9 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: Okay. So, it seems like there is an increasing focus amongst commercial actors, like SpaceX in particular, towards launch services. So, what are the national security implications of increasingly accessible and affordable commercial launch services?

A. Lele: One has to look at this from both sides. One side of this is that this increasing commercial investment is a great driver for boosting up the economic situation and scientific/technical capacity of the country in which the company is operating. But, the other side of this is that if the country does not have any sort of a legal mechanism in place for this, then it is at risk of encountering a situation where it is knowingly allowing a private space actor to launch a private satellite, but the country is unable to accurately verify what the purpose of that satellite is or why that satellite was being launched.

I'll give a slightly tangential example. When we talk about rules and regimes, if the concern is an entity, you have IAEA, and if the concern is mechanical issues, you have OPCW. But, this is problematic because 1) that sort of a mechanism right now is too premature to talk about for space and 2) even if a mechanism is there, it's very difficult to really identify things because you just can't enter into somebody else's satellite to see what sort of sensors are being used and what sort of purpose it serves. So, those are going to be the basic challenges for space. I think United Nations will certainly have to play really major role here, but there has to be a good amount of legal mechanisms at the national level before one can think about certain amounts of international legal mechanisms.

So, right now, I think even if commercial actors come making inroads into space, it's a welcome thing but you need to have a certain amount of legally binding mechanisms so that there remains some means of accountability and control. Otherwise, what will happen is that under the garb of private commercial launches and under the garb of sending satellites at their own whims and fancies, there is a risk that no one will know what sort of satellites are being sent into space and for what purpose they've been sent.

[11] The responses here represent the sole views of Group Captain (Indian Air Force ret.) Ajey Lele, and are not intended to represent the position of the Indian Air Force, Indian Space Research Organization, or Government of India.

Dr. Martin Lindsey

Principal Aerospace Engineer (United States Pacific Command)
7 July 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: Okay. Just one more question. So, you talked a bit about how cooperation is a lot more common than competition, especially in the commercial sector, but how does this compare with proliferation? How much of this cooperation is primarily in the commercial sector, and is it more of a liability in terms of proliferation or is it a net positive for the US and other allies?

M. Lindsey: To me, proliferation means that the spread of technologies, and it also has the connotation of the spread of technology that you want to control somehow so that people that shouldn't have their hands on those technologies don't get their hands on those technologies.

I think what you're going to find is, just like in the cyber world and the electronics technology world writ large, that the same thing is going to happen in space. The cost of a cube satellite now is down under $100,000, which means that there's not a country in the world that can't conceivably fly their own satellites. The only big capital barrier to getting into space that remains is launch itself—actually getting the satellite into orbit—but that barrier is coming down too.

So, that's going to be the final barrier to counter proliferation: As commercial companies increasingly are providing that space launch service at lower and lower prices, everybody that wants to, will be able to, put things into space to do meaningful missions, whether that's ISR missions or communications missions or, in the case of nefarious actors, space control and counter-space missions. That proliferation is already happening, and in my mind it's inevitable. I don't see how you control it at this point—other than the way we try to control other technologies (i.e., just having a great global ISR of who's doing what and calling out the bad actors as we see them).

Dr. George C. Nield

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

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: Right. Okay, great. This next question I think you certainly have a unique perspective in this. In terms of national security implications, increasingly accessible and affordable commercial launch services and also are these the same for US and near peers or states with emergent space capabilities?

G. Nield: A really important question. I think the national security implications are just huge. The US has the advantage that it has extensive experience and tremendous capabilities, but as we look around now and we see the amazing things that you can do with small-sats and as a consequence, lower launch costs, other nations have the option at least to take some significant short cuts on the way to having an impressive set of space capabilities. If I could offer an analogy, it took many, many years for us to have a deep and broad telecommunications network in this country but if you look at developing nations today, they're taking shortcuts. They use cell

phones. They do not have to lay all that cable, they do not have to have all those stations and operators and all the rest. It is not like everybody has to repeat the steps that we went through.

Generally, I think we're saying now that if you are talking about Cube-Sats, you can launch them as secondary payloads or on small expendable launch vehicles. You can do some amazing things without having gone through the step of building facilities like the Kennedy Space Center or space shuttles and all the rest, and so if we're not careful, we're going to have a whole bunch of competition or threats from the rest of the world from people that are taking shortcuts and taking advantage of what current technology is offering.

Interviewer: Do you have any recommendations for how to mitigate the proliferation or ubiquity of that technology and innovation?

G. Nield: Good question. I would try to flip it around and say we shouldn't try to mitigate proliferation but what we should focus on is being the technological leader. I think we have tried some other approaches. We tried to encode GPS signals and make it hard for people to use and then people said, "Well heck, if you're not going to let me use that, then we'll do our own." Now we see many systems instead of just GPS around the world. That's a missed opportunity. Look at things like ITAR. We thought, "We'll take care of international competition by not letting them use US parts." What was the result? We encouraged other countries to develop all these nice technologies and now they do not use US parts for some of their space craft and that is costing US industry business, and it has resulted in competition at the top end. Rather than trying to hold other people back, let's just focus really hard at being the best and being out in front and taking advantage of the technologies as they're developing, and encouraging the innovation and the use of new technologies and better, faster, cheaper and all the rest. It might not be the exquisite, do-everything military systems that we're used to having. But because the refresh rate is so great, think of how cell phones and iPads and everything turn over so quickly… you have new versions coming out every few months. We need to think that way in terms of running military systems and then, Wow! Look at what can happen!

Interviewer: Right. So, it is best to just stay ten steps ahead.

G. Nield: Yep.

[…]

Interviewer: Right. Okay. As far as the next question goes, you know, this can often be sited 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. Midterm 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)
27 September 2017

WRITTEN RESPONSE

This is the world we are already in. The Indian Space Research Organization Polar Satellite Launch Vehicle launching 60 to 90 satellites in one launch at a total launch price of ~$30M is a case in point. Such access to space cannot be stopped through edict. Instead, an approach that would incentivize U.S. spacecraft manufacturers (i.e., tax credits, more favorable EXIM Bank terms, etc.) to use U.S. manufactured launch vehicles over foreign launch vehicles could enable economic forces to work in our favor and thereby have more of those launches occur from our shores and through our industry thereby providing the U.S. better insight to the capabilities being developed and put on orbit.

Dr. Deganit Paikowsky

Lecturer (Tel Aviv University)
11 September 2017

WRITTEN RESPONSE

Space Commercialization

In the past several years, we have witnessed dramatic changes in global space activity towards greater involvement by the private sector. These changes come together under the overarching expression, "New Space". In trying to evaluate this expression, some experts focus on innovative technologies and on new models for performing R&D and project management, others emphasize entrepreneurial activity, commercialization, and new models of financing. New services, new frontiers and explorations all constitute aspects of New Space. All of these elements have combined to create a new environment for global space activity that is currently being developed. For this reason, **"New Space" should be referred to as a new ecosystem for global and local space activities**.

An ecosystem is a system or a network of connected and interacting parts. Observing "Old Space" and "New

Space" through the prism of an ecosystem, means that no one element defines the differences between old and new. Instead, it demonstrates that the changes are a result of an overall mix of elements which have changed; their connections and interactions form a new ecosystem. Understanding the complexity of this evolving ecosystem is important in order to better forecast its implications, opportunities and challenges.

The ecosystem of "Old Space" is highly associated with the Cold War during which it was created and has been shaped. Nevertheless, even though the Cold War ended 25 years ago, the ecosystem of "Old Space" continued to exist. In fact, **currently, we are in a period in which the two sets of ecosystems coexist**.

"Old Space" ecosystem refers to space activity which is being controlled by national activity, and is mainly a state-only playground. The primary actors in this ecosystem are the superpowers and their close allies, which are motivated by national considerations.

The fact that space technology is dual-use and as such has significant military implications played a significant role in space activity during the Cold War. Under Cold War circumstances, the dual-use of space technology was perceived as a major challenge. Each of the two superpowers placed strict restrictions on proliferation of know-how and technology.

The change in the security environment in the aftermath of the Cold War allowed many of the strategic restrictions on proliferation of knowledge and technology to be removed. This process triggered **a shift in favor of the dual-use aspect of space technology, which became an opportunity**. This change generated greater international cooperation, commercialization and expansion of the global space market. Gradually, space capabilities became more accessible, new technologies were introduced, the cost of access to space declined, and the space market further expanded.

As a result of these developments, **two new types of players joined global space activity: (a) small and developing countries; (b) private sector players.** Together, they introduced significant changes on the interconnections and interactions in the ecosystem of space. In this context, a significant change caused by the rapidly growing private sector is that in many of the PPP's there has been a **shift of governmental actors from the driver's seat to the adjacent one,** where they remain active and involved but no longer play a dominant role in directing activities.

Another important change constituting the difference from the old-space ecosystem to the new-space ecosystem is the change in the rationale for going to space. **While governmental rationales are still compatible with the ecosystem of "Old Space",** inter alia, strategic considerations rather than cost-benefit ones. **For non-state actors, cost-benefit considerations are extremely important, if not the most important factor in their activities.** For many of them, space first and foremost is a source of profit – they perceive their activity as a business.

The new-space ecosystem also features new and different models of R&D, finance and management. In the old-space ecosystem, due to geo-political circumstances and technological difficulties, research and development is usually characterized by long and expensive projects involving large satellites, planned for long periods of time in orbit, and financed in a cost plus model. In addition, the fact that satellites are required to operate in the highly difficult environment of space, with the agencies operating them barely able to provide maintenance, intensify the need to assure sustainable and successful operations in orbit. As a result, project management for such projects was, and still is, low on risk taking, making R&D relatively conservative.

Under the new-space ecosystem that is focused on space as a resource and venue for a profitable business, new companies and well-established industries are working to develop low-cost access to space and affordable space technologies and services. **Most new-space undertakings are very different from the traditional approaches to space activities.** The fact that clients and investors are private actors triggers a shift in the financial models from cost plus to fixed price. This change requires different methods of management and demands shorter durations of time devoted to research and development.

The technological miniaturization of satellites enabled a decrease in the costs of developing and launching satellites. Satellites, systems and components can now be purchased off the shelf. Development processes are shorter, and satellites spend relatively less time in orbit. As a result, **project management in these fields is more**

inclined to take risks. It is tuned towards a "good enough" R&D model and performing technological demonstrations while in service, instead of aiming for 100% success in orbit, as was the case for satellite development under the old-space ecosystem. As a result, new-space R&D is relatively much more innovative.[12]

The entrepreneurial and commercial undertakings of "new space" introduce a new spirit to the ecosystem of space. The new-space ecosystem is more energetic, creative and dynamic than the old-space ecosystem. It is likely to continue to effect dramatic changes in space activities, which in turn will be very significant for governmental space activities. Governmental actors and non-governmental actors will have to learn to work together in order to address the questions and challenges which will inevitably arise. Among the issues to be addressed are: the current and future role of countries in the space economy, financing and the allocation of funds; and regulation of space activity: specifically space traffic management, addressing the increasing congestion in the electromagnetic spectrum, space debris, export controls and international cooperation.

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Dr. Luca Rossettini

CEO and Founder (D-Orbit)
16 August 2017

WRITTEN RESPONSE

Undoubtedly, increasingly accessible and affordable commercial launch services are the enabling factor for the new space economy, generating services at global level and delivering significant benefits along the whole product and service chain. However, the increasing and unregulated launch of satellites – 23 thousand satellites have been forecasted for the next ten years and this estimate grows every three months – may pose several risks.

In fact, most of these satellites are designed to be manufactured using COTS (commercial off the shelf) components. Hence, they are less reliable than government-type satellites and their death rate will be higher than the current average. Most will have no propulsion or will use the more economic electric propulsion, and hence will have very limited collision avoidance capabilities, and especially no capability for deorbit and for reentering into designated areas at the end of their mission.

Also, the large number of satellites operating in space, as shown in a study from Aerospace Corporation, may increase the probability of after-end-of-mission impact on inhabited areas up to 10%.

Although regulations and guidelines exist in the US for satellite end-of-life disposal, especially for NASA, NOAA, DARPA, and the FCC, very little has been done so far on the commercial side. This is widely acknowledged as a dangerous situation, and the flight safety of the high number of future satellites cannot depend on the application of the non-obligatory UN “Space Treaty.” Moreover, the increasing frequency of “hacked” satellites requires clear and immediate action from US government and national security bodies:

- All new satellites should be capable of performing suitable collision avoidance manoeuvers, in both cases of malicious or natural potential collisions;

[12] It should be noted that this principle does not apply for all activities under the new-space ecosystem. For example, this is obviously not the case in commercial human spaceflight, especially space tourism. The business model of space tourism requires flight safety of 100%; and cannot settle for "good enough.”

- All satellites should demonstrate a clear strategy for their decommissioning, not impacting inhabited areas in the US (or anywhere else on the planet), adopting a controlled reentry manoeuver even in the case of failure of the satellite itself;
- All satellites should adopt a defined level of encryption and alerting methodology in case of a hacking situation.

We should remember that terrestrial impacts may affect any nation on the planet. However, the US has shown itself to be among the most proactive countries in terms of space situational awareness and space debris[13] mitigation, second only to Europe, and could address at UN level the need for more clear and legally binding regulations. A commercial satellite impacting another satellite may have a limited impact. A satellite impacting a ground infrastructure, such as a bridge or dam, may have a catastrophic impact. However, a satellite with a dangerous payload, falling into inhabited areas – in US or abroad – is a scenario we do not want to see.

In other industries, such as plants or automotive, clear regulations and requirements for the equipment have been issued and agreed internationally. We are expecting the same will happen for space assets as well. If US can lead in this task, it is likely the US could benefit from the most innovative technology on the market before others.

Dr. Patrick A. Stadter

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(Johns Hopkins University Applied Physics Laboratory)
9 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: Okay. So, let's transition to the next question I was hoping to discuss. One of the areas where it seems like there is opportunity for cooperation between government and commercial is with respect to launch services. So, I'm wondering, what are the national security implications of increasingly accessible and affordable commercial launch services?

P. Stadter: So, this is an interesting question. I will answer your question, but I'm not convinced it's the right question to ask. Let me answer the question and then tell you what I mean by that.

So, we have policy relative to US launch, and you need waivers to do anything else [waiver required to launch with non-US companies]. So, full stop there. Unless that's changed or you get a presidential waiver, you're launching American, right? Launch is expensive. Costs going down theoretically means more access to space for both the US, both the commercial and national security sides, as well as adversaries and allies. Reliability is key—in other words, do I have confidence in it? We have good launch structure in the US, and SpaceX and others are coming around as disruptors are a response to the cost of that, but it is pretty reliable, and that's the key.

So, I've been interacting with SpaceX since they stood up, and I'm always very hopeful. The thing to look for in any launch service is not, "oh they got one up," but, "can they hit a consistent rate of launch," because one failure means you stop the line, and if you're in the middle of building out a constellation or something like that, you've got some challenges there.

So, I do believe that the one thing that it can do, is we are challenged in general just to get more stuff up. When you look back to the 70's and the 80's, when we were constantly launching things

[13] Where space debris may be a result of a malicious space warfighting attack or an unwanted collision with other assets or debris in space.

on all different platforms and when we had the Soviet Union and we were basically testing and experimenting them to death. Everything that we would do to try a new capability, they'd have to respond to because we had this pace of experimentation, technology development, and flowing in the operations and systems, and that was on the right side of the curve. We are currently on the wrong side of that curve.

That is, in my opinion, one of the most valuable things that a tremendous additional access to space—and the ability to just throw more stuff up there, try more things, show resiliency, show new capability—but realize because it is potentially commercial and there are foreign entities that are working this as well, that that capability is potentially available to adversaries as well, so we still have that challenge of what do we do if an adversary is constantly sending new stuff up to space? Are we being reactive or proactive? That is a key question.

So, that's how I see the launch thing. Any questions on that?

Interviewer: No. You noted that you had some other questions, so go ahead.

P. Stadter: Here is a way to view this whole situation, not just the launch services, but the disruption in space, if you will. Statement: Technology has proliferated. Anybody can get a high-reliability processor or FPGA or ASIC chip or actuator or anything like that. The technology has proliferated. Okay?

So, that opens up capabilities to a lot of people. The system engineering to put things together is hard. It is very hard. That is proliferating as well—as reliability improves, the system engineering theoretically gets easier. As capability, interfaces, etc. are defined and are available, it helps the system engineering equation. The system engineering is still very hard, but that is also proliferating, if you will.

Sophisticated operations are harder still. The ability to be able to coordinate activities and do those kinds of sophisticated things at the national security level, and we see that proliferating and flowing down into fairly impressive sophisticated operations and capabilities in the commercial world, that again is another step farther I think in the system engineering. But, there again, the technology feeds the ease of the system engineering and the sophisticated operations. That is a construct to consider for looking at the problem of "what is the implication to the US of our adversaries gaining capability, and not just nation-states, but small players."

It's akin to: as spacecraft become commodities, anybody with a decent payload can, in theory, put together a mission, and I guarantee you that the company supplying the spacecraft will integrate your payload and SpaceX or another launch provider would launch it for you. And then, all of a sudden, you've got a situation where a random a mom-and-pop store can have a spacecraft—that is sort of an exaggeration of a future, but that's proliferation as well.

So, this is a construct that I offer to you to consider: how that underlying technology proliferation extends into the really hard things that you only get through the school of hard knocks. An analogy people like to use is as a country like India leapfrogs the whole issue of laying telephone cable and fiber by just going right to wireless that was built and invented here. That kind of thing.

So that's a construct to consider, not just for launch services but space technology in general. And I think these are important discussions.

Interviewer: That's interesting. So, the technology part is there more and more becoming there, so this will eventually fuse into the implementation part?

P. Stadter: Yeah. I'll give you another example. You see it in cars, right? 20 years ago you had this situation where the Japanese had very reliable cars and American cars weren't as reliable. This is a generalization, right? Back then, if your car could get to 100,000 miles, that would have been great. But, now, the reliability and the precision of manufacturing and the reliability of

electronics has gotten to the point where you can go out and buy a base model $12,000-$15,000 car and you're going to expect to get 150,000-200,000 miles out of it because the technology and the manufacturing processes themselves have improved that much. It's equalized a lot of things, right?

You will eventually—even though you don't quite have the numbers—you will eventually, I believe, see the same thing in space.

Stratolaunch Systems Corporation

Steve Nixon
Vice President for Strategic Development

Melanie Preisser
National Systems Director

18 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: Right. Okay. I'll move on to the last question here. It's more of a national security question. But we appreciate the commercial perspective on that. What are the national security implications of increasingly accessible and affordable commercial launch services? Are they the same for US and near-peers or States with emergent space capability? The last point touches on the involvement launch technologies and other innovation. Are these going to be rapidly available across the world or is this likely to remain in the west or in other launch leaders within the next 10 to 20 years?

S. Nixon: Yeah. I think in the next two or three years, our little industry of small launch companies, could potentially drastically change the equation for routine and affordable access to space for small satellite makers. That could have profound effects on rapid innovation cycle that you see in things like iPhone or Android phones or any of those where every year you're getting the new model. These things that hit a price point for both launch and themselves that allow you to achieve that kind of innovation in the commercial market. If these companies can get to launch. It turns out it launches the hardest part of the whole space value chain. It requires the most capitalization. It has the greatest risk and receives the least rewards of the space value chain. I mean it is better in any part of the equation whether it be operating satellites or be in the data analytics in satellites instead of launching them. That's why I think you only see big governments and billionaires are mostly the ones interested in doing launch. But as far as the security implications of having potentially a whole bunch of small satellites up there.

I think the big thing is that that could help stabilize and change people's tactics about space -- that attacking one or two things won't get you much. It could be very stabilizing in some ways. So I think that should be encouraged. The DOD could send large groups of satellites to go up. That would be a way for the DOD to achieve some surprise and other war fighting benefit by hiding among other assets that are going up. That would be a benefit to whichever country takes advantage of that. This is an area I don't think you want other countries to do a better job than us. You don't want to feed access to space to other countries. Because of the choke points that exist in space you want to control that, and that is how you become a super power. Do you want to as a country have a huge space and access to space dependency and let them dominate your ability to reach orbit? That does not seem to be a pretty good idea.

Interviewer: Right. How far would you say other commercial actors and other national actors are behind in developing comparable technology that is being designed and implemented at Stratolaunch? It's quite a leap to… it's quite a development in the launch world in what Stratolaunch is hoping to achieve, right? So how far are the actors behind in copying or coming up with something comparable?

S. Nixon: Yeah. We have a unique aircraft in the world. It's the world's largest airplane and it can carry 550,000 pounds. It's a monumental engineering feat to build the aircraft, let alone design it and requires a massive courage to even think about pursuing it. We've heard that countries like China are interested in air launch now but I would not expect them to do it to the scale that we're talking about with Stratolaunch. Other company like Virgin is able to launch with a 747 class aircraft and so they obviously got to be available. At that level, you could see that a lot of countries could decide to pursue it. You're limited by the size of your launch vehicle to probably about as big as LauncherOne. It probably can't go much bigger than that. But I think that particularly at the small launch vehicle class, I don't think the barriers to entry are that high to other countries. With small satellites becoming more and more capable, the benefits of developing a small launch capability is growing. It's not like in the past we drive the most benefit by putting something in the GEO which takes a monstrous rocket and monstrous spacecraft to that. That's a huge hurdle for the country we get over. But it's a small satellite in the future can provide tremendous capability and all you need is a small launch vehicle to get it there. That's probably within reach, I think, and you see that around the world. A lot of countries are developing small launch and a lot of companies. A lot, a lot of other countries and companies are very… are trying to get in on the small launch business.

Rocket science is so hard and it's not trivial to do this stuff. But the barriers to entry I think are lower than they've ever been to do something really, really meaningful in space with a small rocket and a small satellite.

[…]

Interviewer: Okay, great. We'll move on to the first question here. In interest of time, I'll just read the first sentence of that question and then I'll tee you off that. How do commercial ventures think about the security of their space assets during peacetime, crisis and conflict?

S. Nixon: Yeah. Here I have to make a distinction again, on how we're doing versus my impression of how most of the industry is thinking about this. I think in most of the industry, security and contested space are concerns that don't really help them with their business cases. They're trying to get products into doing commercial stuff as quickly as they can. They don't do a whole lot about security stuff because that doesn't help their bottom line much. Now, I think we are a little different because we position ourselves on some issues as interested in helping the DOD and so we're thinking about it pretty significantly. But even we in terms of investment are limited in terms of how much we can spend of our own money hardening our systems for warfare in the future. We think that's probably something we need help from the DOD on, if we need to augment things to make us more resilient...

The inherent thing about our system is that we're air launch and we use solid rockets. So, there are inherent things about our system that could be very beneficial and interesting for the DOD. Stuff like cyber protection in particular is a huge issue. We probably need some sort of DOD help to harden ourselves for that. I think other companies are probably not even thinking about it for the most part.

One other point I'll make is, most launch is from fixed sites which are incredibly vulnerable to disruption from an adversary. It's a pretty fragile infrastructure that has more and easy access to an adversary. Most launches are still coming from those fixed sites. I think DOD for the most part

doesn't know how to grapple with that. The vulnerability is clear, and it seems they feel that there's not much they can do about it, and so they haven't done much about it.

To the extent that other companies plan to launch that way makes them vulnerable to the same issues. One of the things that we provide is since we're air launch, we can just move to other airports that might be more secure. Just being mobile makes you more secure and having flexibility in a variety of different launch points makes you more secure. That's another thing about our particular system that makes us better suited for that stuff. I think by and large, the commercial industry is not really thinking about it, and particularly if you're launching from Vandenberg or the Cape, that's just inherently a very dangerous climate in a contested environment.

Interviewer: Okay. Yeah. I agree with all of that. I'm going to move on to the next question here. Are other nations outside the West poised to tap into their own commercial space industry for military purposes in the next 5-10 years?

S. Nixon: Yeah. I think that's definitely a good question… India and China are both very aggressively working space launch and things in space. We see a lot of crossover between what they're doing for military and government purposes and commercial, and a lot of concern about subsidies. Which makes it hard for commercial companies. But also, helps the other countries ensure that they have launch also available for military purposes.

There are recent articles about Russia's space agency Roscomos planning to compete with SpaceX. In those articles, the Russians are worried about SpaceX as a threat to them in the global market for satellite launches, and they're talking about making things cheaper including innuendos of government subsidies to keep things cheap.

Interviewer: We're aware of that after the United States, Russia is the next leader in the launch industry. Speaking maybe nations like India and China and maybe European nations, where in the launch world are the commercial sectors about to flourish or on the cusp of a lot of innovation and development? Or is it strictly only in the US and Russia that there's any feasible commercial space industry?

S. Nixon: At the class that we are concerned with, we talk mostly about India actually and their Polar Satellite Launch Vehicle (PSLV). They're doing launches both for international and US small satellites. Out of frustration for a lack of capability in the US, a lot of US companies are putting payloads on PSLV launches. For the small satellite launches that we really focus on, the Indians have found a nice sweet spot in launch capability that seems to attract people, even despite all the hassle of going over to India and launching over there. They're still doing it, even DARPA is planning to launch there.

I think China is being very aggressive too. It seems like… I would not expect DARPA to go to China for launch -- the way we're insulated from competition along those lines in China just because of all the rules. I'd say India is the one that we focus a lot on. Although, yeah. I mean Russia tends to do pretty well. But mostly for bigger things, I think.

Interviewer: Now, is the comparative advantage of launch in India is strictly the price and affordability or is there a specific launch system or type of innovation that India is excelling at or exploit to in the next five to ten years?

S. Nixon: It seems to be mostly price coupled with increasing… the reliability had gotten good enough where people feel pretty good about launch on it. Then after that it becomes a price shootout. They're keeping the price of launching ride-share, small satellites. It's really aggressive. We're all having to watch out to see if they can create systems and business model that are attractive even despite the prices from India.

John Thornton

Chief Executive Officer (Astrobotic Technology)
11 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: As far as the last question goes, we'll keep in the same vein. We won't speak too much about the national security implications, but as far as accessible commercial launch services, is this something that is counted on or at least dependent on in the industry looking forward maybe the next 5 to 10 years, that this sort of technology in service becomes proliferated and universal? Are commercial actors weary of government, let's say, regulating launch and controlling it to such an extent that they're worried about their access to such services?

J. Thornton: I haven't heard the latter. I'm not as plugged into those circles. I think in general, there's a general push for trying to make that as accessible as possible and so far, the agencies that we have talked to that would approve our flights like the FAA, they've been very supportive and they want to help out. They want to make sure that this happens. I think there should be a check in there. There should be the ability in a major wartime situation to be able to clamp down on whatever that activity is or control it as such. But in regular peace time commercial operations, I don't think it should be overly burdensome to slow down or over regulate. I think it's really case by case in determining what's going up and what the use case is. In general, we're seeing a greater commercialization of space and I think that's kind of leading to just the natural progression of technology where space is more common. There's a point where it says, okay, well this is every day now. Let's move the bar a little bit to stuff that's really more complex and things that we can protect. I guess the thing that I'm getting at is ITAR, for example, can sometimes be overly onerous and restrictive on commercial in areas that say, "Well, you probably can't get into that business because you're going to be stuck in ITAR and you can't actually sell your product internationally." That leads to international actors instead building non-ITAR components and selling it to the world. And that kind of leaves the US commercial side out to dry.

ViaSat, Inc.

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15 August 2017

WRITTEN RESPONSE

From the perspective of SSA, EO, PNT, and Satcom ecosystems, the private sector views assured launch service as an implementation means for the ecosystem and not a key component of the ecosystem. Our approach to increase accessibility and affordability to launch services is to work with standard firings and shrouds and in order to have as many launch options available as possible.

Our perspective is that near-peer and states with emergent space capabilities may have objectives potentially driven by the political/economical values of indigenous capabilities. With that context, we recommend a thoughtful discussion on this topic.