

December | 2017



Ally, Adversary, and Partner Use of Space

A Virtual Think Tank (ViTTa)[®]
Report



Produced in support of the Strategic Multilayer Assessment
(SMA) Office (Joint Staff, J39)

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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 (**see Summary Response section**) and 2) the full written and/or transcribed interview input received for the question asked from each expert contributor organized alphabetically (**see Subject Matter Expert Contributions Section**). Biographies for all expert contributors have been collated in a companion document.

* 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

[Q2] How does each entity in the following categories conceive of space operations for military and commercial purposes? How do they approach space operations and services? Is there any difference in how their commercial ventures (if any) consider security during peace, crisis, and conflict?

- a. PRC, Russia, Iran, North Korea
- b. European Space Agency, Japan, India, South Korea, Israel
- c. Canada, Brazil, Australia, Singapore, Ukraine, others

Expert Contributors

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Summary Response

Given the complex nature of this question and the number of countries covered, the body of this summary response has been organized by country. Looking across all these countries, however, several themes and patterns emerge, and these are presented in Table 1 below. While Iran, Russia, the PRC, and North Korea have historically seen space as integral to national security and defense, the expert responses suggest this attitude is spreading. Motivated by the perception that regional instability is increasing, many other states, which previously conceived of their space operations as primarily civil in nature, are beginning to regard space as essential to their national security and defense. This, in turn, has led to a greater focus on dual-use technologies. Many, not just Russia, China, Iran, and North Korea, also view space as a source of national pride and international prestige. Finally, while the specific organization of the space sectors in these countries may differ, all have fewer institutional barriers to military use of civil (government and/or commercial) capabilities than we see in the US. Furthermore, there are institutional and financial incentives for government and commercial entities to work together. These findings are consistent with the analysis of the experts who contributed to Question 7.⁴

² The subject matter expert's personal views, and not those of his organization, are represented in his contributions.

³ The subject matter expert's personal views, and not those of his organization, are represented in his contributions.

⁴ To access the full NSI Space ViTTa Q7 report, please visit: <http://nsiteam.com/commercial-space-industry-for-military-purposes-by-non-western-states/>

Table 1: Summary Table of Actors' Space Operations and Approach to Space Activities⁵

Characteristics of Actor's Approach to Space Activities and Capabilities	Russia	PRC	Iran	North Korea	ESA ⁶	Japan	India	ROK	Israel	Canada	Brazil	Australia	Singapore	Ukraine
Has an increasing focus on dual-use technology	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	-	Yes	-	-
Perceives US dominance in space as a threat	Yes	Yes	Yes	Yes	-	-	-	-	-	No	-	No	-	-
Recognizes and may exploit US asymmetric dependence on space in times of crisis or conflict	Yes	Yes	Yes	Yes	-	-	-	-	-	No	-	No	No	-
Space operations are a source of national pride and international prestige	Yes	Yes	Yes	Yes	-	Yes	Yes	Yes	Yes	-	-	-	-	-
Space operations are increasingly viewed as essential to national security and defense	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	Yes	No	-
Uses, or seeks to use, civil space program for peaceful exploration and scientific research	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
MILITARY														
Has a military space program	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	-	No	No	-
Uses space for military purposes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	-
Participates in joint military space ventures / receives military assistance from other nation(s)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-
Military space activities reliant on partner nation capabilities	No	No	-	-	Yes	-	-	Yes	Yes	Yes	Yes	Yes	-	-
CIVIL														
Has a civil space program	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
Uses space for civil purposes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
Participates in joint civil space ventures with other nation(s)	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-	-
COMMERCIAL														
Has a commercial space sector	-	-	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-
Commercial space sector largely reliant on government funding	Yes	Yes	-	-	-	-	Yes	-	-	Yes	Yes	Yes	No	-
Has a quasi-commercial space sector that is overtly or covertly controlled by the state	Yes	Yes	-	-	-	No	Yes	-	Yes	No	No	No	No	-
Engages in joint commercial ventures with international partners	Yes	Yes	-	-	Yes	Yes	Yes	-	Yes	Yes	-	Yes	Yes	-

⁵ NOTE: A “-” is used within the table to indicate characteristics that are not specifically addressed in the expert contributions.

⁶ NOTE: Coding here relates to ESA specifically, therefore it may not necessarily be reflective of individual member states' national approach to space.

People's Republic of China (PRC)

Kevin Pollpeter of CNA considers China's approach to space to be motivated by the desire to "increase what [the PRC] calls its comprehensive national power ... the basket of everything that makes a country powerful: its military might, its economic power, its diplomatic power, its cultural power." This assessment is consistent among the contributors who discussed China,⁷ although there was some deviation regarding the scope of China's ambitions relative to their military, commercial, and civil/scientific pursuits in the space domain. Veerle Nouwens and Alexandra Stickings of the Royal United Services Institute refer to Beijing's "strategic vision as a global power," whereas Dean Cheng of the Heritage Foundation frames such strategic vision as being more regional orientated and not expeditionary in nature. These ambitions are grounded in the long-term "future-orientated," multi-generational planning (Dr. Namrata Goswami, Wikistrat and Auburn University Futures Lab) characteristic of Beijing's centralized approach to policy development.

How does the PRC approach space operations?

Multiple experts⁸ consider the PRC's geopolitical priorities to be driving all aspects of its space operations and services. Every component of China's space operations effectively serves its objective of increasing national power. The civil, commercial, and military components of the PRC's space operations have varying operational goals and programs, but all are ambitious and holistic in nature. For example, the PRC's civil and commercial efforts in space predominantly fall under the yoke of Beijing's national defense strategy in some form or another, but can still claim objectives independent of military ambitions. Civil space ventures, in particular, are often consistent with the strategy of dual-use technology⁹ that Nouwens and Stickings argue presents the potential for "degrading US assets in space and on Earth." Finally, as Cheng notes, Chinese leaders regard US dependence on space infrastructure as a weakness, and will seek to avoid such reliance as it advances its own space capability.

How does the PRC conceive of space operations for military purposes?

There is broad consensus among contributors that the PRC's military approach to space operations are, as Marc Berkowitz of Lockheed Martin writes, "central to denying the US its ability to sense, decide, and act effectively and thereby deter intervention."¹⁰ The experts' discussions of the PRC's strategic vision for space suggest that there is a concerted effort underway to decrease the United States' advantage in space. Nouwens and Stickings note that the Peoples Liberation Army (PLA) is seeking "information dominance capabilities in space, while developing capabilities to deny or degrade the capabilities [of the US]." Several of the experts¹¹ discuss the recent successful test of the "unhackable" quantum entanglement as evidence of China's aspiration for information dominance. Beijing's development of military space capabilities goes beyond the information domain—the PRC is also developing direct ascent missile hit-to-kill technology which could be used to target satellites or to help it improve the survivability of its nuclear-capable missiles (Grego).¹²

⁷ See the contributions from Hitchens, Sherwood, Goswami, Nouwens and Stickings, and Grego.

⁸ Berkowitz, Lindsey, and Pollpeter.

⁹ During the final review of this report, Grego cited debris clean-up satellites, such as Aolong, as such an example, while noting that the PRC has also made significant and costly commitments to non-dual-use initiatives like human presence in space and scientific exploration, which provide little utility militarily.

¹⁰ This is also supported by Armor, Cheng, Grego, Miller, Nouwens and Stickings, and Pollpeter.

¹¹ Hitchens, and Nouwens and Stickings.

¹² For further commentary on the PRC's capabilities, see the contribution from Grego.

How does the PRC conceive of space operations for commercial purposes?

Despite the military focus of the PRC's space programs, there is significant commercial space activity in China. This activity reflects China's desire "to position itself as a great power that is at the forefront of humanity's exploration of space," and science and technology more generally (Nouwens and Stickings). Nouwens and Stickings note that the PRC "has sought to promote greater innovation in the commercial domain," with entities such as ExPace demonstrating Beijing's response to the success of the American SpaceX (Pollpeter). Tempering the growth of innovation and cooperation in the space domain is what the ViaSat, Inc. team characterizes as China's "lack [of] a culture of openness and trust that is key to private sector activity and innovation."

Major General (USAF ret.) James Armor (Orbital ATK) and Berkowitz remark that, despite the advances made by the PRC in cultivating a commercial space industry, such ventures are simply "extensions of the regime" and will completely yield to functions of the state in the event of a crisis. Furthermore, Dr. Martin Lindsey (United States Pacific Command) and Cheng warn that the dual-use nature of many space technologies enables China to mask military ventures in space as civil-science operations. Consequently, commercial interests "will not deviate from PRC goals during conflicts" (Goswami). Commercial space assets may even be aggressively defended by the PRC during a crisis, and their continued operation viewed as a strategic necessity.

Russia

Russia's approach to space is primarily influenced by its resurgent rivalry with the US. Cheng characterizes Moscow's space operations and services as "one of the various instrumentalities available to achieve deterrent objectives." Yet, as several contributors¹³ note, Russia is falling behind the US in terms of its space capabilities. Victoria Samson of the Secure World Foundation writes of the vagueness of the role space has in current Russian policy, while noting that Moscow is, "just fearful of being left behind and being perceived as being weak." Nevertheless, Moscow is actively resisting US hegemony, although its efforts are hampered by substantial resource constraints (Theresa Hitchens, Center for International and Security Studies at Maryland, University of Maryland).

How does Russia approach space operations and services?

Despite its emphasis on space for defense and national security, Russia has made significant contributions to international civil space by supporting the International Space Station (ISS) and other civil space ventures. Additionally, the development of GLONASS¹⁴ and other commercial space services indicates that Russia is interested in exploiting its space capabilities for commercial purposes (Hitchens). Indian Air Force Group Captain (ret.) Ajey Lele of the Institute for Defence Studies and Analyses notes that Moscow has "succeeded in keeping their space agenda [i.e., 'orbital cooperation' and other civil pursuits] shielded from geopolitical tensions [with the US]." Supported by China, the Russian Federation has proposed a treaty¹⁵ banning space weaponry. Grego suggests Moscow recognizes that securing space operations as orderly, safe, and secure in peacetime benefits both their national security and

¹³ Grego, Sherwood, and B. Weeden.

¹⁴ The Global Navigation Satellite System (GLONASS) is the Russian equivalent to the American GPS and is operated by ROSCOSMOS.

¹⁵ The Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force Against Outer Space Bodies (PPWT) was first submitted to the UN Office for Disarmament Affairs (UNODA) Conference on Disarmament by China and Russia in 2008.

commercial interests, and contends that if “a crisis unfolds and the possibility of armed conflict in space is entertained, [we should] expect that they [will] also prefer constraint and predictability and to be able to manage the conflict.” These points of international collaboration speak to Moscow’s interest in limiting US dominance in the space domain as well as ensuring future Russian space operations.

How does Russia conceive of space operations for military purposes?

Russia is clearly capable of fielding different types of reversible, nondestructive means of interfering with satellites, and has some capability to field anti-satellite weapons and missile defense technologies that are destructive (Grego). The escalatory potential of such space technology embodies the “Russia[n] concept of ‘escalate to deescalate’ ... with its apparent emphasis on a quick resort to irreversible weapons effects” (Berkowitz), and illustrates Moscow’s interest in offensive capabilities (Hitchens). A necessary adjunct to Russia’s military capabilities in space is space-based information capability. Russia’s GLONASS PNT program embodies Moscow’s pursuit of an independent, state-controlled space infrastructure that can support informationalized warfare.

How does Russia conceive of space operations for commercial purposes?

Russia designates over 100 small-to-medium companies as commercial space ventures. However, in contrast to the US, each is administered by, and to a large extent under the control of, Russia’s space agency, ROSCOSMOS (Lele). Although primarily intended for commercial purposes, these companies are subject to Moscow’s agenda and needs. While this degree of control supports defense, the result is that Russia “lack[s] a culture of openness and trust that is key to private sector activity and innovation,” according to the ViaSat, Inc. team. Goswami notes that Russia’s commercial space efforts have included “build[ing] space infrastructure in countries lacking such expertise and sharing its space technology;” a practice which has become a means of revenue for the Russian military industrial complex (Lele; Samson). In addition to generating revenue, Moscow’s civil and commercial space capabilities bolster national pride, and highlight Russia’s international influence and prestige.

Iran

There is overall agreement among the contributors that Iran’s space ambitions are centered on national security and reflect its desire for both regional hegemony and national prestige. Iran’s antagonistic relationships with neighboring Arab nations and Israel provides the motivation for Tehran to pursue sophisticated information dominance and missile defense and offense, while also growing its civil space operations. Goswami identifies Iran as “the most advanced ‘space-assets nation’ in the Middle-East, especially in relation to the Arab states in the region.” She suggests that, as tensions in the Persian/Arab Gulf continue to grow, a space race may occur between Tehran and the Gulf nations.

How does Iran approach space operations and services?

Iran has a “large and sophisticated missile program” (Dr. Gawdat Bahgat, National Defense University) that Grego observes has launched a small number of low-mass satellites that have little demonstrated capability. In fact, discussion of Iranian space operations is often dominated by analysis of Tehran’s missile technology and ambitions, although several experts¹⁶ point out that Iran has other civil space and technological aspirations as well. Grego explains that Iran has long sought to jumpstart its space scientific efforts through cooperation with the European Space Agency (ESA) and Italy, and the funding

¹⁶ Goswami, Grego, and Lele.

of academic initiatives for space exploration. These efforts, along with their missile program, are seen by Tehran as a means of bolstering nationalistic sentiments and pride associated with such pursuits (Bahgat). The prospect of international prestige and the “dual-use nature of technology” (Lele) also make a sophisticated space program irresistible, perhaps even a necessity for achieving Tehran’s aspiration of becoming the dominant regional actor in the Middle East (Grego). Assistance from Russia is vital to Iran’s missile program. China also has shown interest in cooperating with Iran on civil space projects.¹⁷

How does Iran conceive of space operations for military purposes?

Grego writes that, given Iran’s security and domestic concerns, “good intelligence, reconnaissance, and communications would seem essential for its national security as well as for its economic and social development.” Goswami considers these capabilities to be particularly relevant to Iran’s involvement in Yemen, and its fight against extremist groups such as ISIL. Grego believes that Iran is interested in and capable of anti-satellite techniques such as jamming, dazzling, and cyber attacks that could help repel an adversary’s attacks or intrusive uses of intelligence gathering, but that more sophisticated weapons, such as direct-ascent weapons, are not in their foreseeable future. Hitchens views offensive capabilities in space as a priority for Tehran and, looking forward, identifies counter space capabilities as a long-term ambition.

How does Iran conceive of space operations for commercial purposes?

Again, the contributors are not aware of any Iranian commercial space industry,¹⁸ and indicate that the Iranian Revolutionary Guard controls all of its space operations.

North Korea

North Korea’s space activities are motivated by the need to counter what its leaders perceive as the existential threat posed by the US and South Korea. Moreover, to date, North Korea has demonstrated little to no interest in science and technology that does not serve its defense objectives (Samson). Hitchens refers to North Korea as an aspiring actor in the space domain, and despite its lack of significant space capability, Pyongyang places tremendous value on the advancement of space operations. It is likely that North Korea will seek to develop space technologies and capabilities as far as necessary to support its growing nuclear arsenal and oppose regional adversaries.

How does North Korea approach space operations and services?

Perhaps more than any other nation, North Korea’s economy is focused on its primary national security goal of regime survival, and its space program is not an exception to this. Contributors characterize North Korean space operations as either a means of perpetuating the regime or of countering US military superiority, or both. North Korea does not have a commercial space sector; any space operation declared as civil is simply a facade for a military program (Cheng).

¹⁷ Cheng mentions Tehran’s cooperation with both Russia and China, and Goswami and Lele write of cooperation with Russia and China respectively.

¹⁸ See the contributions from Bahgat, Berkowitz, and Goswami.

How does North Korea conceive of space operations for military purposes?

Several contributors discuss military space programs that the Pyongyang regime is actively pursuing in addition to its focus on achieving platforms for nuclear ICBM capability. In particular, North Korea seeks counterintelligence technology capable of “jamming GPS signaling to defuse data on its internal developments as well as jam early missile warning signals” (Goswami). However, strategic capabilities such as communication, counter space technology, and other force enhancement pursuits in space are manifested only by a nascent and unsophisticated satellite program. Ultimately, Pyongyang’s missile program transcends all other activity in space. Samson notes that North Korea’s military space operations are tempered by Pyongyang’s awareness that the development of capabilities such as anti-satellite weapons or EMP bursts are probably unattainable and would lead to a regime ending response if they are ever developed.

How does North Korea conceive of space operations for commercial purposes?

Grego argues that North Korea “does not have a developed civil society that it must be accountable to at some level. North Korea’s battle is for survival. So, ... all its space activities will be tailored very carefully to that aim.” Lele suggests that illegal trade in missile parts or satellite components is the only likely avenue for North Korea to engage in commercial space activity.

European Space Agency (ESA)

The European Space Agency (ESA) is an international space agency, not a state space actor, so it is unique in comparison to the other actors presented in this summary. However, like some of the other space actors presented, ESA appears to be increasingly thinking about dual-use aspects of space capabilities and activities (Agnieszka Lukaszczyk, Planet).

How does ESA approach space operations?

Hitchens and Lukaszczyk explain that ESA was initially established to focus purely on civilian and peaceful uses of space, not on military uses. However, Lukaszczyk notes that Europe’s current geopolitical climate is increasingly driving European interests toward a closer focus on security concerns. She suggests that this is starting to be reflected in ESA’s space interests and operations, particularly with respect to its increasing acceptance of the use of space for security activities, capabilities, and technologies. This is a recent development, according to Lukaszczyk, who notes that just 3-5 years ago there was a clear, distinct separation between civil space and military space in Europe.

ESA is the world’s only regional space agency and its members are, in many cases, involved in other space programs and agencies. Hitchens and Lukaszczyk detail three overlapping types of government space actors in Europe:

- The national space programs, space agencies, and space offices of individual European states.
- ESA, which is comprised of 22 European member states.
- The EU, itself, which has its own space policies, space programs, and space operations that cover its member states.

As Lukaszczyk explains, ESA and the EU are independent from one another and have different member states, different procurement processes, and different ways of spending money. She contends that the key difference between ESA and EU space initiatives is that ESA focuses on activities such as space

exploration, research, and the technical aspects of space operations (i.e., similar to NASA in the US), whereas the EU is more policy-oriented and focuses on the strategic aspects of space operations (i.e., similar to the US State Department and Department of Defense). Moreover, the EU has supranational power that requires member states to abide by its directives, an authority ESA simply does not have.

While Lukaszczyk notes that there have been some instances of friction between ESA and the EU, particularly over issues relating to authority and jurisdiction, she suggests that a significant step toward improved coordination and cooperation was made with the development of the European Space Strategy in 2016, which she describes as a space strategy for Europe as a whole. Perhaps most critically, she asserts, the European Space Strategy was developed through a unified, collaborative effort that included all three of the overlapping types of government space actors and programs within the EU (member states, ESA, and the EU itself).

How does ESA approach space operations for military purposes?

Historically there has been little cooperation or collaboration between civil and military space actors in Europe, and even the idea of dual-use was a sensitive topic of discussion, according to Lukaszczyk. She contends, however, that a perception of increasing regional security threats has opened the door to the idea of strengthening European defense capability by capitalizing on existing civil and commercial space capabilities and technologies for military purposes and dual-use applications.

This change seems to be consistent with wider European perspectives on the role of space. As Lele points out, NATO has historically viewed space as a force enabler and multiplier. He explains that the space domain has been of strategic importance to many EU states for decades, particularly as EU states have served with the US in recent military operations that depended heavily on satellites. Supporting Lele's point, the experts highlight two particularly relevant European space initiatives, both of which ESA is now involved with: Galileo (the global navigation satellite system [GNSS] of the EU) and Copernicus (an Earth observation program). Lukaszczyk explains that both Galileo and Copernicus were initially established as purely civil and commercial space programs but the EU has adjusted each program's mandate to incorporate military and security objectives and operations. Major General (USAF ret.) James Armor (Orbital ATK) and Colonel David Miller (460th Space Wing, United States Air Force) highlight the strategic and operational value of Galileo to the EU as the provision of an independent GNSS capability that increases European control over access to its own communications. This reflects what Miller sees as the core reason why actors get involved in space in the first place: the fundamental need to see and communicate over the horizon, for the benefit of national security objectives, civilian objectives, and commercial objectives.

How does ESA approach space operations for commercial purposes?

According to Lele, European commercial space activity more commonly occurs at the EU member state level, rather than at the ESA level. However, in general, Lukaszczyk suggests that Europeans tend not to trust the private sector as much as Americans do, despite recognizing the obvious achievements and successes of commercial space actors in the United States. Consequently, she explains, European government and military space actors are typically reluctant to turn over control of aspects of their programs to private sector actors. To illustrate this point, she points to a collaborative (ESA, EU, and EU member state) European space communications initiative, Government Satellite Communications (GOVSATCOM). As she explains, Europe has excellent telecom operators (e.g., SES, Eutelsat, etc.) that could, theoretically, meet the necessary security requirements and easily and effectively support GOVSATCOM. Instead, she contends, the EU is planning to build its own, entirely separate satellite

constellation in support of GOVSATCOM because, in large part, it does not want to turn over any control to private hands—thus eliminating an opportunity for cooperation with commercial space actors. Ongoing ESA, EU, and EU member state efforts to attract commercial space startups into the European commercial space marketplace does suggest that this reluctance is receding, however Lukaszczyk characterizes the overall progress as quite slow.

Japan

While Japan is an older player in the space domain, it is also a space actor transitioning the way it conceives of its space interests and operations for both national security and defense purposes, as well as for commercial purposes (Dr. Brian Weeden, Secure World Foundation). Japan has historically viewed space as a non-military domain, according to Goswami. However, several of the experts¹⁹ assert that this appears to be changing as a result of mounting regional security challenges, particularly the growing threat of from North Korea.

How does Japan approach space operations?

Lele explains that Japan has both an established national space agency, the Japan Aerospace Exploration Agency (JAXA), which is the main force behind the country's space program, as well as commercial space entities that have significant international footprints (e.g., Mitsubishi Heavy Industries and IHI Corporation). Moreover, Hitchens believes that Japan's efforts to review and revamp its national space policies, plus its continued commitment to encouraging and enticing commercial actors to get involved in the Japanese commercial space sector, have helped the country become a growing force in the space domain.

Japan also appears to be taking steps to expand its own footprint in the domain of military space. There appear to be two primary factors driving Japan's expanding space interests and operations: security concerns and regional competition. Increasing regional security challenges have pushed Japan to take a more national security and defense focused approach to its space interests and operations (Goswami; Lele; B. Weeden). As Lele notes, Japan launched its first military communications satellite in 2017 and is planning to launch a military space force by 2019. These space operations will increase both Japan's defense capacity (i.e., boosting the broadband capacity of Japanese Self-Defense Forces) and the security of essential capabilities (i.e., protecting Japanese satellites from dangerous debris orbiting the Earth) (Lele).

Lindsey indicates that nationalism and national pride are also a significant factor in how Asian countries, including Japan, approach space interests, ambitions, and operations. Japan and other Asian countries want to be seen as the "first Asian country to do X thing in space." This idea of an "Asian Space Race," (Lindsey) likely provides some additional context and insight into Japan's space interests and operations. Illustrating this point, Goswami notes that JAXA is conducting futuristic space exploration research relating to asteroid exploration and the wireless transmission of electricity, which she suggests could eventually be used for the transmission of electricity from space solar satellites. These kinds of space operations, Goswami contends, could have a major impact on the future of space resource exploration. They would also certainly represent an interesting, noticeable achievement in the context of the "Asian Space Race."

¹⁹ Goswami, Lele, and B. Weeden.

How does Japan approach space operations for military purposes?

As discussed, the experts suggest Japan is transitioning how it approaches space operations, increasingly focusing on national security and defense-related interests and objectives. The experts highlight several key events and decisions that illustrate this evolution in Japanese thinking.

- The reinterpretation of “peaceful use of space” away from meaning “non-military” (B. Weeden).
- The amendment of its national space policy to permit Japanese military activities in space (B. Weeden).
- The decision to utilize satellites for military purposes, including reconnaissance and information gathering efforts pertaining to the seas (Goswami).
- The introduction of ballistic missile defense into its national space policy (Goswami).
- The release of its fourth Space Basic Plan in 2016, putting forward a national space policy as part of an overall national security strategy (Lele).

These actions, together, seem to illustrate an evolving Japanese mindset regarding space operations for military purposes; one that appears to be shifting more toward using space to protect and advance Japan’s national security interests in a time of escalating regional security challenges.

How does Japan approach space operations for commercial purposes?

According to Goswami, Japan has shown a clear commitment to encouraging the involvement of commercial entities in the space domain. She supports this argument by pointing to business-friendly initiatives such as the sharing of state-funded research and development funds with private commercial space entities, and also the creation of national legislation to encourage commercial space activity and construct a more attractive marketplace. Building on Goswami’s analysis, Lele points to two particularly relevant legislative accomplishments from 2016: 1) the passing of law that makes it easier for private companies to invest in Japan’s commercial space sector and 2) the establishment of a space activity law that allows commercial companies to launch artificial satellites. Lele asserts that these actions have paved the way for several new, notable commercial entities to enter Japan’s commercial space sector (e.g., Interstellar Technologies, Astroscale, PD Aerospace, and Canon Electronics).

India

Although India does not have a comprehensive national space policy, the experts generally agree that it is working to expand its footprint in the space domain.²⁰ This is evident through both concerted efforts to develop its commercial space sector and an increasing interest in and willingness to capitalize on space capabilities to support national security and defense-related interests.

The experts note that India has historically conceived of space operations primarily as a mechanism to support its civil and national development interests and capabilities, with the goal of developing space technologies for the purpose of societal benefit.²¹ However, they suggest that how India conceives of space operations appears to be shifting. In particular, Goswami and Samson point to an increasing Indian consideration of security and defense-related factors in relation to space domain interests and operations. As Lele explains, this shift in thinking seems logical given the unique assortment of security challenges India faces in today’s geopolitical environment (e.g., cross-border terrorism, large distances

²⁰ See the contributions from Goswami, Hitchens, and Samson.

²¹ See the contributions from Lele, Samson, and B. Weeden.

of maritime borders to monitor, and having two nuclear weapon state adversaries). It is not surprising, therefore, that the Indian military appears to be increasingly recognizing that it is in its interest to utilize space for security purposes.²²

How does India approach space operations?

India's approach to space operations is driven by both military and commercial interests. On the military side, Lele notes that India's increasing interest in exploiting space capabilities for national security and defense has resulted in increased coordination between India's national space agency, the Indian Space Research Organisation (ISRO), and components of the Indian military. Commercially, Lele and Samson explain that India has demonstrated clear and expanding interest in its commercial space sector and has started to take steps to grow and develop its commercial space environment. However, as is the case in most of the other states discussed in this summary, India's commercial space sector is still largely dependent on state support.

As mentioned in the discussion of Japan, nationalism and national pride are also a significant factor in how Asian countries approach space interests, ambitions, and operations (Lindsey). As Lindsey explains, India and other Asian countries want to be seen as the "first Asian country to do X thing in space," and this idea of an "Asian Space Race" likely provides some additional context and insight into India's space interests and operations. Interestingly, despite the inherent level of competition that naturally emerges from this "Asian Space Race," Goswami and Lele note that India has demonstrated a willingness to share space services with other regional space actors. For instance, India is offering its satellite services to its neighbors through the launch of the "South Asia Satellite" (Goswami), and has also developed its own regional navigation system (i.e., like that of GPS in the US), the Indian Regional Navigation Satellite System (IRNSS), which it is likely interested in expanding into and/or sharing with surrounding countries (Lele).

How does India approach space operations for military purposes?

Though India's national space agency (ISRO) is mostly focused on space operations for civilian purposes, Lele and Goswami note that ISRO has been expanding its coordination with, and support to, the Indian military. As several of the experts highlight,²³ expanded ISRO coordination with Indian military services has included activities like launching national security-dedicated satellites, using dual-use satellites for national defense activities, and providing augmented data on areas of concern (i.e., India's disputed borders with China and in the Indian Ocean region), and is expected to expand into activities relating to counter space anti-satellite capabilities. Goswami also suggests that the establishment of an Indian military space agency may be forthcoming, as there have been discussions within India to establish an Aerospace Command separate from the Air Force.

How does India approach space operations for commercial purposes?

While the experts generally agree that India has a growing commercial space sector, Lele stresses that commercial space operations in India are in their infancy and India's commercial space actors largely depend on government assistance. There are several examples of startup commercial space actors that have been making investments in the Indian commercial space market, but, as Lele notes, at this point the country's commercial space actors are mostly dependent on ISRO for jobs and/or funding and are generally expected to simply be service providers.

²² Goswami, Lele, and Samson.

²³ See the contributions from Goswami, Hitchens, Lele, Samson, and B. Weeden.

The expert contributors from ViaSat, Inc. suggest that there is significant interest from Indian commercial entities in developing a robust commercial space sector modeled on those achieving success in Western nations. It appears that both ISRO and the Indian government are taking steps in support of this. Goswami and Lele present three particularly relevant examples to illustrate this initiative:

- ISRO plans to engage the commercial space sector in launch activities by offering technology transfer agreements.
- The Indian government has shown a keen interest in developing ground infrastructure for prospective commercial space clients.
- The Indian government is working to establish national space legislation that will regulate private space actors in accordance with the international obligations laid out in the Outer Space Treaty.

However, despite these steps toward commercial sector development, several of the experts²⁴ highlight concerns about government ownership of commercial space activity, and the true level of independence and openness in India's commercial space sector. They note that India is not known to have a culture of openness and trust, and underscore concern that this may limit India's ability to attract private, commercial sector innovation in space operations.²⁵ Goswami and Lele point out that government ownership of India's commercial space actors and activities likely means that if a crisis were to arise, the commercial actors would have just limited, if any, autonomous influence on security matters and decisions would be made by the government.

South Korea²⁶

South Korea's regional security environment is challenging, particularly given the uncertainty and instability stemming from North Korea. It is not surprising, therefore, that South Korea increasingly conceives of, and approaches, space interests and operations with national security and defense-related objectives in mind (Lele).

How does South Korea approach space operations?

South Korea's approach to space operations appears to be driven largely by national security interests and elements of national pride. As mentioned in the discussions of Japan and India, nationalism and national pride are a significant factor in how Asian countries approach space interests, ambitions, and operations, and this is certainly true for South Korea (Lindsey). Moreover, in what seems to illustrate a fusion of national security and national pride factors, Lele points out that South Korea's evolution toward a more heavily national security and defense-related approach to space has notably coincided with a growing aspiration for space-related cooperation with the United States, particularly cooperation concerning mutually beneficial security objectives. Expanding space domain cooperation with the US helps to increase South Korea's operational capability and international standing.

How does South Korea approach space operations for military purposes?

To illustrate this increasing national security and defense-related focus of South Korean space interests and operations, Lele points to South Korea's development and implementation of a new defense

²⁴ Goswami; Hitchens; Samson; and ViaSat, Inc.

²⁵ See the contributions from Hitchens; Samson; and ViaSat, Inc.

²⁶ Please note that only one SME answered all parts of this question from South Korea's perspective. Any other SMEs cited in this section only briefly mentioned South Korea in their submission.

doctrine for outer space. Notably, this new outer space defense doctrine highlights a particular South Korean interest in incorporating advanced technologies with military relevance in space, an interest in which he indicates the burgeoning US-South Korea space partnership has also taken steps to advance. As he explains, space technologies form an important element of any missile defense system, something that will almost certainly remain a key focus for both the US and South Korea for the coming years given escalating tensions with North Korea.

How does South Korea approach space operations for commercial purposes?

Lele expects South Korea's commercial space sector to progress significantly in the coming years. This expectation driven by:

- The country's standing as a technologically advanced state, and the belief that South Korean commercial space operations will be well-positioned to capitalize on these technological capabilities.
- The increasing availability of financial resources as the number of venture capital firms involved in South Korea's commercial space sector is rapidly growing and the overall investment in commercial space operations is expected to continue to increase.

However, while South Korea seems poised to further develop its commercial space sector, Lele believes that the regional security situation will likely dictate its future. Accordingly, Lele suggests that the nature of the threat from North Korea and the regional security environment overall may be what decides the future of South Korea's commercial space operations, particularly in a time of crisis.

Israel²⁷

Israel is a sophisticated producer and user of space technologies and applications (Dr. Deganit Paikowsky, Tel Aviv University), with space interests and operations that appear to be largely driven by national security and defense-related interests and objectives. Given high levels of government control and ownership within Israel's commercial space sector (Hitchens), Israeli commercial space interests and operations are certainly influenced by national security and defense-related interests and objectives.

Paikowsky suggests that the significance of space in Israel's strategic concept shapes its perspective on space security today. Her characterization of Israel's approach to space suggests a fundamental tension between pragmatic goals and broader ideals. Israel, she contends, views space as a global commons and aspires to contribute to a secure and sustainable space environment. Toward this end, Israel is interested in greater international collaboration and cooperation in the space domain with the goal of maintaining space as a peaceful environment for the benefit of all. However, Paikowsky notes that Israel also acknowledges and accepts the worldwide use of space as a mechanism for supporting terrestrial military activity, as well as for defense and deterrence efforts against harmful activities in space—particularly with respect to the protection of satellites and space systems in its own case.

How does Israel approach space operations?

Israel's approach to space operations and services appears to be largely driven by national security interests. Paikowsky explains that as a small country, Israel is able to enhance its overall national power

²⁷ Please note that only one SME answered all parts of this question from Israel's perspective. Any other SMEs cited in this section only briefly mentioned Israel in their submission.

through space in ways that might otherwise not be possible. According to Paikowsky, Israel both enjoys and suffers from a growing reliance on space systems for its critical national infrastructure. For this reason, she explains, Israel has concerns about the growing global trend of space militarization because the resulting threats, if realized, could lead to Israel losing any relative advantages it might currently have in the space domain. Therefore, she maintains that Israel is interested in achieving a sustainable space environment, particularly one in which Israeli satellites are not endangered

How does Israel approach space operations for military purposes?

Longstanding regional security concerns and threats have driven Israel to commit significant effort and resources toward securing and assuring its overall national security. Israel's narrow borders, Paikowsky contends, constitute a lack of strategic depth and pose an existential threat that necessitates a search for solutions to avoid strategic surprise and sudden attack. For these reasons, she explains, Israel's security doctrine demands advanced intelligence capabilities for early warning. An orientation toward space assists Israel in coping with the challenges presented by this aforementioned lack of strategic depth, and Israel's space program, therefore, is recognized as a critical component of its national security strategy, according to Paikowsky. More specifically, she asserts that Israel is particularly focused on space capabilities for identifying and addressing threats from an intelligence and operational point of view (i.e., early warning; intelligence, surveillance, and reconnaissance; deterrence; and self-reliance in advanced technologies). She contends that Israel views these types of interests and operations as force multipliers that boost national space capability and infrastructure in both the military and civilian realms, thus strengthening Israel's overall national security and regional status.

Despite its space domain ambitions, Paikowsky notes that Israel's space interests and operations are limited by resource constraints imposed by its relatively small size. She argues that this forces Israel to be more selective in its space operations, necessitating a concentration on those most critical to national objectives (e.g., developing, operating, and launching satellites into space), as well as several specifically targeted niche areas that present potentially high return on investment opportunities (e.g., Earth observation, low-Earth orbit launch capability, and communications). Another notable way in which Israel attempts to neutralize domestic resource constraints is by building partnerships with other space actors. Paikowsky notes that Israel does not build all of its systems entirely on its own (e.g., Israel does not have its own navigation system, weather system, or manned missions), but rather seeks to cooperate with international partners—particularly the United States—on mutually beneficial space-related projects. Therefore, it is important to recognize that while Israel's size might present some limitations with respect to available resources, the strong US-Israel cooperative partnership does in part help to buffer Israel against domestic resource constraints. As Bahgat notes, the US provides a significant amount of political and economic assistance in support of Israeli space interests and operations.

How does Israel approach space operations for commercial purposes?

Since the establishment of its commercial space sector, Paikowsky contends that Israel has developed a robust commercial space industry and a strong scientific sector. Hitchens, however, notes that while Israel does technically have a commercial space sector and commercial space actors, there is a high level of government control and ownership involved. Therefore, these Israeli "commercial operations" might not be as truly independently "commercial" as one might imagine (Hitchens).

Canada

Canada has had a few decades of experience with both military and commercial space (B. Weeden). It is among the group of space-faring nations that utilizes space and have both a strong space policy and a government space agency (Samson). Canada, like most countries discussed by the contributors, implements a different model for commercial space operations than does the US (Hitchens). Canada's space sector lacks a clear distinction between civil, military, and commercial operations. There is also significant government investment in the commercial sector, which reflects the government's commitment to building up the nation's commercial space sector.

How does Canada approach space operations?

Many of Canada's commercial satellite companies still have broad government investment and therefore cannot be deemed as entirely independent entities, unlike the United States' commercial satellite companies (Hitchens). For instance, Canada makes frequent use of Synthetic Aperture Radar (SAR)²⁸ satellites for both military and commercial use, and is even ahead of the US in its widespread use of such satellites (Hitchens). This is one of Canada's key areas of investment, and the dual-use (commercial and military) nature of these capabilities is indicative of the lack of segmentation within the Canadian space sector (civil, military, and commercial) as a whole.

How does Canada conceive of space operations for military purposes?

Charity Weeden of the Satellite Industry Association states that Canada's recent defense policy documents indicate a determination to incorporate space capabilities into critical national security infrastructure. This emphasizes Canada's recognition of the importance of space for national security and defense. In particular, space is vital to the scope of Canada's Arctic operations and NORAD missions since it requires Automatic Identification System (AIS) and radar satellites to protect its coastlines (C. Weeden).

Canada has its own military space assets, including satellites intended for military use. However, Hitchens emphasizes that many of these assets are connected to US operations, and Canada often requires the United States' support for its military space ventures. Thus, while Canada appears to have an interest in utilizing space capabilities for military operations, it currently requires outside assistance to achieve its goals.

Canada also closely collaborates with the rest of the Five Eyes community (Australia, Canada, New Zealand, UK, US), whose member nations are currently working to build space relationships with each other (B. Weeden). B. Weeden notes that discussions have been occurring under the rubric of the Combined Space Operation Center (CSPOC) to organize Five Eyes nations' operations within a national space integration cell. The CSPOC would then act as a set of concepts of operations (CONOPS) for how these national space integration cells would interact with each other (B. Weeden).

How does Canada conceive of space operations for commercial purposes?

Canada's commercial space operations and services are tightly linked with its national security and defense efforts (C. Weeden). Furthermore, based on Canada's extensive experience with and ownership

²⁸ SAR satellites implement a side-looking radar system which utilizes the flight path of the satellite to simulate an extremely large, electronic antenna. After compiling the stored data, a high-resolution remote sensing image of the terrain below the flight path is generated.

of satellites, the experts suggest that the nation's commercial sector is focused on building up this facet of its space industry.

Brazil²⁹

Juan Hurtado of United States Southern Command stresses that Brazil has more space capabilities than many other countries in the region. However, it is still not on par with many other more advanced space-faring nations due to its dependence on international support for launches, satellite manufacturing, and orbital mechanics. Despite Brazil's classification as an emerging space power, Hitchens stresses that the US should keep an eye on Brazil because it may become a larger player in the space domain in the future.

How does Brazil approach space operations and services?

Brazil has its own government Space Agency, the Agencia Espacial Brasileira (AEB), which facilitates the nation's civilian and commercial space operations. In addition, there are various government organizations that assist with space operations. The Instituto Nacional de Pesquisas Espaciais (INPE), which sits under the Brazilian government's Ministry of Science and Technology, oversees most governmental space research and development efforts (Hurtado). The Center for Space Operations, under the oversight of the Fuerza Aerea Brasileira (FAB), conducts most of Brazil's space operations (Hurtado). Combined, these government organizations are responsible for administering the nation's space program, research, education, and operations (Hurtado). While the INPE in particular works closely with Brazil's military, military benefits are secondary to civilian interests and applications (Hurtado).

How does Brazil conceive of space operations for military purposes?

As stated above, INPE works closely with Brazil's military; however, its primary focus is on civilian space operations (Hurtado). This, combined with the placement of Brazil's government space programs within the civilian sector, suggests that Brazil is primarily focused on commercial and civil space ventures.

How does Brazil conceive of space operations for commercial purposes?

Brazil is specifically interested in making advancements in the field of small satellites, with a secondary focus on the development of launch facilities and launch vehicles (Hurtado). In terms of research, the nation's primary focus is on space physics and heliophysics³⁰ rather than any planetary research (Brent Sherwood, NASA Jet Propulsion Laboratory). Both Brazil's commercial sector and its universities augment the activities of its government programs and operations (Hurtado). Brazil's commercial ventures are not overly active in the security and stability domains (Hurtado), and thus do not view security differently during times of peace, crisis, and conflict.

²⁹ Please note that only one SME answered all parts of this question from Brazil's perspective. Any other SMEs cited in this section only briefly mentioned Brazil in their submission.

³⁰ Heliophysics is the study of the Sun's effects on the solar system.

Australia

Since the 1940s, space has influenced Australia's national strategy (Brett Biddington, Biddington Research Pty Ltd), and the country recognizes the importance of developing space capabilities. Samson states that Australia "use[s] space, recognize[s] space as being important, and [has its] own space interests and capabilities;" however, the country still lacks some of the capabilities that more advanced space powers possess.

How does Australia approach space operations?

Despite Australia's long history of involvement in space, several of the experts³¹ note that it still lacks a national space agency and a central coordination office. However, the government is developing a new space policy (B. Weeden) and has recently announced intentions to establish a central space agency. Although small in terms of population and GDP, Australia is responsible for approximately 15% of the Earth's surface (Biddington). Earth observation satellites and communication satellites therefore have the potential to significantly enhance efforts to regulate, govern, and monitor Australian territories, and they are a major component of Australia's space investments (Biddington).

Despite its desire to have a successful space program, the nation's limited monetary resources restrict its ability to spend on space ventures.³² Nevertheless, Australia has allocated funds to revitalize its space industry (B. Weeden), further highlighting the nation's interest in investing in satellite launch capabilities. Australia presently has the capability to purchase foreign satellites and operate launches in other nations (Gilmour Space Technologies) but lacks the capability to launch on its own soil. A \$3-4 billion project for space-based remote sensing was outlined in a recent Australian defense white paper and investment plan and, according to Biddington, the development of Australia's own government-owned Earth observation satellites is on the horizon as well.

How does Australia conceive of space operations for military purposes?

Australia recognizes and values the benefits that space services from other countries provide Australian military forces and is determined to preserve those benefits (Duncan Blake, International Aerospace Law and Policy Group). Australia has long been a popular location for the US, ESA, and other space-faring nations to place ground stations, and it is starting to build some of its own ground-based space surveillance capabilities (Biddington). The Gilmour Space Technology team contends that they could also see the Australian government looking to domestic commercial space industries to launch military satellites within the next 5-10 years.

The US has helped advance Australian space operations significantly (Dr. Jason Held, Saber Astronautics), and the two countries have worked together quite closely on space ventures for decades (Biddington). The US possesses the money and resources that Australia lacks to conduct these military operations (Biddington), and Australia has the geographic position that provides the US with extended satellite coverage. Much of Australia's military assets are linked to United States operations, and Australia does not conduct many military activities in space on its own (Hitchens).

Australia also closely collaborates with the rest of the Five Eyes community (Australia, Canada, New Zealand, UK, US) on space technology development and national security-related space matters (Lindsey). B. Weeden explains that discussions have been occurring under the rubric of the Combined

³¹ Biddington, Samson, Gilmour Space Technologies, and B. Weeden.

³² See the contributions from Biddington and Held.

Space Operation Center (CSPOC) in an effort to have all of the Five Eyes nations to operate a national space integration cell. This CSPOC would then act as a set of concepts of operations (CONOPS) for how these national space integration cells would interact with each other (B. Weeden).

How does Australia conceive of space operations for commercial purposes?

In terms of commercial space, Held suggests that Australian commercial activities drive the nation's space industry. The nation has a variety of private companies that use space, and these companies have differing relations with government, both in terms of control and funding (Hitchens). The diminishing price of satellites is encouraging small, startup companies in Australia, as elsewhere, to start buying and launching satellites without any government funding or assistance (Biddington; Held; Lindsey). This lowers the barriers for entry for less-experienced companies (Biddington; Lindsey) and removes the need to rely on large-scale government investments.

Despite these developments, Australia's commercial space sector currently lacks a cohesive identity (Biddington). As Biddington explains, some Australian companies utilize satellites as part of their telecommunications business, but they view themselves as telecommunication suppliers who happen to use satellites to conduct their business rather than as commercial space companies. He also stresses the need for these companies to recognize their role as commercial space companies as well as the extent of their dependence on space.

Singapore³³

Singapore's involvement in the space domain is relatively recent (Jonathan Hung, Singapore Space and Technology Association). In fact, Singapore's commercial space activities began about 5 years ago, and the nation still lacks both a government space agency and a national space policy (Hung). Despite the absence of these institutions, Singapore has identified space as an area of interest for economic development (Samson). The nation recognizes the importance of space, invests capital and resources into space, and has its own space interests and capabilities; however, these capabilities still remain limited (Samson).

How does Singapore approach space operations?

The key ambitions and interests of Singapore's commercial space entities are improving and developing satellite communication, strengthening its telecommunication and imaging services, improving Earth observation on the ground, and providing accurate data (Hung). Singapore also aspires to develop its space capabilities so that it can further extend its commercial services to the rest of the world (Hung). Overall, Singapore's main area of interest is small satellites, and the nation has chosen to focus on providing commercial space services via small satellites rather than investing in large telecommunication satellites (Hung).

How does Singapore conceive of space operations for military purposes?

According to Hung, Singapore does not conduct space operations for military purposes, nor is it looking to do so.

³³ Please note that only one SME answered all parts of this question from Singapore's perspective. Any other SMEs cited in this section only briefly mentioned Singapore in their submission.

How does Singapore conceive of space operations for commercial purposes?

Singapore views space as a commercial business opportunity as well as an opportunity to create jobs and conduct groundbreaking research (Hung). Consequently, the nation's interest in space is driven by its commercial and economic interests, and it is predominantly focused on how it can improve and advance in the realm of commercial space (Hung). Most of the commercial space research being conducted in Singapore focuses on satellite imaging and observation activities and, as the price of small satellites continues to decline, Singapore is investing more in research and development of such capabilities (Hung).

Ukraine

According to Samson, in a ranking of national space capabilities, Ukraine belongs in the lower tier of space-faring nations. Ukraine falls into this category it is interested in making advancements in space, recognizes the importance of space, and has its own space interests and capabilities, but does not have the advanced space capabilities and resources that other higher-tiered nations possess (Samson). Nevertheless, due its clear interest in space, further investment in Ukraine's space operations is anticipated.

Other Actors

Luxembourg

Goswami predicts that along with the United Arab Emirates, Luxembourg will "emerge as a major space player in the future of setting space norms and utilizing insights drawn from space-based information services." She supports this argument by pointing out that Luxembourg has invested extensively in asteroid mining and has established legislation that allows private companies to settle in Luxembourg by promising ownership of outer space resources. Thus, Luxembourg is primarily focused on its commercial space ventures, recognizes the economic opportunities available in space, and supports ownership of outer space resources.

The Middle East

For most Middle Eastern countries, there are two major barriers to becoming a space-faring nation: money and scientific infrastructure (Bahgat). The Gulf States, specifically Saudi Arabia, the United Arab Emirates (UAE), Qatar, and Kuwait, have the economic resources to conduct space activities, but lack the necessary technical infrastructure and scientific expertise (Bahgat). Despite these shortcomings, Goswami predicts that the UAE will "emerge as a major space player in the future of setting space norms and utilizing insights drawn from space-based information services." This prediction stems from the UAE's efforts to partner with more advanced space-faring nations to build expertise, stimulate the process of obtaining space-based capabilities, and gain access to the wealth of space knowledge that these nations possess (Goswami). Other Middle Eastern nations, including Egypt, Jordan, and Lebanon, do not have the required financial resources to build a space program (Bahgat). According to Bahgat, this helps explain why the only Middle Eastern countries with space programs are Israel and Iran, both of which have resources and infrastructure.

New Zealand

New Zealand does not have a national space agency (Biddington) and, according to B. Weeden, it is not engaging in many space activities at the moment.³⁴ However, it is a member of the Five Eyes, whose member nations are currently working to build space relationships with each other (B. Weeden). B. Weeden elaborates that discussions have been occurring under the rubric of the Combined Space Operation Center (CSPOC), and the goal of these efforts would be for all of the Five Eyes nations to operate a national space integration cell. The CSPOC would then act as a set of concepts of operations (CONOPS) for how these national space integration cells would interact with each other (B. Weeden). Therefore, we can anticipate an increase in New Zealand's interest in space in the near future.

³⁴ During the final review of this report, Lindsey noted that, "[This] is no longer true. In 2016, New Zealand established a space agency. This was in large part due to the success of RocketLab, USA. As I understand it, they realized they needed a New Zealand government agency to engage with the FAA on getting RocketLab licensed to operate in New Zealand. There is a growing small satellite research presence in academia there, as well. Interestingly, New Zealand's growing space sector spurred the Australian government to announce the establishment of their civil space agency this past September [2017], when they hosted the International Astronautical Congress." For additional information on this initiative, Lindsey pointed to: <http://www.mbie.govt.nz/info-services/sectors-industries/space>

Subject Matter Expert Contributions

Major General (USAF ret.) James B. Armor, Jr.³⁵

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

WRITTEN RESPONSE

PRC, Russia, Iran, North Korea: commercial as an extension of military/political objectives. PRC allows commercial, but that includes PLA engagement

European Space Agency, Japan, India, South Korea, Israel: commercial as support for economic well-being of region (including defense). They assume US space (military) dominance in their calculus, so they can save that expense. They all consider systems “dual use”, with some exceptions (science mostly)

Canada, Brazil, Australia, Singapore, Ukraine, others: mix-mash: each has economic, political and geo-political objectives for their interests. They try to emulate the US sectors, but don’t have the budgets.

Dr. Gawdat Bahgat

Professor of National Security Affairs
(National Defense University’s Near East South Asia Center for Strategic Study)
7 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: [Q2] Okay. So, the first question I wanted to ask you is about how other actors, particularly Iran in this case, perceive of space operations for military and commercial purposes. So, can talk a little about how other non-US actors, particularly Iran in this case, conceive of space operations for military and commercial purposes?

G. Bahgat: Okay. Iran has a large and sophisticated missile program—the space program and particularly long-range missiles, as far as I understand, is part of the missile program. So, Iran has a sophisticated and large missile program.

If we focus on space, most Iranian missiles are short- and medium- range. They do have long-range missiles, and just few days ago they tested missiles as part of their new long-range space system. The United States was not happy about this. The US, along with Germany, France, and UK submitted a letter to the Security Council, complaining about this.

So, Iran has the program. Iran denies that it is for military reasons, they claim it is civilian. According to most experts, Iran does not have the capability to launch military long-range missile yet, but they have developed domestic expertise, so this cannot be ruled out. What is not clear based on open sources, is if this Iranian program is civilian or military.

Interviewer: [Q2] From perspective, what do you see as Iran’s key ambitions and key interests with respect to the space domain? You mentioned Iran’s missile program and the development and investments there, but, in addition to the missile program, what other actions has Iran taken in pursuit of its key ambitions and key interests in the space domain?

³⁵ 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.

G. Bahgat: I believe there are two important points here.

One of the main motives for Iran, the main reason and the main drive for this space program, is pride. Iran has the nuclear deal according to the IAEA and United Nations, and, so far, Iran is not in violation of the nuclear deal, but they have great pride in the program. They want to prove that they have the scientific knowledge to launch long-range missile space programs.

The other point I want to make is that the program is legal. During the negotiation for the nuclear deal, the United States was trying very hard to include missiles in the agreement and Nuclear Accord, but the Iranians fought very hard and succeeded. According to the nuclear deal, from July 2015, there is nothing against Iran's missile program, including the space program. There was a previous Security Council resolution that made this illegal, but according to the latest resolution 12331, the resolution calls on Iran not to develop a space program but it is not illegal (i.e., it is softer than previous resolutions).

Interviewer: [Q2] You mentioned the legality of the Iranian actions regarding its space program, so, along these lines, is Iran cooperating with or working with any other countries in pursuit of its space interests? And, on the other hand, do Iran's space interests and ambitions openly conflict with any other country, despite the legality of what they are doing?

G. Bahgat: Some of what is going on is contentious. For example, Iran is working with North Korea, with Russia, and with China. These are the Iran's three main partners here.

Iran has also developed domestic infrastructure, they spend a lot of money on education and developing their capability to be self-sufficient. But, according to most experts on the subject, so far Iran still depends on foreign sources for some parts of the space program and the missile programs. Iran is not 100% self sufficient, but they have made great progress in this direction.

Interviewer: [Q2] So, I imagine that Iran's cooperation with North Korea and Russia, maybe even China as well, creates some tensions or point of conflict with some other countries, particularly the US?

G. Bahgat: Sure. The US has imposed sanctions on Iran since 1979, and the US has been getting better at imposing and executing these sanctions. Also, on the other side, Iran has been under sanction since 1979, so they've learned how to avoid these sanctions. They have developed very sophisticated networks to get around these sanctions. So, it works both ways. We, the United States, have been learning what works and what does not work, and the same things have been learned on the Iranian side since the 1970s. While under these sanctions, Iran has not been allowed to import almost all kinds of weapons, but they learned how to smuggle and how to create networks to avoid these sanctions and to work around these sanctions.

Probably another important point here was the nuclear deal. Most European sanctions have been lifted. We, the United States, still keep most of the sanctions, and under the Trump administration it looks like we will impose even tougher sanctions. But, since the deal, Iran has had an easier time with Europe, with China, with Russia, and basically with the rest of the world.

Interviewer: [Q2] Is there a commercial space industry in Iran? If so, what does the commercial space industry look like? What is the relationship like between the Iranian government and Iranian commercial space and entities?

G. Bahgat: To the best of my knowledge, there is no private or commercial space program. The program they have is run by the Revolutionary Guard, which is the main power in Iran. The Revolutionary Guard was created shortly after the revolution to protect the revolution, and it is different from the traditional army but it is the most powerful institution in Iran. The space program and the missile program in general is run by the Revolutionary Guard.

If I may add one point here, the United States is considering designating the Revolutionary Guard as terrorist organization. We have not made this decision yet, but according to the media, the Trump administration is considering this option.

Interviewer: So, what would be impact of doing that (the US designating the Revolutionary Guard as terrorist organization) from an Iranian government perspective? I imagine that would embolden Iran, but what do you think?

G. Bahgat: Two points here.

One, there are some people here in the United States that believe that this will be illegal according to our laws because the Revolutionary Guard is part of the Iranian government. We have not designated any government entity as a terrorist organization yet, so this would be the first time and it is not clear if this will be legal or illegal according to our laws.

Second, for the Iranians, they have threatened to retaliate. As I mentioned, the Revolutionary Guard is the strongest institution in Iran. Basically, they are in charge and they are stronger than President Rouhani, the elected president, and they are threatening retaliation. They have not been specific in exactly what they will do, but what can be said is that this would be a big setback for US-Iran relations.

Interviewer: [Q2 indirectly] Okay. So, sort of transitioning a little to another one of our questions. You spoke about how Iranian pride is driving some of its activity and interest in the space domain. The second question I was hoping to ask you is about the motivations of nation-state and non-state actors to contest the use of space, so please feel free to address this question with Iran and the Middle East in mind. So, what are the motivations of nation states and non-state actors to contest the use of space in times of peace, instability, and conflict, and what are the political, military, environmental, and social costs associated with acting on those motivations?

G. Bahgat: So, as I mentioned, I have been working on weapons of mass destruction for a very long time. At one point, nuclear weapons were considered very prestigious and countries were trying to make the bomb so they can join elite countries. But, eventually, nuclear weapons lost this attraction, but this is different from space programs because space programs are not only for military use. A space program consist of satellites and communications infrastructure—it has many civilian uses. This is why space programs are is still prestigious.

The only two countries with space programs in the Middle East are Iran and Israel. It also happens that these two countries are more scientifically developed than the rest of the Middle Eastern countries. There is a lot of pride and prestige that comes with developing a space program.

In Israel, the program is funded mainly by the United States. We contribute a lot of money to developing Israel's space program. Iran does not have these same financial resources. Iran had planned to send human beings to space, but they cancelled this program because of lack of funding. So, these are some of the recent developments about Iran's space program. Probably even with all the pride involved, one of the big challenges for Iran is to secure funding for the space program. With the current oil prices, Iran does not have much available funding, so they are trying to balance the pride they want to get by developing this program with the shortage of funding they have.

Interviewer: [Q2] Do any other Middle Eastern countries, beyond Iran and Israel, have interest in or are working towards further development of their space program?

G. Bahgat: For most Middle Eastern countries, there are two main requirements: money and the scientific infrastructure. The Gulf States—Saudi Arabia, UAE, Qatar, Kuwait—have the money, but they do not have the technical infrastructure (e.g., scientists). Countries with more human resources and better technical infrastructure—like Egypt, Jordan, and Lebanon—do not have the required financial resources. So, this is why the only two Middle Eastern countries—based on open source information—with space programs are Israel and Iran. Even with respect to Turkey, I have not read anything that Turkey has developed a space program, and to the best of my knowledge, Turkey still today does not have a space program and does not have plans to develop one.

Interviewer: [Q2 indirectly] Okay. So, transitioning to one of our other questions, which has to do with insights from other domains that might be helpful and applicable for providing insights for the space domain and for space operations. From your perspective, what insight on current space operations can be gained from understanding the approaches used for surveillance, reconnaissance, navigation, communication, timing synchronization, and indications and warnings before the advent of the space age?

G. Bahgat: I believe that maybe besides Russia and China, Iran is the most watched country in the world. The US and Iran have been enemies since 1979, so the US watches everything happening in Iran. In my research, I often wonder how much we know about them. Also, Iran publicizes its space program, and, as I mentioned, their official argument is that it is civilian and not for military. They claim that they are not trying to make a nuclear bomb as part of their space program, but that it is for civilian uses. So, because of this, they publicize their program. When they tested their long-range missile space program, it was in Iranian media, they talked about it, they took pictures, and they wanted to take credit to show pride, not only to the outside world but to their own people. The Iranian government, with low oil prices, is under pressure, and they try to take pride by scientific achievement given that they cannot meet the economic expectations of the Iranian people. So, they widely publicize the successes they have regarding their space program.

I believe we have good picture of what they do. Probably what is not clear, and there is no way to know, is what exactly their intention is. Something about having a space program, it is easy once you develop the capability to launch long-range missiles for civil use to then switch it to military use—once you develop the expertise to make space vehicles, space programs, etc. you can put them on missiles instead of just civilian satellites. So, these are concerns that at one point if they get better in developing space program, they might switch to military use. There is no way to know what their intentions are.

[...]

Interviewer: [Q2 indirectly] Hi Gawdat. I think it's very interesting that you spoke about nationalism as a reason for the development of and contribution towards the Iranian space program. I also thought it was particularly interesting how you talked about how the Gulf States have the money but not the necessary technological infrastructure. So, I'm wondering if comparable level nationalism could serve as the same catalyst for any of the Gulf nations to begin to develop a space program of their own?

G. Bahgat: Sure. I'm glad you mentioned this because, as I kept saying, one big point about space programs is that it brings a lot of pride for the country. Gulf States lack of the scientific infrastructure, so the best they can do is pay a lot of money. I believe it was Saudi Arabia that actually joined its space program with United States. But, the Saudis themselves, and the same thing for UAE, cannot build a space program of their own inside their country to the level of other countries because they lack the scientific infrastructure.

Iran is under sanctions, yet Some of the Iranian universities are among the top universities in the world. Sharif University is one of the top 100 universities in the world. You cannot buy science with money.

Also, it is a matter of national security. The United Arab Emirates has the money, but the challenge they have is can they employ Jordanians, Egyptians, or Indians in these programs? There are concerns about this because this is very sensitive work, so it has to be a UAE national, but most UAE nationals just do not have the qualifications. UAE is much more advanced than the other Gulf States. They will be the first Arab country to have a nuclear reactor. They are one of our closest allies in the region. But, most of the labor force in UAE is from foreign countries, so the small population and the lack of the scientific tradition of research is limiting their capability.

Interviewer: [Q2 indirectly] That's the very interesting that the pool of talent and lack education is a contributing factor. So, to add on a little bit to that, the UAE and other Gulf nations are experiencing a historic détente with Israel, it seems. You talked about cooperation with other regional actors, so could cooperation with Israel and its space program and space expertise be possible? Could we see a possible burgeoning relationship in that regard or is that just another far-fetched reality?

G. Bahgat: This is an excellent question.

First, and if I may address the point about education. I have done a lot of work with Georgetown University in Doha, and Gulf states like Qatar, UAE, Saudi Arabia, and Kuwait, have the money but after September 11 it became harder for their students to come here, so many American universities opened campus branches there. The idea was to educate young people in the Gulf since they cannot come to United States for security reasons. It ended, though, as American universities decided to maintain their high standards and they refused to lower their standards to accommodate Emirati, Qatari, and Kuwaitis. This is almost funny because Georgetown University in Qatar was opened to educate Qatari people but the great majority of students there are foreigners basically because the university is striving to maintain its high standards. This highlights the gaps in education.

For Gulf States to work with Israel, this is in the media now and I believe it is very credible. There is something, people call it Arab NATO, and basically it is one of the goals of Trump administration to have Arab countries work with Israel against Iran. And there are reports in the media about high level meetings and exchange of visits between Israeli leaders and Sunni Arab countries like Egypt, Jordan, and Gulf states. One main challenge for this so called Arab NATO is whether there will be a solution for the Arab-Israeli conflict. In the last few days, this conflict in Jerusalem with the closing of the mosque there, has shown that it is very hard for Arabs to either to come in public and make peace with Israel or ally with Israel while there are disputes about Islamic holy sites in Jerusalem. The United States, all American administrations and presidents, have been pushing for peace between Arabs and Israel. I believe if they can at least contain the conflict between Palestinians and Israeli, this would help. What I'm trying to say is that it is very hard for the Saudi King and for the Emir of UAE to publically ally with Israel as long as the Palestinians have basically no rights in Israel. To advance the peace process will help to create this Arab NATO.

[...]

Interviewer: [Q2 indirectly] So, it seems like the barriers to for creating a space program are decreasing over time as the prices of materials are decreasing. You noted that for some Middle Eastern countries the barrier to the development of a space program is funds, and it would seem that some Middle Eastern countries would be hopeful and optimistic about eventually, within the not too far foreseeable future, being able to create a space program of their own, so which of these countries do you see as being most motivated to get to that point where they can create a space program?

G. Bahgat: If I had to put money on it, I would say probably Turkey and Egypt, and maybe Saudi Arabia. They have the resources. Saudi Arabia is different from other Gulf States—it has a population about 30 million people, it is a large country, and it has the money. Though, the challenge for Saudi Arabia is probably about succession. If the young Crown Prince can establish himself—the King is about 81-years-old and nobody knows how long he will live—then Saudi Arabia has the potential and the ingredients to make advances in science, economic development, and in other areas, if they can avoid a succession crisis—which could happen any time now because the King is 81 and his son 31. If the King lives over 5-6 years, then I believe this will be enough time for the young Crown Prince to establish himself, and he has the potential to lead the country to become real power.

For Egypt, its challenge is its economic conditions. Egypt has about 90 million people, has relatively developed scientific infrastructure, has reasonably good universities, and has good talents there, but Egypt lacks the money. Can Egypt make up for this lack of funding by working with Saudi Arabia, with UAE, etc.? The problem is that Arab countries have never trusted each other, and there have been efforts before to cooperate but these eventually did not work out. Egypt has the infrastructure, but does not have the money.

As for Turkey, in United States sometimes we will consider Turkey part of the Middle East and sometimes we would not, but if we consider Turkey to be a Middle Eastern country, it has the necessary money and the necessary human and technical infrastructure. I believe Turkey would be the best candidate here to develop a space program. One last point about Turkey, Turkey is NATO member, so Turkey probably does not need a military space program and most likely it would develop a space program more towards civilian uses.

[...]

Interviewer: [Q2 indirectly] Great, thank you Gawdat. The last question we always ask folks is a general question, but I will ask you as well. Is there anything I haven't asked you that I should have, or is there any final point that you'd like to conclude with.

G. Bahgat: I think that the last point that I'll make is that as far as I understand, space programs are very much dual use—they can be used for both military and civilian uses. We, the United States, have the best technology, and I believe if we cooperate with other countries, including Iran—and the Iranians are open to work with us in science, in economic development, etc.—then being there will help us to see this. If I were advising the American government, the administration, I would say we have basically two approaches: either to contain or to engage. I believe engaging—being there and watching what they do—will be better for us, and better for us to make sure that the program stays civilian and does not switch to military. For sure, they might try to cheat, but being there, being on the ground talking to them and watching them, I believe will be better for the United States.

Marc Berkowitz

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

WRITTEN RESPONSE

[Q2] How does each entity in the following categories conceive of space operations for military and commercial purposes?

Russia, China, Iran, and North Korea have “commercial” space enterprises or front companies that are wholly-owned by the regime and conduct “commercial” operations as cover to obtain currency, technology, and know-how for military purposes.

Both Russia's and China's concepts for military space operations are driven by their military strategy and doctrine. In Russia's case, this is different than the Soviet Union's and reflects a greater reliance on nuclear weapons for intimidation and coercion as well as to offset perceived US/NATO technological advantages. Space control operations are seen as central to denying the US the advantages of its “reconnaissance-strike complex,” i.e., the utility of its nonnuclear precision strike capabilities.

China is not a lesser included case of the Soviet Union or Russia. Its space operations concept reflects China's active defense strategy focused on “informationalized” warfare. Space control operations are seen in the context

of information-based warfighting to deny the US its ability to sense, decide, and act effectively and thereby deter intervention.

[Q2] How do they approach space operations and services?

China's recent establishment of its Space Support Forces (that include nuclear, electronic warfare, and space control assets) reflects a different organizational approach to space operations for informationalized warfare than Russia. Their approaches also differ with respect to their concepts for deterrence and escalation control. Indeed, Russia's concept of "escalate to deescalate" is a dangerous idea that could lead to rapid and uncontrolled escalation with its apparent emphasis on quick resort to irreversible weapons effects. In contrast, it appears that China's is a graduated and controlled approach with a more deliberate shift from reversible to irreversible weapons effects.

[Q2] Is there any difference in how their commercial ventures (if any) consider security during peace, crisis and conflict?

The term "commercial," for the purposes of US space policy, refers to space goods, services, or activities provided by private sector enterprises that bear a reasonable portion of the investment risk and responsibility for the activity, operate in accordance with typical market-based incentives for controlling cost and optimizing return on investment, and have the legal capacity to offer these goods or services to existing or potential nongovernmental customers. (Note - this definition is actually less stringent than the commercial definitions in previous Presidential directives.) Neither China, Russia, Iran, nor North Korea have commercial ventures that meet this definition; in fact, their "commercial" enterprises are merely extensions of their regimes and thus consider security in a comparable manner.

Actual commercial ventures in Europe, Asia, Australia, and South America are concerned about security in the context of their profit motive to generate revenue to obtain a return on investment, compete effectively in their commercial market segment(s), and extend and grow their sales, orders, and profits, and provide value to shareholders. They provide security and protection of their mission critical employees, information, infrastructure, and assets only to the extent required as part of their business plan to protect their investment and generate returns. This typically entails cyber, information, and physical security practices primarily to protect against natural hazards in the space environment, unintentional human-made threats, and the likeliest intentional threats during peacetime.

Private sector enterprises, in general, do not see their assets as likely targets in crisis or wartime and have no incentive to provide passive or active countermeasures for protection and defense against the spectrum of threats beyond cyber, electronic, and low intensity physical attacks. To the extent commercial ventures think about the security of their assets in crisis and wartime, they expect their governments to provide for their protection and defense.

Brett Biddington

Founder (Biddington Research Pty Ltd)
9 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: **[Q2 indirectly]** Okay. So, what about a term like "space" itself or a term like "outer space?" Are there any differences in how Australian policy and US policy define "space" or "outer space?"

B. Biddington: That's a really good question, too. I've talked quite a lot about this. At the senior political level in Australia, the word "space" is basically a dirty word. The reason for that is because over many, many years, the agenda in this country for space has been fundamentally set in two places.

The first place is in the classified domain and the Department of Defense. Since the 1940s, space has been at the heart of Australia's national strategy. In the 1940s and 1950s and into the early 1960s, it was basically the relationship between Australia and the United Kingdom around the activities of the Woomera test range. When the Brits withdrew, that's when the Americans basically came in and said, "Have we got a deal for you," and that has led of course to the joint facilities that are so important. That's really the long poll in the tent of the Australia-US alliance. And I don't see that changing, actually, but it's something that our government in Australia finds very difficult to talk about because they don't want to say anything that might in any way compromise the capabilities that are supported.

The second place is the civil and commercial aspect where that agenda has been largely set by scientists, and their view has been to go to the government with their hands out for money for pet-projects that have not necessarily been in the national interest but have been in their own particular research interests. So, there has been a lack of coherence in that approach for a long, long time.

There is some evidence that this may be changing quite rapidly, but the past is still with us in terms of this over-emphasis on science and under-emphasis on the economic importance of space to not just the national economy but the global economy, as well. That economic argument has not been well-articulated. If I lift this one level, this means that there is no coherent national narrative in Australia around space, and that's what I've certainly been trying to create for the last decade.

Interviewer: [Q2] Okay. That's very interesting. And I think that segues nicely in to the first that I was hoping to ask you, which has to do with how other actors conceive of space operations for both military and commercial purposes. So, how does Australia conceive of space operations for both military and commercial purposes?

B. Biddington: Again, all of the questions that you're asking are things I've been battling with for a decade, so they're good questions. Firstly, I would say that I think that war is already on in space—it's just not declared. I was at the space symposium in Colorado Springs in April and went to the AGI stand and of course got the briefing about the Russian satellite that cozied up against a NRO asset, and this was all presented at the unclassified level. Equally, the Chinese satellite that cozied up against an Optus commercial satellite, which is an Australian communication satellite.

However, this is just not well-known. What's happening in space is not in the public consciousness. There's a little bit, of course, about debris, which has been popularized by films like *Gravity*, but this is still a very arcane and private conversation among, relatively speaking, a very small group of people (i.e., policy makers, lawyers, technicians, and engineers). This is just not really something that the rest of the world has coherence and understanding about. So, that's the first point I'll make.

The second point is about space operations from the Australian perspective. Australia is a tiny nation when it comes to investing in space. Australia has, I believe, the 14th largest economy in the world, but it is not investing much in space in GDP terms—Australia is about just under 2%, I think, of global GDP. Australia doesn't invest anything like that proportion of its treasure in space activities, so it underperforms against that very crude measure. But then, because of Australia's alliance relationship with the United States, it effectively had, if not a free ride, then one that's been very good value from a tax payer's perspective. But, if I lift that up a little bit, the entire world benefits from GPS, which, of course, is now a global utility courtesy of the US tax payer. So, Australia has to balance, I suppose, just how much it really should be investing as a small or medium power.

The Australian paradox is that we have two numbers that matter: a big number and a small number.

The big number is that Australia is responsible, one way or another, for about 15% of the Earth's surface. That's our national territory, plus the oceans that we have search and rescue responsibility for, and plus Antarctica, of which Australia claims about two-thirds of the continent. To give you a picture of what that means, and this is where Mercator's projection doesn't help us, but think of the map you have in your minds of Australia. The piece of Antarctica that Australia claims is the same size as the Australian continent but minus the state of Queensland. So, that's the big number: 15% of the Earth's surface. And, of course, Earth observation satellites and communication satellites are very helpful in regulating, governing, and understanding what's going on.

The small number is Australia's population—about 25 million people trying to run a continent the size of the continental United States. Sure, Australia doesn't have all of the infill cities like the US does, but it gives you a sense of the paradox that this massive sort of global responsibility with a tax base of about the size of New York state. So, ask yourself the question, "How would you all do that in your country?" And the answer is, of course, "with a lot of difficulty." Therefore, Australia has had to make some very big decisions about where it places its investments, and space has just not been one of those. And a big reason for this is because of Australia's alliance relationships.

So, moving to the operations point. If space goes to hell in a hand basket, there's very little that Australia can do about it other than, of course, helping the United States, and the West more generally, and maybe the global community because, ultimately, all of us stand to lose if we muck up the space environment more than we already have—it affects China and Russia just as much as it affects the United States in terms of satellites. So, Australia has to think really hard, I think, because of its strategic geography about how it can contribute to, and I hesitate to use the word the "order of space," but at least to the regulation of space to ensure that's it's there for all to use.

Interviewer: [Q2 indirectly] So, you started off by saying that "war is already on in space—it's just not declared." That's an interesting statement, and one that I would think would be somewhat controversial, right?

B. Biddington: Yes, that is a controversial statement. Of course, the euphemism we use is proximity operations, one way or another. And, of course, we do proximity operations every time we supply the Space Station. The profound issue here is, of course, that almost everything we do in space is dual use or can be badged as being dual use. And, I have no doubt at all—and I have no insight into the classified world at the moment for these things—that there are nations, particularly the US, Russia, and China, that are essentially doing bad things to each other. They're not yet blowing things up, because that's to nobody's interest, but, certainly, there's very intense competition within the space environment, I would suggest, simply on the basis of the examples I gave to you.

The big three nations (the US, Russia, China) are really trying to understand very, very carefully what each of the others is doing, with a view to be able to shut these things down very, very quickly in the event of conflict. Of course, this is where you get the relationship, then, between space operations and cyber operations.

Interviewer: [Q2] Okay. You talked a little bit this Australian paradox and some of the issues that Australia encounters with determining where it invests its money, so, I'm wondering, what do you sort of see as Australia's key ambition and interests with respect to space domain, and what sort of action has the country has taken in pursuit of those ambition and its interest?

B. Biddington: So, firstly, Australia is a very low and flat country with large areas of land that are mostly empty of people. This means that there are large areas of the landscape where radio frequency interference is minimal, and that's why, for example, we do a lot of testing of really interesting electronic warfare capabilities out of the Woomera test range, which is five times bigger than China Lake just to give you some perspective.

Since World War II, Australia has made a couple of big bets in research nationally. One has been in immunology, and the other has been in astronomy, and especially in radio astronomy and radio astrophysics. Australia has used its landscape here, of course, because being quiet electronically makes Australia a great place for radio telescopes. So, Australia does that very well. Australia came out of World War II with a lot of radar research, and then out of Australia's radio astronomy capabilities, came WiFi, which was an invention 15-20 years ago but that's where it came from.

Australia continues to invest, in particular, in radio astronomy and radio astrophysics at the research level and the operational level.

So, moving to the operations side of things. Australia, again, because of its geography, hosts important ground stations for the United States, the European Space Agency, and others. And I think that that will continue. Whilst it certainly is the case that it is now technically possible to simply have constellations of satellites talk to each other, so you don't necessarily need ground stations in other countries, I think that prudence and redundancy and resilience for networks will give some of these ground station long lives. And, of course, for the very deep space missions, like those that the NASA station near Canberra, Australia helps to manage you still need three ground stations spread around the world to ensure that the probe is always in view of one of them. Because of this, Australia will continue to support ground stations.

An interesting question for Australia and the United States is whether or not we will start to support ground stations from Russia and China. Russia and China are certainly asking if they can put ground station on Australian territory. So far, I think we have said "no," although there is a commercial Swedish organization, that has a ground station in Western Australia, and there is certainly a Chinese commercial lease running through that ground station. So, already, because of the way the world works, we have communications with people who are not necessarily our best friends and allies—from a national security perspective—using our territory commercially, at least.

So, if I now go to space regulation and space control, there are now facilities at Northwest Cape, which is at the western extremity of the Australian continent. There is currently a space radar, a C-Band radar, that has been brought from Antigua downrange from Cape Canaveral (Cape Kennedy) to Northwest Cape. There will also soon be a couple of operational space telescopes that are being relocated to Northwest Cape as well. So, Australia is starting to build some ground-based space surveillance capability, and I think Australia will continue to do that. There is also a cooperative research center, which is a joining together of universities and companies and other research organizations based in Canberra, that is looking at how we can improve space situational awareness, tracking, and prediction, particularly of space debris. This will then need to be fed in to a national and, ultimately, an allied and even international system so that we can make sense of it for the whole world.

So, these are the sorts of things that I think Australia will do.

In terms of its own space activities, Australia has no government-owned Earth observation satellites at the moment. The only satellites with an Australian flag on the side that are registered with the United Nations, are communications satellites, which are from the Optus company and also from the National Broadband Network company, which is a government-owned business enterprise. In the current Australian defense white paper and investment plan, there is a \$3-4 billion project for space-based remote sensing—now, just what translates to, who knows? It could be a combination of commercial leases to buy data that somebody else has already got, but, almost certainly, I think there will be some Australian capability as well—in other words, Australia will start to run its own Earth observation satellites.

Interviewer: [Q2] Okay. So, what does the Australian commercial space industry look like in comparison to maybe some other countries' commercial space industries?

B. Biddington: So, the Australian commercial space sector is fragmented. There is no center of gravity of companies that self-identify as being space companies. What there are, are some companies that run satellites as part of their telecommunications business, and they see themselves as telecommunication suppliers who happen to use satellites for part of their business. On the Earth observation side, we have a number of companies that sell or re-sell data that come from satellites owned by foreign entities, but they don't identify themselves as space companies, they identify themselves as data companies. So, part of the challenge that we have in Australia is to say to these organizations, "Look, you do need to start to at least think a little bit about the dependencies that the bread and butter that you put on your tables has on secure and assured access to space and to satellite services. And you need to invest in thinking about how to help government, and how to help yourselves, ensure that we make the near space environment as safe and secure as possible."

So, again, this brings you back to the question of, "So what should a small to medium power do that is realistic and helpful, and does not fall into the trap of over-staking your own capabilities in sense of importance and influence in these matters?"

Interviewer: [Q2] Sure. So, what is the relationship like between the Australian government and Australia's commercial space entities? Are there any key noticeable hurdles in the relationship that we should be aware of?

B. Biddington: So, civil and commercial space in Australia is the responsibility of the Department of Industry, Innovation, and Science, and responsibility is buried in the department at the level of middle-ranking bureaucrats. There is no space agency in Australia. There is no central sort of coordination office. There's no identifiable leader in government of Australian space activities at a level that is recognized both nationally and globally (i.e., you cannot simply say, "This is the person who looks after space in Australia"). The responsibility for space in Australia been dissipated and spread around many departments over many years.

Now, in part, that's because, at the national strategy level, the big questions of space have been answered by Australia's alliance relationships, so Australia hasn't really had to think about space issues too hard because people in the UK or, since the 1960s, the US, have really looked after the big questions for Australia. And, as I said before, if space goes to hell in a hand basket, there's not much that Australia can do to mitigate that other than potentially provide its real estate to help the United States. This has made Australia massively dependent on its allies here, particularly the US—I mean, \$1 of every \$2 spent in the world on space is spent by the US, so the mere fact of the size of this US investment is a good reason to stick closely to the United States. It just makes good sense economically and strategically.

So, Australia has civil and commercial space buried, from a policy perspective, in the middle of a relatively small government department, which does not wield huge influence and whose minister is not a member of the National Security Committee of Cabinet. The default position of the Australia government for a long time has been, "how little can we invest," not "how much can we invest."

With that said, of course, technology is changing this world rapidly, and small startups in Australia and elsewhere are starting to say, "Well, guess what? We can now afford satellites. We can launch satellites. We can make money in a way that previously we could not," so government is having to react to that. Australia even has a company that I think has a 50/50 chance of setting up a successful launch business in northern Australia, looking specifically at equatorial launches into lower Earth orbits in the first instance, which is of course something of great interest from a security perspective to Australia.

Interviewer: [Q2 indirectly] Okay. So, to transition into the next question I was hoping to ask, what are the motivations of nation-state and non-state actors to contest the use of space in times of peace, instability, and conflict?

B. Biddington: My view on this is very old-fashioned. I see space as the preserved still of nation states. And that's because launch is so difficult, and, therefore, relatively easy to regulate by the nation state. So, where nation-states have lost control really of the Internet—I know that there are arguments about organization of the Internet but, ultimately, the Internet will go where it goes; however, that's not the same with space. It's very, very difficult to launch anything in space, and that allows governments to maintain a very close reign on what gets launched and by whom within their own jurisdictions. That, to me, plus the advantages that satellites give nation states, I think implies the high ground of peace and war. And I think that will remain ever thus.

What that means is that despite the record pace of civil and commercial entrants into the domain and increasingly complicated landscape that is emerging, ultimately governments will be in the position to call the shots and prevent launches if they're not perceived to be in their national interests. So, that means that small and medium powers that don't launch themselves will be dependent on others to launch for them, and, of course, that means that those dependencies will lead to vulnerabilities.

I really see the future in space as one that's run by nation states acting in their own interests, and because of what satellites can and can't do, they will make a very important contribution to national security. To me, the question is how you build sufficient consensus, especially between the big 3 space actors (the United States, Russia, and China), and sufficient trust and understanding so that everyone actually works to keep the space environment accessible to all, rather than completely trashing it—as we have started to do in the lower Earth orbits. As such, how you begin to clean space up, to me, is where this challenge immediately comes to the fore. As much as I applaud the people who say, "Let's go chase the debris and catch it," the engineers and the technologists who are running these conversations simply struggle with the concept that your garbage truck is my space weapon—they don't really understand or acknowledge the policy consequences of what they are saying. So, my plea is for a lot more people to start thinking about space policy and the issues around policy and law than is the case at present.

Interviewer: [Q2 indirectly] Okay. Great. Thank you for going through all of those questions with me. We always conclude these interviews with a general question, which I will ask you as well. Is there anything that I haven't asked you that I should have, or is there any final point that you would like to conclude with?

B. Biddington: I don't think so. Though, we haven't talked about Australia's region or the region's aspirations, so I will just make a quick comment on that. In Australia, certainly, we have people who criticize the Australian government for not having a space agency, and then they point to the fact that Indonesia, Singapore, Malaysia, and New Zealand all have space agencies, and then they use that to say that Australia is so far behind because it doesn't have a space agency. However, these people fail to understand two critical points. First, they fail to comprehend how deeply involved in space Australia is and has been since the 1940s through its alliance relationships. Second, they fail to understand that Australia, through civil programs, has been using space-derived data since the 1960s. For example, Geoscience Australia (which is like the Geological Survey in the US), the Bureau of Meteorology (which is sort of like NOAA in the US), and CSIRO (which is Australia's civil research organization) have all been using space-derived data since the 1960s—they know data, they contribute to it, etc. Australia does very good stuff in processing, but it just hasn't had the requirements until relevantly recently to start to invest in its own satellites—though, there is now money in the defense budget to begin to change that, and some of that money will be used for dual use activities.

So, what I'm trying to say is that Australia needs to have a more sophisticated conversation than what many people are prepared to concede, and this gets back to the point I made earlier about the challenge of constructing a coherent narrative to a country full of paradoxes when it comes to space activities.

Duncan Blake

Law and Strategy Consultant (International Aerospace Law and Policy Group)
3 July 2017

WRITTEN RESPONSE

Introduction

I have been asked to contribute to a Strategic Multi-Layer Assessment (SMA) Space Project requested by US Air Force Space Command and undertaken by Joint Staff of the US Department of Defense (DoD). I have been specifically asked:

- How does Australia conceive of space operations for military and commercial purposes?
- How does Australia approach space operations and services?
- Is there any difference in how Australian commercial ventures consider security during peace, crisis and conflict?

I have also been invited, on the basis of my expertise, to answer any of the other key questions of interest, as listed in the document titled, “Open-source SMA Space: Questions for Outreach to Academia, Industry and Think Tanks”, which was attached to the email request.

My answers below are limited to the areas of my expertise. For this purpose, I will include a short biography in the email reply that includes this document. In summary though, I have been a legal officer (or ‘Judge Advocate’ in US terms) in the Royal Australian Air Force for 22 years until January this year (2017) and have predominantly focused on laws applicable to military operations at the tactical, operational and strategic level (whole of Defence and whole of government) at home and on multiple deployments to areas of conflict. Since 2009 my focus has been on the law applicable to military uses of space. I have chaired an inter-departmental working group on strategic space law across Australian government and I have chaired an international working group on strategic space law among allies in the Combined Space Operations (CSpO) initiative. In 2015 and 2016 I managed the development of a future joint operating concept for military use of space across the Australian Department of Defence, looking out approximately 15 years (a non-legal position). Given the relatively small size of the Australian Defence Force, the Australian economy and population, any future strategy in Australia for military use of space must encompass the needs and capacity of the nation as a whole in respect of outer space and therefore the research implicit in the development of this operational concept involved a considerable amount of liaison with industry. In respect of law applicable to outer space, among other things, relevantly, I initiated and am now the Deputy Editor-in-Chief for the project to draft a Manual on International Law Applicable to Military uses of Outer Space (‘MILAMOS’, see www.mcgill.ca/milamos). This is a global, civil society effort to clarify the application of the laws of war to the space domain for the benefit of all nations, prior to the outbreak of any hostilities involving outer space. Therefore, in short, my area of expertise may be described as the fusion of law and strategy in respect of the use of space, especially in a military context.

Given my expertise, I am well placed to answer questions under the heading, “Space Law & Norms” and some questions under the heading “National Security & Space”, as well as the specified questions under the heading “Ally, Partner & Adversary Use of Space”. The email request sought 1 to 3 pages in response to each question. I have set out my response to cover many of the questions under the headings that I’ve listed above and I’ve highlighted text to make the link to particular questions more obvious. While I am well placed to provide broad comments about the commercial space sector in Australia, especially as it pertains to military use of space, I am not well placed to provide in-depth comment on the sector. I can provide points of contact for this purpose if necessary.

Understanding “victory” in the space domain

The documents that were provided for this SMA Space Project allude to, but do not directly address, a foundational issue that must be considered before a coherent strategy for future military use of space can be concluded. That foundational issue is:

Why?

Why does the US government need to “regain the initiative in the space domain e.g., by outpacing adversaries’ development and deployment of space capabilities; countering intent or efforts to deny US freedom of action in this vital area.”? This preliminary question is implied in the 5x8 document where it requests that writers “Identify the rewards and risks of a policy that views space as a joint warfighting domain.”

The rationale for being prepared to fight and win in the space domain cannot be self-referential – it is not an end in itself. It begs a question: What is it that dominance of the space domain offers the US (and its allies) as a whole, that cannot be fully achieved by other means? At this point it is important to distinguish between the space domain and terrestrial domains and to adapt our understanding of win/loss or victory/defeat to the nature of the domain. It is not possible to seize and hold ground as a military force would on land. In the foreseeable far future, it is conceivable that a military force may be sent beyond Earth to seize and hold parts of the Moon and other celestial bodies (leaving aside, for the moment, the legal framework applicable to this scenario) – but that is several decades away. Earth orbits and beyond are very different to sea lines of communication and air lines of communication – although there are similarities. In the near and medium-term future, the benefit of space is defined by reference to the indirect benefit that space services provide on Earth, not by reference to space itself. That is, win/loss or victory/defeat in respect of the space domain should be defined by reference to the capacity to assure uninterrupted access to space services, while being able to deny the benefits to an adversary. The challenge is to pursue this objective without actions or narrative that would compel potential adversaries to develop the capability to compete with US efforts towards assured access.

This is reflected in the guiding principle for Australian military use of space – that is, support for a stable, rules-based, global order for outer space (see successive Australian Defence White Papers). Australia recognises and values the benefits that space services (most of them from US sources) provide to us as a nation and to our military forces. Our focus is on preserving those benefits and it would not make sense to develop the capability to dominate outer space beyond what is necessary to assure a stable, rules-based, global order. Furthermore, the emphasis is on assured access, in the first instance, through stability and through, ideally, an order that is based on rules and rules that are accepted globally. This appeal to universally-accepted rules is intended to avoid actions and narrative that would compel potential adversaries to develop the capability to compete with US efforts towards assured access. An arms race in outer space is more likely to be counter-productive to assured access to space, whereas preparing to ‘fight’ the strategic narrative (on which I expand below) is a more certain path to ‘victory’.

An appeal to rules should not be regarded as naïve and ineffectual – the rule framework applicable to outer space includes rules that allows a State, in appropriate circumstances, to respond to breaches of the rules by other States, to take action to defend itself (and others) in outer space and to give effect to United Nations Security Council resolutions. Thus, preparing to ‘fight’ the strategic narrative implies developing and maintaining capabilities that would allow the US (with allies) to defend its assured access to space and to secure access to space in support of United Nations sanctioned operations. Furthermore, an appeal to universally-accepted rules has the effect of coopting allies to the cause of the United States (thereby being able to form powerful coalitions in the event of hostilities) and the effect of alienating those who seek to define win/loss or victory/defeat by reference to more jingoistic, expansionist concepts. In addition to the links to capability, in addition to the fight for the strategic narrative and in addition to the formation of coalitions with allies and the alienation of others, the a favourable rules-based order has other benefits that I discuss below under the heading, “Winning’ the strategic narrative’.

The ‘battle for legitimacy’ or ‘fight for the strategic narrative’ has already begun. From an Australian perspective, the continuing global leadership of the United States remains the best means to ensure a stable, rules-based, global order for outer space. It is imperative that the United States does not cede leadership in this preparatory battle (for legitimacy) to seemingly positive initiatives by Russia and China such as the draft Prevention of the Placement of Weapons Treaty (PPWT) and No First Placement (NFP) resolution. The foundations that are set now, in a time of apparent peace, will be the foundations on which the battle for legitimacy is fought at a time of hostilities.

The reference to space as a ‘warfighting domain’ is useful internally within the military forces of the US and its allies to mark a paradigm-shift in thinking about the nature of the domain. It implies operationalization of the domain including, for example, Space Operations Centres that are part of the overall weapon system, in the same way that an Air Operations Centre is part of air weapons systems. The phrase is unhelpful externally though, because it implies a desire on the part of the US (and its allies) for conquest over the space domain. A better external message would be to emphasise US acceptance that, as a superpower, it can make a greater contribution and bears a greater burden than others in the shared responsibility for a stable, rules-based, global order for outer space.

Characteristics of stable, rules-based, global order for outer space

What would a stable, rules-based, global order for outer space look like? In parallel with the alliteration that describes the current strategic challenges in the space domain (congested, competitive and contested), an alliteration describes the characteristics of a stable, rules-based, global order for outer space: regulated, resilient, redundant and repercussive.

Regulated

There are four key elements of a regulated space domain.

CLARITY. First, there must be clarity in the norms of responsible behaviour.

The discussion about those norms tends to be at a relatively ‘macro’ level. The *Outer Space Treaty* (OST), in spite of its many benefits, is expressed in broad statements of principle and even the laws of war are generic – because they apply in a broad range of circumstances. So, we talk about how ‘scale’ and ‘gravity’ and other things are important indicia of an ‘armed attack’ for the purposes of the laws of war ... but the operators want detail. For example, what are the dimensions of a zone around a satellite and exactly what are the consequences if the line is crossed. Lawyers working with operators want to provide such clarity, but a unilateral and arbitrary pluck is likely to be disruptive of space security, not a step towards a better regulated space domain.

Rather than a unilateral and arbitrary pluck, there needs to be some global consensus around such norms. However, in a climate of heightened global strategic tensions, relative insularity, apprehension and paranoia, consensus seems impossible. The MILAMOS Project (www.mcgill.ca/milamos) takes the consensus-building out of that climate by insisting that experts participate in a personal capacity, not a representative capacity and focus on what the law is, not on what one or other State might want it to be. But the MILAMOS Project is only a small part of the solution. We need to develop more detailed technical solutions and specific industry standards – around things like space debris, space traffic management and electromagnetic interference.

Technical standards can have a really positive strategic impact – even though the extent of their strategic significance may not be immediately apparent. Regulation can be valuable even in respect of delinquent actors in outer space – because if most actors comply with the regulation, it becomes easier to filter out aberrant behaviour and call it out for what it is. Bear in mind that only the most overt aspects of military activities involve explosions – the vast majority of military activities, even in the context of hostilities and build-up of tension leading to hostilities, are not so obvious.

Thus there is a symbiotic relationship between laws of war, for example, and the potential regulatory outcomes of the COPUOS guidelines on the long-term sustainability of space. (Among other initiatives, I am working with a group of Australian companies to develop multi-disciplinary (technological, economic and regulatory) approaches to Space Traffic Management and we would be keen to contribute to efforts in the US DoD or elsewhere in this regard).

AWARENESS. Secondly, there must also be awareness in respect of regulatory standards. COPUOS and national space agencies and regulators would play a large part in that. Awareness also extends to the anticipated effects of space activities. Continuing research is essential, for example to improve orbital predictions, thereby facilitating regulatory compliance in situations analogous to the 2009 collision of a Kosmos and an Iridium satellite. Also, if hostilities do spread to the space domain, greater understanding of orbital dynamics helps to minimise collateral damage.

TRANSPARENCY. Thirdly, the conversation should go both ways – from regulators to industry and from industry to regulators. Transparency is essential. It may seem at odds with a desire to maintain the technological edge, maximise profit from intellectual property and protect national security. Yet, it is often possible to provide sufficient detail to demonstrate that a capability is well-adapted for a benign purpose, but ill-adapted for hostile purposes.

ATTRIBUTION. Finally, we need to improve the ability to attribute activity to a space actor. This extends not only to identifying or predicting where things were, are or will be in outer space, but also what they were doing, including what frequency they were using. Modelling of effects in outer space also offers significant national security value in distinguishing deliberate from natural sources of interference.

Resilient

Resilience involves making space infrastructure more protected and more recoverable in the event of hostile interference with it. (NB, my use of the term ‘resilience’ is not necessarily coincident with the use of the term in Office of the Assistant Secretary of Defense for Homeland Defense and Global Security, *Space Domain Mission Assurance: A Resilience Taxonomy*, White Paper (September 2015) online: Federation of American Scientists <<https://fas.org/man/eprint/resilience.pdf>>). Space infrastructure which is more protected and more recoverable is a less attractive target. Also, space infrastructure that is well-protected and highly recoverable is less likely to be a valid target under the laws of war.

PROTECTION. Many enterprises are already looking at new ways to protect space assets by ‘hardening’ them against kinetic effects of large masses, shielding them against radiation and securing them against corruption or disruption of data. Space assets can also be made more manoeuvrable, to avoid conjunctions. They could conceivably be given on-board defensive capabilities, although the weight cost for an effective system may be prohibitive. It is more likely that active defensive systems would be off-board. One good example, is a proposal for active debris management, using a laser to move a piece of space debris before a predicted conjunction occurs. There are many legal complexities with such a capability, but the biggest policy and potential legal issue is that it raises the spectre of offensive capabilities and an arms race in outer space. This is also an example of where transparency could be a valuable commodity for the US and its allies, especially if it could be shown that the system is well-adapted for the benign use and ill-adapted for hostile use.

Space objects, or elements of them, also gain some protection by being concealed. Declining to register space objects and launching them in secrecy is one means to achieve this and enterprises could conceivably find new ways to make satellites more difficult to find and to track. However, this undermines space as a well-regulated domain. Also, the use and mode of operation of a component (eg, hosted payload), satellite or constellation could be obscured, by technical or other means. The advent of cubesats, that can be adapted to many different purposes, including functioning as a formation or constellation of satellites, makes this easier. A cubesat could even be deployed as a decoy, to attract unwanted hostile attention, rather than the real capability. Again, though, opacity does little to build trust and confidence and promote a well-regulated domain. In the context of hostilities, a satellite used for military purposes, but posing as a commercial satellite, is perfidious in nature and the operators may be culpable of a war crime.

Dual use infrastructure (used for both military and non-military purposes) is commonplace terrestrially, as it is in outer space and there is nothing unlawful about that. However, one advantage of integrating military payloads or space services within commercial space infrastructure, that is sometimes proffered, is that it creates complexity – ambiguity that makes attribution and targeting more difficult (because targeting risks involving otherwise neutral third-parties). As a matter of policy and reputation, hiding behind the coat-tails of commercial and civil space enterprises demotes the military to the level of insurgents that hide among the civilian population and deliberately using them as a shield in the context of hostilities could conceivably be a war crime.

Protection also links to awareness and attribution. Understanding what is happening in the space domain and being able to attribute action to hostile or natural causes increases the protection of the system. This can be amplified if awareness and attribution is shared.

RECOVERABILITY. There are many ways of improving the recoverability of satellites and constellations and the systems of which they are a part, and many enterprises are already contributing to these. Developing satellites capable of self-diagnosis and repair is a good example. Another good example is satellites with ‘plug n play’ components and components that can be flexibly re-used and re-purposed, especially in conjunction with an on-orbit servicing capability. On-orbit servicing capabilities could be used, though, for hostile purposes – to interfere with a non-cooperating satellites.

As opposed to big, multi-purpose satellites, small, single-purpose satellites could be positioned much more rapidly and in response to operational needs. The storage of small satellites capable of multiple purposes with a slight configuration change and the possibility of positioning of multiple satellites with the same purpose all offer great options for recoverability. Some launch service providers are now foreshadowing a regular schedule of launches (as often as weekly) to provide flexibility and certainty. A manoeuvrable, re-use space vehicle, like the USAF X-37B offers the possibility of rapid positioning of multiple, small satellites. However, due to opacity around its mission, it may have done more to add to the strategic challenges in the space domain, rather than reduce them, due to fears of its hostile purpose.

Constellations of satellites also offer recoverability in a limited sense – the constellation as a whole continues to operate in spite of the loss of a single satellite and suffers only continuing ‘graceful degradation’ in the face of further losses.

A decision to rely on the space infrastructure of others is very recoverable, as long as other providers of the services can be fully accessed in the event that the original provider is no longer able to provide the services, and so long as the customer is willing to accept this dependence on a capability outside its control. Brokers of space services therefore facilitate the resilience of the space domain.

Redundant

In the event of the failure of protection and recoverability of space infrastructure in response to interference, ideally there would be alternative systems to supplement the space infrastructure, and/or means of rapid reconstitution of the space infrastructure. This involves not only technological development, but also economic development – that is, a global space industry in which there is quick, easy, competitive access to alternative space services. Redundancy reduces strategic challenges in the space domain by reducing the criticality of any one component. In the context of hostilities, this reduces the justification for States to respond with force to a deliberate attack.

In some cases, an alternative service could be provided terrestrially. A good example is the development of terrestrially-based navigation systems that may one day be fully viable alternatives to the Global Positioning System. There is nothing about the development of terrestrial alternatives that necessarily contributes to the existing strategic challenges.

The same is not true of near space alternatives. Near space platforms to facilitate communications, positioning, navigation and remote sensing have all been developed, at least experimentally. On the one hand, they provide redundancy for space infrastructure and reduce the strategic impetus to target space infrastructure. On the other hand, their development is potentially disruptive to stability because they represent a more direct threat to national security of other nations. While there are no national borders in outer space, there are in airspace. A legal delimitation between airspace and outer space still does not exist. In theory, a near space object could be ‘flown’ over the territory of another State without violating the sovereignty of the other State. The development of near space capabilities could motivate States to finally settle this question of delimitation, which would be a good outcome in terms of a better regulated space domain. In the interim, though, uncertainty about the legal status of near space would be likely to contribute to strategic challenges. On balance, the development of near space alternatives to space-based systems would offer the space domain more redundancy and may galvanise States behind one aspect of a better regulatory regime for outer space.

Repercussive

The strategic challenges in the space domain will remain if there are no consequences for irresponsible behaviour in outer space. Consequences for such behaviour by a non-State actor can be imposed domestically, by legal

process within the courts (for breaches of the domestic regulatory framework), and by policy decisions (for a broader range of behaviour). Where the breach is committed by a State itself, or with the tacit support of the State, what are the means to impose consequences on the State?

A proper understanding of the idea of imposing repercussions on a State that acts irresponsibly in outer space needs to start with an understanding of the strategic interests of a State. ‘Strategy’ refers to decisions aimed at optimising the capabilities, structure and preparedness of a State in order to pursue national objectives and protect its national interests. In the military context, ‘strategy’ focuses on the capacity to use of force to protect national interests and pursue national objectives, although this is often a ‘blunt instrument’ and other ways and means (such as diplomacy, economics and the control of information) are generally preferred.

Control of resources invariably lies at the heart of States’ national interests and objectives. However, especially as many global resources approach depletion this century, it does not seem possible for one State to accommodate another State’s interests in control of the same resources. Their interests are indivisible. Consider the current disputes of oil-rich maritime areas in the East China Sea and South China Sea.

International relations scholars cite two dominant factors that undermine the ability of States to reach a *détente* in such situations. First, without good information about the capabilities, preparedness, interests and strategies of one another, States are prone to strategic miscalculation. That is, relations between the States are characterised by ‘information asymmetry’. Secondly, in the absence of an effective set of principles or norms, neither State can make ‘credible commitments’ to hold to such principles or norms. In the space domain, these factors are exacerbated, because space is so much ‘out of sight, out of mind’. That is, it is difficult to get good information about what is happening up there, and without good information and some consciousness of the potential impact on our everyday lives, it is difficult to establish an effective set of principles and norms. The situation is particularly unstable in circumstances of a potential power transition, when the rise of one State threatens the dominance of another (such as the rise of China, relative to the US).

“Winning” the strategic narrative

An effective normative framework (stable, rules-based, global order) for outer space influences States’ assessments of whether the use of force and certain capabilities are the best means to protect their national interests and pursue their national objectives. An effective normative framework reduces the information asymmetry between States and facilitates credible commitments. To be effective, though, a victim State would need to be put in the situation where it can assert a strategic narrative in terms similar to what follows.

1. We know you did it (attribution)
2. We can demonstrate to the satisfaction of the international community that you did it (verifiability)
3. There is a normative framework covering irresponsible behaviour in outer space (normative framework)
4. The normative framework is widely accepted throughout the world (legitimacy)
5. It clearly applies to you in these circumstances and you clearly breached the normative framework (clarity)
6. We have the capability to impose consequences (capability)
7. The consequences will have a substantial effect on you (effectiveness)
8. Imposing those consequences will not have an unacceptable adverse effect on us (minimum recoil)

ATTRIBUTION. Has already been discussed above. Australia is keen to contribute to attribution through terrestrially-based sensors in Australia for Space Situational Awareness. This is a niche area where Australia sees an opportunity to contribute geography, skills, international relations and other things as a high-value trade for access to other things.

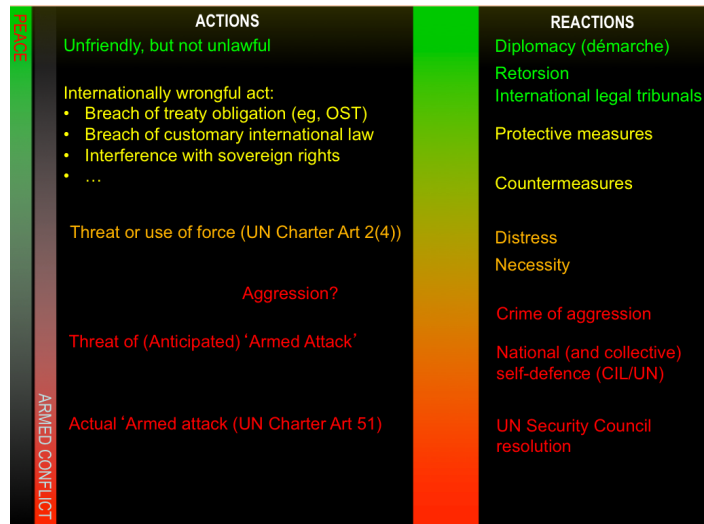
VERIFIABILITY. The step beyond attribution is verifiability. Even if one, or a small number of States, have information attributing irresponsible behaviour to another State, that other State could still act with impunity if it thought that there was no prospect that the first State(s) could use that information to galvanise the international community against it. Add value to domain awareness by developing forensic processes to verifiably establish the nature and authorship of deliberate actions in outer space. The Satellite Sentinel project is an example of an organisation thinking this way in respect of actions observed terrestrially (potential war crimes) from remote

sensing satellites. Evidence derived from satellites has already been used in support of environmental litigation. The same thinking needs to be applied, looking upwards (for ground-based sensors) and outwards (for space-based sensors). As those examples demonstrate, the challenge lies not so much in the means of verification (there are many sensors that could be used for verification purposes), but in the acceptance of the means of verification. This is closely linked to Clarity and Awareness above, especially the role of technical standards as a means of filtering or ‘parsing’ the space domain to distinguish normal behaviour from aberrant behaviour. That is, the development of industry technical standards should be strongly encouraged because it will help with verification and lead to more acceptance of the means of verification.

NORMATIVE FRAMEWORK. The OST and other space-specific treaties contain few rules that overtly cover military uses of space. This has led some commentators, including officials at the highest levels of government in the US, China, Russia and elsewhere, to comment that the space domain is relatively under-regulated – comparing outer space to the Wild West. On the contrary, there is a comprehensive legal framework applicable to military uses of outer space even in the context of hostilities and the build-up of tension leading to hostilities. Even though the OST and other space-specific instruments are expressed in broad statements of principle, they are not the only laws applicable to the space domain. At first glance it may not be apparent why the drafters of the OST, more than 50 years ago, felt it necessary to expressly include a statement confirming that the use and exploration of outer space is subject to the broad body of international law, not just the treaty itself. The drafters covered some military activities, but they anticipated that they could not foresee every future aspect of the exploration and use of outer space – thus the specific ‘drawing-in’ of the broad body of international law.

The laws applicable to hostilities and the build-up of tension leading to hostilities have continued to develop over the last 50 years, including through projects in other domains, similar to the MILAMOS Project – such as the *San Remo Manual on International Law Applicable to Armed Conflict at Sea*, the *Harvard Manual on International Law Applicable to Air and Missile Warfare* and the *Tallinn Manual on International Law Applicable to Cyber Warfare* (versions 1.0 and 2.0). Those manuals have had a significant impact in the target audience – military commanders and their legal advisors – as well as in tribunals, policy circles, the media and in academic commentary. The laws of war enjoy broad acceptance globally and breaches of those laws undermines the legitimacy of the responsible State or non-State actor and tends to galvanise the international community against them. Consider, for example, the international reaction to the alleged use of chemical weapons by Syria. Condemnation of the use of chemical weapons by anyone has been near universal, even though attribution to Syria or a non-State actor remains a challenge, as it is in the space domain.

In addition to the challenge of attribution, there is also the challenge of clarity. The laws of war undoubtedly do apply to the space domain – although this specific topic will be covered in the MILAMOS Manual. However, it is not yet clear just how the comprehensive framework of rules on the conduct of hostilities and the build-up of tension leading to hostilities, applies to space.



The apparent lack of clarity about the legal framework applicable to military uses of outer space has led to some strategic paralysis among leaders in wargames such as the Schriever series. In the absence of clarity, leaders are left without the normal level of guidance about what is permissible and what is not – or from a more strategic perspective, what course of action are more likely to galvanise a coalition and alienate the enemy, as opposed to course of action that are more likely to split a coalition and provide the adversary with the opportunity to create a favourable strategic narrative. The issue, though, is not a lack of clarity about what law applies, but about how it applies. Thus, the legal concepts that apply in the spectrum from peace to armed conflict can be clearly represented graphically as it is below. How those concepts ‘map’ to outer space is where the difficulty arises.

The MILAMOS Project involves more than 40 globally-acknowledged legal experts, with assistance from technical experts of a similar calibre, drafting succinct rule statements of the application of the law of war to the space domain, with commentaries accompanying each rule, explaining the basis for the rule and giving examples. The experts come from all over the world, including China, Russia, the United States, Japan, Germany, India, Canada, Australia and many more. Even though some come from government backgrounds, as I do, we all participate in a personal capacity and we express our personal opinions on what we believe the law actually is, as opposed to what any particular State might like it to be. This will give the manual a universality among its target audience and help the US and its allies in an approach to space strategy that emphasises a stable, rules-based, global order.

Notwithstanding that the OST 'draws-in' other bodies of law, such as the laws of war, there may still be a need to supplement the OST. This is partly because there are still 'gaps' in the legal framework not covered by either the broad principles in the OST and other space-specific treaties or the laws of war and partly because the US and its allies may wish to modify how the laws of war apply to space. Examples include:

- the treatment of dual-use objects in outer space
- the establishment of protective zones around satellites (by analogy to the safety zones established around offshore platforms under maritime laws, or Air Defence Identification Zones under air law)
- the status of military astronauts in times of hostilities
- protection of specific categories of space objects (such as satellites used in disaster relief or as 'National Technical Means of Verification or for missile warning)
- protection of space object and sites on the Moon and other celestial bodies of cultural heritage
- duties of neutral States with respect to access to their space objects in times of conflict

The International Astronautical Congress (IAC) in late September this year will occur just before the 50th anniversary of the entry into force of the OST. Three days prior to the IAC the Space Generation Congress (SGC) – initiated on the request of States through COPUOS to represent the interests of the next generation in outer space – will conduct a Working Group of young delegates from across the globe, to develop and propose a set of supplementary protocols to the OST, to adapt global space governance to the needs of the next 50 years. Whereas a State may have difficulty in gathering support from the international community through official lines to undertake such an effort, the SGC, representing the next generation, has a moral mandate to initiate and propose such a set of supplementary protocols and these, in turn, could form the genesis of formal, international efforts. I set up this initiative and am mentoring the group of young professionals who organising and leading the Working Group. We would be keen to work with officials in the US DoD or elsewhere in respect of this initiative and future, related steps.

LEGITIMACY. There is often cynicism about whether there are any effective consequences in international law. Domestic courts can exert jurisdiction over other States only in very limited and indirect ways. It takes a long time for a matter to be resolved in the International Court of Justice and other international civil tribunals, and often one or more of the States at fault do not accept the outcome, for a variety of reasons. The International Criminal Court would have limited jurisdiction over activities solely with effects in outer space, because 'satellites have no mothers' – there are few human beings in outer space and therefore most of the war crimes over which the ICC has jurisdiction are not applicable (although some war crimes are conceivable). For these reasons, disputes are usually settled diplomatically or politically.

Nevertheless, it is easy to understate the impact that simple shaming can have. It can affect domestic support and start a ground-swell of opposition on Twitter. It can undermine efforts to achieve a certain outcome in the UN Security Council (such as a favourable resolution), or undermine efforts to garner support for your proposals in a variety of other fora. It could alienate a State as a pariah, making it difficult to form a military coalition. Such a State could find foreign States closed – unwilling to host military forces on their territory and unwilling to buy or sell military equipment.

In contrast, the victim States and other States seeking to prevent the irresponsible behaviour may find it easy to maintain domestic support on Twitter and elsewhere; they might find that other States welcome them warmly when they seek host bases; other States will be willing to join their coalition and provide them with equipment;

and they will have more success seeking the UN (or other) resolution that they seek. There is significant power in legitimacy.

In this context, legitimacy refers to wide acceptance of the normative framework. This partly depends on effective awareness-raising. Acceptance is more than just awareness, though. It requires consultation and advocacy and an adequate forum for consultation, advocacy and awareness-raising. The process for development of the MILAMOS Manual and processes that might be associated with the development of supplement to the OST are both helpful in this regard. The US and its allies should consider sponsoring a range of other international initiatives that are likely to generate awareness and acceptance of the laws applicable to military uses of outer space.

CLARITY. Good technical foundations to the normative framework ensure that it is clear and manifestly applicable to a comprehensive range of foreseeable, irresponsible behaviour. Technical Experts are integral to the development of the MILAMOS Project and should also be an integral part of any other initiatives.

CAPABILITY. The *Charter of the United Nations* and general international norms require that States should attempt to settle disputes by peaceful means in the first instance. However, diplomatic, economic and other non-forceful means of imposing consequences on an offender State are indirect and often take time to ‘bite’ – to take effect – if at all. This is especially the case when the irresponsible behaviour concerned, involves a use of force. A counter-attack, to destroy, degrade or disrupt the capability that is the source of the irresponsible behaviour is much more direct and more immediately effective. International law establishes legitimate responses by victim States to irresponsible behaviour. In other words, a breach sends a clear strategic signal to the international community that the victim State may now authoritatively impose consequences on the offender that definitively prevents it from re-offending.

The ideal would be the ability to impose a consequence that immediately stops the offending behaviour, that deters the offending State from repeating the behaviour and deters other States from considering the behaviour – yet also makes escalation unlikely. Furthermore, in spite of possessing such a capability, the State should be able to manifestly demonstrate no current intent or preparedness to use it. That is a challenging ideal.

The offending State will need to make a strategic assessment about whether escalation will serve to protect its national interests and is the best means to pursue its national objectives – and it will make this assessment in an environment of information asymmetry. Four factors will have a big impact on its strategic assessment. Firstly, where the victim State has the capability to impose further consequences (escalation would be too costly), but no current intent to use it (escalation is unnecessary). Secondly, where the victim State has a limited objective of stopping the offending behaviour, but otherwise supports the normal participation of the offending State in the international community (escalation is unnecessary). Thirdly, where the victim State continues to enjoy legitimacy in respect of its actions and therefore, international support (escalation risks further galvanising the international community against the offending State). Finally, where the victim State is transparent about all of the above (it is manifest to the offending State that escalation is not the means to protect its national interests, nor to pursue its national objectives).

While this component is challenging, it is important not to consider this component in isolation. Coupled with all the other components, the US and its allies should be able to make credible commitments not to use a counter-space capability except in accordance with the stable, rules-based, global order of which they are champions.

EFFECTIVE. In light of the challenges discussed above, the focus of development should be on capabilities that can be used in a very targeted way – to stop offending behaviour, without unintended outcomes. The capability should also be repeatable – a one-shot capability does not deter further offending behaviour by the offending States or by others.

MINIMUM RECOIL. The victim State, when imposing consequences, will not want to lose the international and domestic support that it enjoys. It would lose support if it took action that is considered excessive by its domestic constituency and by the international community. It could also lose support, as well as undermine its own capabilities, by imposing consequences with wide collateral effects – on satellites of other States, on its own space infrastructure and on the unrelated space infrastructure of the offending State.

The challenge, for the purposes of this attribute, is disambiguation. However, as discussed above, there is an impetus to complicate the space domain by integrating with civil and commercial space infrastructure, and thereby use the civil and commercial space infrastructure as a shield. Yet, actively deceiving an adversary that there is no military use of civilian objects is perfidious, if used as a cover for hostile activities, and would be a war crime. Actively concealing military use is not perfidious, although it still undermines the protection afforded to civilian objects under the law of armed conflict. It puts one's own civilian space infrastructure at risk of being targeted. For this reason, State's should opt for transparency about military use of civilian space infrastructure. It is then an easier case to make that responsibility lies on the attacker to distinguish between civilian satellites and military satellites, and to minimise collateral damage to civilian components of a satellite used partly for military purposes.

The goal here is to develop capabilities that States could use to impose consequences on irresponsible behaviour that, either separately or as part of a system, are able to distinguish adversary military objects or components from all others and confine the effects of an attack on the adversary military objects or components only. Again, this would be the ideal and the difficulty of developing such a capability is conceded.

Operationalisation

Finally, the ideas expressed here can be usefully 'operationalised' in the military context. Just as the Collateral Damage Estimation Methodology is a staff process heavily based on legal and strategic policy concepts but used in Operations Centres and headquarters across the joint services to help achieve operational effects, similarly a stable, rules-based, global order for outer space could be operationalised for use in Space Operations Centres and headquarters throughout the US and its allies. An efficient and effective staff process would help the US and its allies to 'get inside the OODA loop' of an adversary in the battle for legitimacy. I have begun work in this regard and again, would be keen to work with the US DoD and others in the US, in a consultant capacity, to operationalise such a strategic approach.

Caelus Partners, LLC

Jose Ocasio-Christian
Chief Executive Officer

24 August 2017

WRITTEN RESPONSE

Caelus Partners has analyzed all these nations space industry programs, and is willing to provide analysis generalities about how these countries see space at this time. (Note that these may change at any time and it is a snapshot in time):

- Nation-states do not see the world as peace, crisis and conflict. They all think of space as vital to national interests and their security apparatus. They all need to be prepared to at a minimum defend themselves, contain aggression, and compete for natural resources.
- Technologies are aligned to an economic benefit as well as a security benefit. Think of "dual use" and multi-tasking of technology. This allows for the greatest chance for a technology to be successful in space.
- Generally, countries with fewer regulatory measures for operating in space will have non-state actors that attempt to employ technologies in space. Higher regulatory or centralized forms of government will work diligently to develop and employ technology without the help of commercial companies.

Dean Cheng

Senior Research Fellow

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2 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: [Q2] Okay. That's helpful, and I think segues nicely into the second question I was hoping to ask you, which has to do with how US allies, partners, and adversaries conceive of space operations for military and commercial purposes. mentioned these three categories. So, from your perspective, how do other actors conceive of space operations for both military and commercial purposes? And, given your expertise, please feel free to focus on China here if you'd like.

D. Cheng: Sure. So, I will talk mostly about China. I would say that China uses space holistically because they've used space as a part of the broader information networks—so, in China, space industry is part of information industry, space dominance and space superiority is part of information dominance and information superiority, and space business is part of the larger portfolio of information business and services.

Thus, the Chinese are looking at commercial space as more than just either manufacturing satellites or launching satellites—they are looking at it as things like getting people to use BeiDou instead of instead of GPS. In all likelihood, in the future as we watch the Chinese establish quasi-private companies that do space things, they are going to try and blur the line between state enterprises and private enterprises because those “private enterprises” are always going to be responsive to mandates from the state.

Interviewer: [Q2] Okay. That is an interesting point about how the Chinese sort of blur the lines between commercial enterprises and the government, particularly in the sense of government ownership in commercial entities. So, I'm wondering, are the Chinese working with or cooperating with any of other states with respect to space operations or space interests, whether it be government driven or commercially driven?

D. Cheng: Absolutely. We can see that the Chinese, for example, have signed memoranda to access the Brazilian, French, and Swedish space observation networks. That's one thing. We also see that the Chinese are trying to—and successfully doing so—export satellites to Bolivia, Pakistan, Venezuela, Bangladesh, and Nigeria. And when the Chinese export a satellite, they also export the entire ground infrastructure, so they build mission control facilities and tracking facilities, and they train the people to operate those facilities.

Now, an interesting question—and this goes back to what I said earlier about space weapons—is what we don't know, for example, is whether or not both that ground infrastructure or those satellites have backdoors built into them that the Chinese can exploit in time of crisis, and in all likelihood they do indeed.

One of the other things that the Chinese are doing is that they have explicitly said that they want their space systems like BeiDou, which is PNT, to be part of the ground infrastructure of the “One Belt, One Road” project into Central Asia. Meaning, that when you think about things like pipelines, how do you coordinate pumping stations with respect to batch waves and things like that? You have to sequence the pumping, and that requires a timing signal. And what the Chinese want is to use BeiDou as the timing signal, not GPS. And that kind of effort then creates a captive long-term consumer base that will have to rely on the Chinese.

Interviewer: [Q2] Okay. So, on the other side of the spectrum, do you see Chinese space interests and activities as being, or becoming, potentially conflictual with those of another international actor?

D. Cheng: Well, the whole purpose of this is to mute or prevent those sorts of contradictions. The Chinese use space diplomatically. They have forged relationships with the European Space Agency knowing that this would then be yet another inroad in separating Europe from the United States. And Europe, being the people that they are, for example, right after the 2007 ASAT test, the head of the European Space Agency publicly said that they want to cooperate with China. I mean, talk about conflict, that is Europe conflicting with the US, not Europe conflicting with China.

Now, arguably, as China make further inroads into Central Asia terrestrially via the “One Belt, One Road,” you’re going to see increasing friction between China and Russia because both of those countries have terrestrial interests in Central Asia. So, China is using its space pieces alongside all of the other DIME or PMESII pieces to basically achieve terrestrial strategic objectives—whether it is forging new relations, whether it is preventing relations with Taiwan, whether it’s neutralizing United States, whether it’s competing with Russia. For China, space is one piece on the board, probably a bishop, possibly a knight.

[...]

Interviewer: **[Q2 indirectly]** So, what about the argument that heavier investment and increased infrastructure in space might disincentive space actors from aggression and conflict? The idea is, I guess, that by putting more of their own things into space and advancing their interests in space, actors would be disincentivized from creating a conflict because they have more and more to lose.

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

I have a sneaky suspicion that part of this argument is coming from ... because some folks there keep insisting that, for example, China will become as dependent on space as the US is. If you ask them why that is, the answer seems to be that apparently there’s some unidentified law of physics that says this will be true. However, the reality is that when you look at Russia and you look at China, both of their primary strategic interests are offshore or in their near abroad—meaning, they can cover communications, ISR, PNT, etc. by using non-space-based capabilities. The US, though, is expeditionary. The US needs those space-based capabilities in order to communicate on the other side of the planet. Now, maybe we’re going to see Russia becoming Soviet Union again with interests in the Indian Ocean and South America, but that’s going to require a whole lot of other changes. We might see China become not strategically committed to Djibouti, but, again, where is the evidence of this? What we see with “One Belt, One Road,” which is probably the single most massive Chinese investment, is that it is primarily focused in Central Asia, and, to a lesser extent, port facilities in the Indian Ocean—not defensive facilities. No one that I know of really seriously thinks that the Chinese are going to start doing expeditionary operations in western hemisphere, or even in Africa, and even that is different than fighting a war against an adversary who can access space and where China would need the space capability.

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

Interviewer: **[Q2 indirectly]** Okay. How would the Chinese define “space security” or “a secure space domain?” Does the Chinese definition and perspective on this differ from, say, that of the US or the EU?

D. Cheng: Well, to begin with, the Chinese are not that interested in space security. This is part of what we are getting at here. The Chinese focus is on national security, which is defined by core interest, which begins with territorial integrity and sovereignty, the preservation of the Chinese Communist Party’s rule, and the preservation of economic development. Space is a tool to obtain

that, but there is not “space security,” per se, any more than there is “oil security.” When you talk about “oil security,” you are not talking about preserving oil rigs in Libya—you are saying, “Can I, country X, get enough oil to keep my economy running?” So, the Chinese, if they are going to define “space security,” are going to say, “First off, what do I need space for?” (note that those requirements for China are very different than those requirements for the US) and then, “What do I need to do to make sure that those missions are fulfilled, which may not have to be by space?”

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

[...]

Interviewer: [Q2 indirectly] Okay. So, let’s shift gears a little bit in to the deterrence side of things. How should space feature in US deterrence strategy, and what changes to US deterrence thinking are required to incorporate the rapidly evolving space domain?

D. Cheng: So, the first thing we need to do is to stop thinking about deterrence in space (i.e., how do I deter an adversary from operating against a certain satellite or from developing certain capabilities?). Because: 1) you are not going to stop somebody from developing a capability that they think is necessary and 2) you are not going to stop them from attacking something of yours if it’s sufficiently vital to you.

By the way, this goes back to the question, “are other countries going to end up as dependent as we are on space?” Other countries have all us as an example—they will not replicate our infrastructure. So, if we are dependent on space, two things happen: 1) we invite attacks, essentially, against our space systems and the entire space enterprise and 2) we make sure that other people don’t become as dependent on space.

So, what is it that we can do? I would say that the Chinese and the Russians actually have the right idea on this, which is “deterrence through space”—not just “deterrence in space.” Space is one of the various instrumentalities available to achieve deterrent objectives. During the Cold War, there was a joke where two Soviet tank commanders sat under the Eifel Tower, and one turns to the other and says, “Who won the air war?” The point here is, if you successfully “deter” action in space and you lose Taiwan or you lose Poland, is that really a success?

So, we should be thinking about what can we do in space to raise the price of terrestrial aggression, and, conversely, what is it that we are doing on the ground that reduces the vulnerability of our space capabilities? For example, when the Chinese buzz an EP-3 or a P-8 as they just done yet again in the past couple of weeks, I would say that that would’ve been a perfect time for us to have done a GSAT close approach towards a high value Chinese satellite system that we know of. The point is: you buzz us, we buzz you—it doesn’t have to be terrestrial.

The adversaries, if they are limited in their reliance on the space, then in that case we really aren’t going to be able to deter much. But, on the other hand, if they do require space, and as the Chinese seem to more and more identify targets in the Central Pacific, then we want to demonstrate a range of abilities to counter that. By the way, those don’t have to be kinetic. For example, passive denial of information can still be useful. If we can demonstrate, as we did during the Cold War, that even with overhead persistent coverage, I can sail a carrier group off of Petropavlovsk (the main Soviet submarine facility at that time), then that is a very powerful deterrent message. That does touch on space? Well, to some extent because we were able to evade their space capabilities.

So, going back to your last question, the problem there is going to be, “Well, you have ubiquitous persistent overhead coverage, how do you avoid being detected and tracked?” I think it’s still possible, but that’s a lot of energy in that sense.

[...]

Interviewer: [Q2 indirectly] So, how would that differ from what you think a Chinese policymaker needs to be thinking about?

D. Cheng: I mean, Chinese “policymakers” who go to Geneva, etc. are irrelevant to actual Chinese policymaking, so they can say almost anything they want. They are given instructions to do things like promote convention proposals, but they aren’t the ones who are actually making any of these policies. There are no “international space policymakers” in China. In China, the Foreign Ministry is irrelevant. One of our common big mistakes is giving any credence to speeches made by the Chinese Foreign Minister in Geneva, because I could make a speech in Geneva and it would have as much impact. The Chinese Foreign Minister has not been on the politburo since 1999, and the politburo sets policy.

So, one of the big problems we have when you use terms like “international policymakers,” is that you actually are talking about a conglomeration of different groups and entities with very different perspectives. You have space technical policy people. You have space policy people from different countries. You have experts on countries, some of whom have some knowledge of those countries’ space policies. So, you wind up with people who, for example—I hate to say this, but—there aren’t that many American folks who look at China’s space policy. We have a lot of folks who look at China and various pieces of China (e.g., the military, the foreign policy, etc.), but we don’t have many people look at Chinese space policy. Conversely, you have people who look at space policy and they talk to the various Chinese, but they often don’t understand China. And then you have the technical folks who can you tell you all about the Long March 5, and that’s a whole different aspect of China and space. And I have a bad feeling that we have the same problems with Russia, and to a lesser extent with the West. We certainly have this problem with Japan. I will tell you right now that with respect to the way the Japanese are approaching space security policy, a lot of our space people don’t understand that and it’s not clear how many of our Japan experts understand that, because what is needed are people that are familiar with both Japan and specifically Japanese space policy.

But, when you talk about, “what will be various countries’ response options in the realm of principles and codes, etc.,” for what you’re talking about, in China for example, it’s not going to be the Foreign Ministry that makes that decision—it is going to be the politburo, which is going to be heavily influenced by the military, and by a worldview that is only marginally informed by the Foreign Ministry. Russia, for example, is going to be completely different. Though, I won’t speak to Russia because I’m not a Russia expert. But I have done a little work on Japan, and I will tell you that the Japanese, for example, are looking at space increasingly through a National Security Space Policy Secretariat, which is within their new National Security Council, which is far smaller than the US NSC, but it’s really the Prime Minister, the Prime Minister’s Office, and a couple of other people. That increasingly is going to define Japan’s national security space approach, again, with more limited input from the Foreign Ministry, although it will be more substantial than in the Chinese case.

[...]

Interviewer: [Q2 indirectly] Okay. So, given these levels of ambiguity and uncertainty around who’s actually making space policy internationally, and then also the ambiguity surrounding some of the laws, treaties, and agreements that currently govern space, plus some of the ambiguity that is naturally inherent in actual space activity and operation itself, it would seem that developing and solidifying norms is especially important in the space domain. So, I’m wondering, what can the

US do to best facilitate the development of verifiable norms that maintain a peaceful space domain?

D. Cheng: Well, first of all, I fundamentally challenge your assumption that we need more norms. Norms are great among people who already think alike. That is a nice lubricant to minimize friction. But, ... [speaks in Mandarin Chinese] ... norm. So, did you understand any of what I just said?

Interviewer: No.

D. Cheng: Right. Because what I just said in Chinese is, “if I only speak to you in Chinese, how exactly are we going to establish norms?”

So, my point here is that we talk about creating norms because we live in a rule of law society governing through mediation, and we believe that the law itself has value, separate from whoever comes before it. If I am the Chinese, laws and norms and principles and treaties exist, like space and other things, for me to achieve political ends—those ends take precedence, not your norms. So, you can go ahead and create as many norms as possible and you can make them as restrictive as possible, and I will sign on to them and I will try to hold you too them. I will make you live by your rules; you will not make me live by them. And the more restrictive they are, the better they are because you are self-straightjacketing.

So, to begin with, I fundamentally question this constant American reiteration that we need more norms. Now, after that, the question becomes, what is the purpose of these norms and when are these norms supposed to operate? I’m willing to accept that there’s certain norms that might be useful in peace time, because they help establish a baseline and channels of communication that may be able to avoid a crisis. But the farther you go down the road of crisis and conflict, the less positive role norms play.

I mean, as one of foreign diplomat observed about the Chinese: for the Chinese, hotlines only work when they’re cold. We have lots of evidence in this in other domains, but not in space—but it doesn’t really matter because, as I keep coming back to, we keep sort of saying it’s about space, but it’s not. Chinese behavior at sea with its region, on land with India, on many issues with the Japanese, etc. demonstrates that in a crisis, China doesn’t pick up the phone. China just does not abide by norms. For example, “though shall not send troops out 20 miles into your nuclear-armed neighbor’s borders,” but China doesn’t abide by those kinds of norms even though it expects you to abide by them.

So, again, in a peacetime, can you create norms? Wonderful. China will sit down and negotiate and have a chance to have a conversation. However, the minute a crisis hits, China won’t pick up the phone, and they don’t call you, so what exactly are these norms creating?

Interviewer: **[Q2 indirectly]** Okay. So, it sounds like you believe that the establishment of these norms during peacetime then just puts the US at a disadvantage during periods of conflict because on one hand, the US will be sitting there obeying the norms and following the norms and playing by the rules of the norms, while on the other hand, an actor like China could fully go along with the norms during the peacetime but then just totally disregarding them once things start getting tense?

D. Cheng: Exactly. So, creating norms with France, with Britain, with Japan, that all makes perfect sense. With China? No, not so much.

Certain folks from both the arms control community and the ... will inevitably say, “Well, look at what happened after the 2007 ASAT test when China was demarched.” But my question has always been, “Well, what did happen?” Well, so China hasn’t conducted a test like that since. Okay, so, what does that prove? The argument is that we by protesting somehow demonstrated to China and persuaded them not to conduct a destructive ASAT test like the 2007 test. Well, guess what, I personally, Dean Cheng, have not conducted a destructive ASAT test like that since

2007, either. Is that evidence that those demarches have made a difference to me? The assumption is, and this is translated into policy recommendation, that China does not do X after we do Y. So, we have drawn a causal-effect relationship by people who themselves have demonstrated a lack of understanding and knowledge of how China is evenly governed in the broad name. If I talk to you about the Republic of Great Britain and its presidents, why would you pay any attention to my recommendations about Anglo American security? And yet, we have made the equivalent arguments about China and then we say, “See, this proves that demarches and norms work.” That is problematic.

[...]

Interviewer: [Q2 indirectly] I also think it is very interesting how you’re challenging the premises for a lot of these questions. So, I just wanted to clarify a point with you and then follow up with a question. Please correct me if I’m wrong, but I think you challenged the notion that China is dead set on becoming a leader in space. Is that correct?

D. Cheng: No. China wants to develop space capabilities, but that is very different from saying that China will become *dependent* on space capabilities.

Interviewer: [Q2 indirectly] So, is this because the proliferation of innovation and technology in the space domain is allowing China to avoid dependency? Or, is it a calculated move on China’s part?

D. Cheng: It is a combination of the geostrategic reality that China’s interests are primarily within areas that do not require space to access, to support, etc., coupled with specific strategic decisions not to become that dependent. So, the first thing to recognize is that China views space as part of “comprehensive national power (CNP).” Comprehensive national power is basically how the Chinese rack and stack all countries, including themselves. Comprehensive national power encompasses military capabilities, economic power, political unity, diplomatic respect, science and technology capacity, cultural security, etc. From the Chinese view, space touches just about every piece of comprehensive national power—so, you benefit your overall comprehensive national power as a multiplier effect when you improve your space capabilities. But, this works in both directions: by improving your overall comprehensive national power, you also garner benefits for science and technology, including space. So, that’s one piece of this.

Developing space capabilities will develop human capital that is familiar with, for example, systems integration and systems engineering. That’s something the Chinese themselves keep saying, “Why do we need to go into space? Well, in order to create a workforce that is high quality, used to precision manufacturing, and that will be able to do systems integration and systems engineering.” But, that’s not just for space. We have seen the Chinese transfer cost management out of aerospace to things like the Commercial Aircraft Corporation (COMAC) to facilitate the development of China’s first domestic wide-bodied airliner. I suspect that if we could get the workforce laid out for the new Chinese indigenous aircraft carrier, we would find people who have worked in the aerospace industries, for the same reasons—the aircraft carrier is a large complex use of systems integration and systems engineering.

Ultimately, China wants to promote innovation throughout the economy. All of these sorts of things benefit by having essentially an incubator in the form of aerospace. But, at the same time, we also see the Chinese laying down lots of fiber optics, developing near space capabilities, etc. that alleviate the requirement to rely on space for communications, ISR, etc. off of China’s shores. That, I would suggest, is partly a strategic decision not to become as reliant on space.

Interviewer: [Q2 indirectly] Okay. So, dependency is obviously very important, not just for the US but for all of international security in space. So, are there any opportunities for the US to foster or create dependency in space for China, or is this just a strategic decision at the party level that we have little bearing on?

D. Cheng: It is a strategic level decision at the party level. Frankly, I think we are more than a little arrogant and overblown on the idea that we can create dependencies in other people. Again, going back to that earlier heroin example, unless you're going to tie me down and inject heroin into my veins, I become dependent on heroin because I chose to take that first bite. So, maybe countries will become that dependent, but I'm not sure we can make them dependent. And in fact, bizarrely, even at the business level, we see people avoiding dependency. GPS signals are free. It's really hard to beat a free service, and yet we see China and Europe both developing their own GPS-type capabilities, and India has talked about it as well. And the goal of that is to avoid dependency on an outside player.

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15 August 2017

WRITTEN RESPONSE

There are country specific nuances, however, it is important to recognize that the fundamental need for self-defense drives the approach. This question requires significant country specific research would be a good topic for a specific study that we could provide by building a taxonomy to include each country with their approach to space operations and services for military versus commercial use versus peace time or crisis and conflict.

Gilmour Space Technologies

Adam Gilmour
Chief Executive Officer

James Gilmour
Director

13 July 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: [Q2 indirectly] Okay. Moving on, we'll jump right into the commercial use of space. We'll start with the first question off that list. How do commercial ventures think about the security of their space assets during peacetime, crisis and conflict? Do industry leaders think about warfare in or through space differently than military leaders? What are their main concerns? How reliant are they on governments for warning or protection of space? What are their threat priorities? Feel free to tee off from any of those.

A. Gilmour: Yeah, we don't really think too much about security of our space assets during peacetime crisis or conflict because we got launch people who spend a lot of time in space. I guess I'd be a little

bit concerned if the Chinese or the Russians started knocking down anything that's starting to fly, but, I think, we'd have bigger fish to fry if that happened.

I think, we look at warfare very similarly to military leaders, mainly because we bring in a lot of discussions with them. We think our views are similar to what we hear these defense people say in about what are the risks in space, what happens if GPS satellites get knocked out and other communication satellites get knocked out. That is what I think is their main concern. The military, I think it's communication and PNT, when weapons are guided from GPS. If that gets knocked out, we're in a world of hurt.

It's one thing to conduct warfare on countries that can't shoot your satellite down at the sky, but very different when you do go against the country that can.

J. Gilmour: Yeah, and we're talking from a commercial perspective. Obviously, the different landscapes, we'd be intimately involved with defense. But, in terms of an Australian perspective, we believe that there is a need for access or space capability within the decade. It works to have that opportunity of providing the leaders of those capabilities.

A. Gilmour: We will be very reliant on government for warning or protection in space. But, right now, I don't see a big stretch. I don't think it's going to be a space war in a hurry.

Interviewer: **[Q2 indirectly]** Considering commercial perspective and the business calculus, there's not too much thought given to, "Okay. Do we need to protect anything we're sending up in the space or loss assets?"

A. Gilmour: No.

Interviewer: Space, I think at this time, is relatively secure, right?

J. Gilmour: Yeah.

A. Gilmour: Yes. I will concur with that.

[...]

Interviewer: **[Q2 indirectly]** Okay, good. Okay, I think that covers that question. Moving on. Are other nations outside the West or it has happened to their own commercial space industry for military purposes in the next five to ten years? Obviously, I want to get the Australian point of view on this. But, if you feel knowledgeable on the other Asian-Pacific nations or elsewhere, I'd appreciate that input as well.

A. Gilmour: Yeah, we think our government's pretty behind the apron on looking at space capability, but they're getting there and we've had some decent conversation this year with people in the Defense Department. I'm pretty confident in the next five to ten years, the Australian government will look at domestic commercial space industry for launching military satellites and stuff like that.

We operate in Singapore and Australia. We've had discussions with the Singapore military about technical satellite launches and they're interested. Again, very similar to Australia, taking their time to develop a mandate or request for capability.

I'm not aware of any significant desire from the rest of the ASEAN countries, like Malaysia, Thailand, Philippines, Vietnam, to do any domestic space launches or space industry for the military. I'm not aware of that.

Interviewer: **[Q2]** Okay. This will segue into the next question. Now, you mentioned Singapore; how robust would you say the cooperation is between commercial sectors on a national level outside of the US? In other words, the commercial industry in Australia, is it... I imagine it's deeply invested with the US, but does it also have a burgeoning relationship with China or other Asian-Pacific nations?

- A. Gilmour:** Well, really, it's still, I think, the Americans are the best in the world at linking up their military and their space industry. The rest of the western allies can learn a lot from the US. We're a long way from that. On a scale of one to ten, I give United States about a nine out ten for cooperation between military and industry, and Australia about a two.
- Interviewer:** Wow.
- A. Gilmour:** I give Singapore about a one.
- Interviewer:** That's interesting, Okay.
- J. Gilmour:** In terms of those, I think we're very much tied with the US.
- A. Gilmour:** Yeah.
- Interviewer:** **[Q2 indirectly]** Okay, great. All right. Okay, I'll come back to that in a second. Now, how are the components of the commercial space industry allocated outside of the US? I know Gilmour Space Corporation is in the launch industry, right?
- A. Gilmour:** Yeah.
- Interviewer:** **[Q2 indirectly]** Is that a particular forte of the Australian commercial space sector?
- A. Gilmour:** No, we're not really... It's not a big industry here. There's a couple of satellite, small satellite manufactures here, that are looking for the launch. We got funded from venture capital that also funded another small site company that was looking at internet and basic connectivity. I think we're the only legitimate launch company here, so it's a very small industry in Australia right now.
- Interviewer:** **[Q2 indirectly]** I see. Okay. Now, the last question on the commercial section here goes, what are the bigger hindrances to successful relationship between the private and the government space sectors and how can this be minimized? I know you just mentioned Australia, your rate about two out of a ten on that. Could you speak on it, maybe a few different points, as to why you would rate it so low?
- A. Gilmour:** Well, we don't have a launch range here. We don't even have the—
- J. Gilmour:** A space agency.
- A. Gilmour:** We don't have a space agency. We don't have... the people that are in, space-related division to the military, is about three people; one in the Air Force kind of thing, one in the army and I don't think any in the navy. There's not even a space command or space wing and any defense that's really significant. You have one person kind of kicking around and that's all.
- J. Gilmour:** That's tied it with another department. For example, for me the Department of Innovation, if any real game-changing capabilities are present, it takes a long time for that to speed up to a ministerial level or, I guess, allocation of resources.
- A. Gilmour:** I'm going to keep going. There's no space agency. There's no contracts that are done between the space industry and the government for any kind of space asset. The policy that governs launching activities in Australia is incredibly prohibitive and requires massive insurances, tons and tons of paperwork, and there's no expertise in the approval of space launch here. We're finding it quite daunting to go through that process to try to launch here and we're actually thinking we'll probably launch from Kennedy Space in the first into orbit. The infrastructure in Australia is basically non-existent compared to the United States or interacting with the government.
- Interviewer:** **[Q2 indirectly]** I see. Now, looking forward, as far as working with NASA, what if any, obstacles exist for you at this point in time or do you anticipate, being an issue, a few years down the road, that you feel the US could improve on?

A. Gilmour: Not really. We have a good understanding of what it takes to do business with the US government. It's been well-explained to us. We have the United States subsidiary based in Texas that we will intend to compete, the US government business with. We understand we have to make 50% of the launch vehicle, the right value in the United States that compete with government business. We have a pretty good understanding of what we have to do. I don't see any roadblocks ahead of us. It's just an execution issue.

Interviewer: **[Q2 indirectly]** Okay that's very interesting. Now, we can move on a bit. If you see the question under allied partner and adversary use of space, how each entity in all categories compete with space operations for military and commercial purposes. If we could just skip down to the third bullet point for Australia, I was wondering if you can give me a commercial perspective on that question. How do they approach space operations and services? Are there any differences in how commercial ventures, if any, consider security during peace, crisis and conflict?

A. Gilmour: I know. Look, I'm struggling with the question because we don't have a space industry here at the moment.

It's very nascent. As I said, we don't have a space agency. We don't even have a launch range. What we're looking to do is to have a launch range here, discussing of having a launch range, discussing of having a space agency. There was a press release yesterday saying that bringing community forum to discuss a space agency in the government. So, how does Australia currently approach base operations? We're basically buying foreign satellites and launch them on foreign launches. That's what Australia does right now. That is looking to change in the future.

[...]

Interviewer: **[Q2 indirectly]** Wow. That is amazing. Okay. As far as disruptive innovations, and particularly the launch component of the space domain, how has that weighed in on a developing company like Gilmour Space Corporation? Is this something that is, not necessarily a worry, but is this... is R & D, in other words, a constant concern to an upcoming company?

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

Interviewer: **[Q2 indirectly]** That is now the biggest barrier entry for a new company in this landscape. Would you agree with that?

A. Gilmour: I think so.

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

[...]

Interviewer: **[Q2 indirectly]** Okay, great. Well, thank you both, gentlemen. This was a great interview. It's always really amazing when we get a nice commercial perspective that's international. Let me just end the interview by asking one more question that I will ask everyone. Is there anything, any question, you feel you would've liked to have answered that you think is important that I didn't ask? Anything in general you would just like to comment on further?

A. Gilmour: Well, I just want to say that we spend plenty of time talking to the US military about the risks of attack on space assets, and we agree with them, and that we think they're already looking at commercial partners to fulfill, the de-risking of that. I'm talking specifically about past technical launches of communication satellite. We think that's a very smart way to go and I encourage them to keep going in that format. We're not the only commercial company that can provide the service and they shouldn't only have one commercial company to provide the service. But it's

definitely something that is a bit of a mind change from 20 years ago to use commercial operators with quick launching, small tech satellites. I think that's something I definitely would want to say that I agree with a lot of the people in the defense force, on the need to develop that capability.

Dr. Namrata Goswami

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Subject Matter Expert (Auburn University Futures Lab)
15 August 2017

WRITTEN RESPONSE

PRC

The PRC has a long history of consciously creating the institutional, political and societal culture towards building space assets. While most of its space science is geared towards achieving civilian technological capability in space, the utilization of space for military reconnaissance, surveillance as well as battlefield advantage is a part of its overall defense strategy. Unlike countries like India where space is under a civilian authority, China's People's Liberation Army (PLA) has a major influence in China's space policy as well as forms an integral part of the institutional decision-making process. The importance of space operations for the military can be gauged from the fact that in 2007, China carried out its first anti-satellite missile test. On 30 October 2015, China tested the *Dong Neng-3* exoatmospheric vehicle capable of ramming into U.S. satellites and destroying them. Added to this space capability are the *Tiangong 1* and *Tiangong 2* space labs, and the indigenously built *Tianzhou* cargo ship capable of on-orbit refueling that extends access and logistics lines. Autonomous cargo delivery and on-orbit refueling are critical building blocks of an end-to-end supply chain for space presence and space resources, or the construction of on-orbit power stations. Chinese security experts believe that China needs to invest in Ballistic Missile Defense (BMD), as well as create space based capacity to create vulnerability for U.S. space assets that are used for military operations.

In connection to this goal is the recent reorganization of the PLA with the establishment of the Strategic Support Force (SSF) indicating China's goal to establish cutting edge 'jointness' in its space, cyber, and electronic warfare capabilities. These are designated as 'new type' of forces indicating China's future direction regarding military innovation. These innovations are aimed at achieving critical advantage regarding space and cyber-space. That said, the key unknown is whether China has the capacity and the technical knowhow to achieve these precise goals. Consequently, it may aim to achieve technological superiority by 'stealth' from other countries. China's thrust on space is 'future-oriented' based on long term planning (2049), and the process of adaptation to becoming the lead in outer-space, has started.

Regarding commercialization of space, China is encouraging commercial entities like OneSpace and Landspace to develop technology and enter the lucrative market of satellite launches and space tourism. Its space policy makers are also discussing the need for 'national legislation' like the 2015 U.S. Commercial Space Launch Competitive Act to create an enabling environment for its own private actors. However, the private actors are dominated by China's state driven space agencies and will not deviate from PRC goals during conflicts.

Russia

Russia's space goals have suffered with the breakup of the Soviet Union. However, the country continues to enjoy expertise and has its unique history of being the first to launch a satellite into space. The role of Russia in augmenting the space ambitions of Asian nations cannot be emphasized enough. China benefited immensely from Russia opening its space sector for commercial purposes, especially with its purchase of Russian space shuttles and Russian help with its heavy lift booster technology. It was on Russian rockets that Vietnam, Japan, India, Malaysia, sent their first astronauts into space. More recently, Russia is collaborating with the European Space Agency (ESA)

to explore MARS. Russia also continues to enjoy high-end know-how of military satellite technology. As a result, Russia is viewed by countries lacking space expertise favorably, as a country that is willing to provide this knowledge for the utilization of space for intelligence gathering and shoring up military capacity. For instance, countries like Ethiopia and South Africa are looking towards Russia for space based collaboration and technology transfers. Egypt, with the aid of Russia, has invested in a military satellite.

Russian thrust for commercialization appears to be lacking in resolve and state backing though with the recent spurt of global interest in space based resources, Russia may join the fray. Key insight regarding Russia is its relevance to build space infrastructure in countries lacking such expertise and sharing its space technology for a price. Russia also remains the only country on earth that can launch humans regularly into space.

Iran

Iran's space ambitions received a major boost this year with the successful launch of its *Simorgh* rocket plausibly carrying an intelligence satellite. If proven true, the satellite is a boost to Iran's situation awareness capacity especially in countries like Syria, Yemen and Iraq. With this launch capacity, Iran could have acquired the capacity to launch inter-continental ballistic missiles. Given the 'geo-politics of fear' connected to regime change in Iran by external forces, its polity thrust may be to utilize this test as a 'global signaling' of capacity. The impact of Iran's successful rocket test as well as its successful launches of its Rassad satellites establishes Iran's status as the most advanced 'space-assets nation' in the Middle-East, especially in relation to the Arab states in the region. Iran's success may have motivated the UAE to establish its space agency in 2014 and finance its Mars mission, claiming that if it succeeds by 2021, UAE will become a hub for space activities in the Islamic world. Iran will utilize its growing capacity in space for military reconnaissance, satellite jamming and intelligence gathering, to include data gathering in its fight against terrorist groups like ISIS and in Yemen. Russian cooperation in augmenting Iran's space program is critical. In 2014, Russia and Iran signed a deal that fostered Russian cooperation regarding satellite and launch technology. Iran's space program is state driven and aimed at scientific temper amongst its citizens. As of now, there are no private Iranian outer-space entities.

North Korea

North Korea aspires to project an image of developing advanced space technology that could be utilized for launching inter-continental ballistic missiles. To achieve this aim, the National Aerospace Development Administration announced its aims to launch satellites into orbit by 2020 as well as plant a flag on the moon. As per its five-year plan in 2015, the North is investing in Earth observation satellites and its first geostationary communications satellite by 2020. The February 2016 launch of the *Kwangmyongsong 4* demonstrated North Korea's growing space capacity since its 2012 launch of its first satellite. With improved space capacities, North Korea would aim to jam GPS signaling to defuse data on its internal developments as well as jam early missile warning signals. This has direct impact on the response mechanisms of target countries. North Korea has no private entities in space.

Japan

Japan is an old player in space like China. The Japan Aerospace Exploration Agency (JAXA), formed in 2003 by merging the Institute of Space and Astronautical Science, the National Aerospace Laboratory, and the National Space Development Agency, is conducting futuristic space exploration research. This includes investing in wireless transmission of electricity, once proven, could be used for transmission of electricity from Space Solar Satellites. Japan's *Hayabusa* and *Hayabusa2* are aimed at asteroid exploration. Such space activities will have a major impact on future exploitation of space for resources. While Japan historically viewed space as a non-military entity, 2003 proved a turning point in Japan's space policy with the introduction of BMD especially due to the growing threat from North Korea. It was also decided to utilize satellites for military purpose to include information gathering and reconnaissance especially pertaining to the seas. Japan has a commitment to encourage commercial entities in space and share state funded R and D with private entities. Japan is working on its national legislation to encourage private actors and meet its international obligations. In times of conflict, private actors will act according to Japan's stated policy.

India

India's space activities are mostly aimed at satellite launches, as well as conduct interplanetary exploration missions. India is the first Asian country to successfully launch a MARS orbiter. Its space program is expanding to include a Venus mission by 2020-2021. It is also offering its satellite services to its neighbors with the launch of the 'South Asia' satellite. While the Indian Space Research Organisation (ISRO) is mostly aimed at civilian space, there has been a recent shift towards providing the Indian military with augmented data on areas of concern regarding its disputed borders with China and the Indian Ocean region, where there has been a tremendous leap in submarine activity. There are discussions within India to establish an aerospace command, separate from the air-force. This strategic development could be in response to China's change in its military organizational structure. While ISRO remains the main state funded actor in India, private industry has started to make itself felt with *Team Indus*, the Indian private space company, competing for the Google Lunar XPRIZE. Other private actors include *Bellatrix*, *Astrome*, *R-Beam*, etc. The Indian private space actors are however tied to ISRO and hence will have limited autonomous impact with matters regarding security. India is working towards establishing national space legislation that will regulate private space actors, as well as meet its international obligations under the Outer Space Treaty.

Dr. Laura Grego

Senior Scientist (Union of Concerned Scientists; Global Security Program)

2 July 2017

WRITTEN RESPONSE

Iran and North Korea

Iran has put a small number of low-mass satellites on orbit. Its pace of launch attempts is slow, possibly due to the effect of sanctions on its ability to make progress, perhaps because they are sensitive to international reaction to launches because of the similarity to ballistic missile launch. No data, as far as I'm aware, have been published from their satellites, so either they didn't work as anticipated or they worked but the results were not impressive and judged not to improve the reputation of the program.

While some would argue that its space launch program is solely to provide legitimacy or cover to its pursuit of long-range ballistic missile technology, Iran does seem to have a sincere interest in space, both for space services it would derive as well as for the prestige that accrues with mastery of sophisticated technology. Iran has sought to partner with other countries to get access to space. For example, in the late 1990s, Iran partnered with Italy to build a small satellite. It has recently been discussing cooperation on space ventures with European and Asian space agencies. Iran also seems to be funding the construction of small satellites at a number of domestic academic and industrial institutions, rather than only building satellites via its military. It also has used resources to support a suborbital program to launch living creatures.

It makes sense to me that Iran would seek space-based imaging and communications capabilities. It is a large country with big deserts and mountainous geography that divides the population. It is prone to natural disasters such as droughts and earthquakes. It has adversarial near neighbors. Good intelligence, reconnaissance, and communications would seem essential for its national security as well as for its economic and social development.

Additionally, Iran has a strong sense of history and culture, it has a long past and wants a long future, and wants to be seen as the dominant power in its sphere. Being dominant technologically would seem to be an important part of that picture, a way that it can demonstrate its superiority. While Iran is some distance away from providing robust launch capability for itself, much less for commercial customers, I could imagine in the coming decades that Iran could focus on building or operating satellites and selling services to its neighbors. In that vein, I think that while it's undoubtedly a remote possibility, there is a chance that Iran would forego development of an indigenous

satellite launch capability (and intercontinental range ballistic missile technology) for assured access to space launch by some other country with which it could develop this kind of commercial capability.

I think Iran would (and almost certainly does) avail itself of relatively low-tech anti-satellite techniques such as jamming, dazzling/blinding of sensors, or cyberattack in situations that it felt threatened. However, I don't think that even in 20 years that Iran would have direct-ascent or on-orbit capabilities for interfering with an adversary's satellite in a destructive way. I would think that in a crisis situation, its focus would be on disrupting space-based force multiplying capabilities, rather than attacking strategic systems, for example.

There's relatively little to say about North Korea. It has demonstrated an ability to put low-mass satellites on orbit. Without any published data, it's not clear that they provided any useful capability. In my nonexpert observations, North Korea differs from Iran in that it does not have a developed civil society that it must be accountable to at some level. North Korea's battle is for survival. So my impression is that all its space activities will be tailored very carefully to that aim; space is not for impressing neighbors with how scientifically advanced they are.

North Korea is focused on survival and Iran desires to be a regional power, neither has credible capability to be global powers. They do not need the types of space infrastructure that the United States does to support global action.

Russia and China

Space capability, of course, plays a large role in the Russian identity. This has long been one of their most successful technical areas, and it continues to launch successful civil and military space programs. And space has long been a bright spot of US-Soviet/Russian relations, even when things were otherwise going poorly.

However, Russia's preeminence is waning. Russia is experimenting with commercializing its space capabilities, but its usually-reliable launchers have had a string of failures which cannot be helping that effort.

The US has been far ahead of Russia in space for quite some time; currently the US has more than four times as many satellites actively working as Russia does and has a thriving commercial market. That part is no surprise. What is more surprising to those who haven't been paying attention is that Russia is not the second place space power, it is third, and not really even in the same class as China. China has many more satellites, and is expanding and innovating, and has ambitious goals.

In the 1980s, China was very concerned about falling behind technologically, particularly behind the United States and wanted to ensure its technological self-sufficiency.³⁶ It made significant investments and created long-term plans to keep abreast of international developments in science and technology and to identify potential breakthroughs that could help solve urgent problems in China's socioeconomic development and its national security. These plans are coming to fruition as China develops and launches its own precision navigation and timing constellation, builds a variety of earth observation and communications satellites, and creates an independent space science and exploration program. China has also sought opportunities where it might be recognized for its unique contributions to space science and to improve the human condition. This may be seen in the Chinese Moon and Mars exploration programs, and in its recent launches of astrophysics and greenhouse gas monitoring satellites.

China is a large and populous country with enormous a challenge to provide a good standard of living in a sustainable way. It also wants to be seen as a dominant power in its region, and being the possessor and provider of sophisticated technology is important. Space launch and satellite services are important parts of these solutions.

As for the military attitudes toward space, it was not lost on China nor Russia what the US military can do when supported by space-based services. Neither China nor Russia appear to have near-term ambitions to be global powers, but very much want to be the dominant regional powers. So in that sense, national security space plays an

³⁶ Kulacki, G. Strategic Options for Chinese Space Science and Technology A Translation and Analysis of the 2013 Report from the Chinese Academy of Sciences. November 2013.
<http://www.ucusa.org/sites/default/files/legacy/assets/documents/nwgs/strategic-options-for-chinese-space-science-and-technology-11-13.pdf>

important role for both countries, for example, intelligence, surveillance, and reconnaissance; precision navigation and timing; and secure communications. Because China does not have a launch on warning posture, it is believed that it does not have satellites to provide early warning of ballistic missiles. It has a nascent ballistic missile defense capability, and for it to be a robust defense against long-range missiles, China would likely want to have such a satellite. On the other hand, China may be working on ballistic missile defense in order to understand the technology sufficiently to improve its ability to penetrate it. Russia has early warning satellites, but has not prioritized keeping this capability in tip top shape.

Much has been made of the idea that China is planning an asymmetric attack against the United States space capabilities. Certainly some of this concern stems from the inherent vulnerability of individual satellites, as well as their critical importance to many missions. It is not at all clear that this is really the way China approaches the issue,³⁷ or that the idea makes sense in a strategic context.

I would assume that both China and Russia have invested in radiofrequency/jamming and optical dazzling/blinding antisatellite and cyber attack technologies. Both are developing on-orbit capabilities to autonomously approach non-cooperative satellites, an anti-satellite enabling technology, which is also useful for “benign” purposes. China has demonstrated direct ascent hit-to-kill technology against a satellite as well as suborbital objects, in a missile defense mode. Russia’s missile defense system uses a nuclear-armed interceptor, which relaxes the requirements for targeting, but is reportedly developing conventional hit-to-kill technology, which would be useful both for missile defense and anti-satellite missions, in the same way that the US and China’s programs are. So both China and Russia have some capability to interfere with other satellites in reversible, nondestructive means as well as destructive, debris-producing means.

That said, China and Russia have joined together to promote a set of constraints on space weaponry in the Preventing the Placement of Weapons in Space Treaty. They have participated constructively in the development of the UN Committee on the Peaceful Uses of Outer Space’s Long Term Sustainability Guidelines. I think that it is clear that certainly in peacetime, they are invested in having space operations be orderly, safe, and secure, for both national security missions as well as for their commercial and civil pursuits. As a crisis unfolds and the possibility of armed conflict in space is entertained, I expect that they also prefer constraint and predictability and to be able to manage the conflict. Because it’s a new medium for conflict, the potential for misunderstanding and miscalculation is great.

Harris Corporation, LLC

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15 September 2017

WRITTEN RESPONSE

PRC, Russia, Iran, North Korea: Each clearly recognizes that the U.S. ability to use space to support military and intelligence operations is a massive asymmetric advantage for U.S. forces. Unfortunately, each is equally aware that the high and still increasing level of dependence on space by U.S. military forces is also an asymmetric vulnerability. In a crisis that escalates to a use of cyber or kinetic attacks, any adversary with the capability to do so

³⁷ Kulacki, G. An Authoritative Source on China's Military Space Strategy, March 2014.
<http://www.ucsusa.org/sites/default/files/legacy/assets/documents/nwgs/China-s-Military-Space-Strategy.pdf>

is almost obliged to attack U.S. space capabilities early in a conflict...and most likely even before, the onset of combat operations in other domains; with the goal of disrupting or denying U.S. forces' the use of space. Additional information about the individual or collective views of the above nations in terms of military or strategic importance is available from the Intelligence Community.

European Space Agency, Japan, India, South Korea, Israel & Canada, Brazil, Australia, Singapore, Ukraine, others: The countries listed above, and other nations that have or are building an indigenous space industrial base, one that includes design and manufacturing capabilities for either/both satellite and launch, view "space" as an engine for economic development and technology advancement. Many of these countries, e.g., France, India, Japan, etc. also view their acquisition of satellite and launch capabilities as symbols of national power and stature in the international community. As one example, as early as the mid-1960s, France decided to embark on a national space capability because it came to view possession of space capabilities as a pre-requisite to superpower status (in much the same way that France sought its own nuclear weapons capability in part for the same reason).

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: [Q2] Okay. In the second paragraph here, I thought this was a very interesting point about how some of these space programs have a nationalistic element to them. I'm wondering if in this nationalistic pursuit, how much of an opportunity does the US (commercial sector or otherwise) have to cement their role in the development of these programs, if any? Or in the case of French, India and Japan as a pursuit of these capabilities, strictly domestic in their own rights or does the US have an opportunity to play a role there.

T. Gould: [Q2] I guess there are two parts to that issue. One is how much do they want. The fact that they want to develop this capability indigenously would seem to indicate that they want to do it without being reliant on the US for all the reasons that we state in our answer, prestige, national pride, etc., what it means to their technological base, and how they can leverage those technologies in other areas. But the second part of the equation, is frankly how willing are we, as the US government, to share technology, especially in special mission areas with our allies. As an example, we were just at a trade show and were talking about sharing electronic warfare capabilities with an ally. Of course, in order to share electronic warfare capabilities and integrate them onto another nation's aircraft, both parties need to share sensitive information. The platform provider will need to share some information on its sensors, processors, and mission capabilities to ensure our electronic warfare techniques do not interfere with their systems; and we would need to provide some pretty sensitive information on our system to the platform provider to ensure their cyber security and information assurance requirements are met. For these reasons, there are times when we are unable to assist or leverage foreign capabilities because of proprietary and/or national security concerns.

I don't know if that answered your question, but it's part release-ability issue and part national security issue. When we talk about indigenous space capabilities, we are not talking about just satellite communication...that's relatively simple. But the ability to do what I'll call the critical functions of getting to space and maintaining the domain; these are sensitive issues. I'd be interested in your team's thoughts on whether they thought there were any national concerns either way with the US contributing to a foreign nation's space program that was being developed indigenously.

Dr. Jason Held

Chief Executive Officer (Saber Astronautics)
17 August 2017

WRITTEN RESPONSE

Australia Space

- Australia has its own inertia in the space domain that is different from the rest of world.
- China has been seen as a commercial partner in the past. (Australia avoided the last recession due to China's purchase of minerals). Commercial factors are driving the Australian Space industry, Chinese money is running out and so a pivot to the US could be fostered.
 - The Trump administration is deterring this burgeoning of the potential relationship with the US.

"China is a major trade partner for Australia in the mining sector but not space. They have limited inroads to space (although they have made some investments in Australian UAVs). The USA remains the primary space partner on the government side. Airbus (France) has been aggressive with chasing and supporting space startups. BAE has always been a presence for UAVs."

- Australian government is conservative with the space industry, but they want to fund a success.
- Current startups have begun without any government funding or assistance, but now is currently catching on.
- Australia is in charge of 1/6th of the earth and only has 25 million people currently, and is good at space control, SatCom is a particular strength. Australia will not compete very well against America but this could change.

Theresa Hitchens

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19 July 2017 (written submission)
30 June 2017 (interview submission)

WRITTEN RESPONSE EXCERPT

This is a really broad and mixed up set of questions. It would take some time and analysis to answer thoroughly. Roughly, PRC, Russia, France, Italy, Germany, India, and Israel have independent and well thought out military planning for use of sats. Russia, PRC, Israel and India have interest in offensive uses of space; and have relatively high levels of state control of industry. Canada, UK, Australia have assets that primarily link into US operations; have private companies but with different levels of relationship than in the US. ESA operations are strictly for peaceful purposes and do not include miltat operations. Japan is still working out its military space concepts and operations. I'm not so sure re Brazil/South Korea and Singapore – would need to do some research to catch up. Brazil builds its own sats, I think the others do too. NK is an aspiring space actor, not really a factor yet.

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: [Q2] Now let's move into question two, which focuses on ally, partner, and adversary use of space. As you can see from this question in our list, it presents a number of countries to think about. So, before we jump into the question, I just want to check with you and see which

countries from that list that you feel most well-suited to talk about and/or feel most comfortable addressing.

T. Hitchens: I will start by caveating that I am not an expert on any one of these countries listed in the question. With that said, I do believe I have enough information in general on some of these countries to be helpful. I'm not a country area expert to be honest, but I can talk about modus operandi in generic terms.

For more country-specific experts, I would encourage you to reach out to Dean Cheng for a China perspective, Pavel Podvig for a Russia perspective, Jeffrey Lewis for a North Korea perspective, and somebody from the Mansfield Institute for a Japan perspective.

I can provide a more high-level, overview perspective to some of these questions.

Interviewer: [Q2] Okay, thank you, that is really helpful. So, as I ask you these questions, please feel free to just pick and choose whichever country you feel most comfortable with talking about at a more general level.

First question: What are the key, essential, and major things that we should know about these countries' space programs, space interests, and space ambitions, both with respect to the government and commercial realms?

T. Hitchens: Well, let's start by bracketing these countries to put them in categories.

Roughly, from sort of a birds-eye view, China, Russia, France, Italy, Germany, India, and Israel all have fairly independent and well thought out satellite programs, including for military usages. These countries have actual military satellites and military programs where they integrate satellite operations into their forces to a greater or lesser extent. But all of those countries do have a military aspect to their space programs.

If you move down the list and look at Canada, the UK, and Australia, and you want to look at their military assets, those are primarily linked into US operations—these countries don't do a lot on their own militarily, things are linked in to US programs and operations, etc.

With respect to South Korea, I don't know all that much about them. South Korea is a relatively new player in the satellite family.

I think Brazil actually builds its own satellites, but I'm not sure.

Certainly, North Korea is an aspiring space actor, but I wouldn't say they have any real capabilities yet to speak of. North Korea is kind of behind the power curve a lot. That's what I would say.

The other thing that you need to understand is that all of these countries, every single one of them, has a very different approach to commercial satellite companies in operation than that of the US. None of these countries have wholly, really wholly independent satellite companies, except from maybe Canada and the UK, but even Canada and the UK have fairly broad government investments in their commercial space companies. In places like Israel, for example, or even France, the government tends to hold a majority share in all of the country's commercial companies—or if not a majority share, then at least an even share. So, these countries' models for commercial space operations are totally different than the US. India has a burgeoning kind of niche space commercial sector, but those people are really frustrated because they feel that the Indian government, because most of India's satellite development is done through a civil agency, is actually competing with them and is in their way, so that's a problem in India.

The other interesting thing I would say is, if you are looking at the European Space Agency, we should remember that they don't operate any military satellite programs. While France, Italy, Germany, and the UK do so individually, the European Space Agency doesn't. The European Space Agency is a group, an inter-governmental organization that focuses on peaceful uses and

doesn't really have a commercial relationship so to speak. The European Space Agency is completely different from national agencies—it is funded by the EU and member states.

So, the models are different. What I am trying to get at is that it is hard to look at the commercial marketplace because you can't look at it in the same way across these other countries as you probably can in the United States.

Interviewer: [Q2] That first bracket of countries you mentioned, how you are sort of bracketing them, seem to have pretty robust space programs, at least on the government and military side.

T. Hitchens: Yes.

Interviewer: [Q2] So, with respect to the space programs of the countries in that first bracket you present, in general are there any particular areas of focus within those space programs that the various countries are most focused on (i.e., is one country more focused on satellites, exploration, or something else, or is the focus more evenly distributed across all areas of the space program)?

T. Hitchens: It is really a case-by-case situation. If you look at France and Italy for example, they have military satellites. They also have, I believe, a radar satellite system that is a Franco-Italian satellite system. The Germans have a SAR satellite system. India is really focused at the moment on communication and Earth observation satellites. Israel has had a focus on communications and Earth observation as well. China has, as probably everyone knows, a fairly robust interest in building a number of different kinds of satellites, both for commercial and civil purposes, and Russia as well, kind of across the board.

If you are going to look at these countries and think about who is interested in perhaps warfighting in space or anti-satellite capabilities, you'd be looking at Russia and China and India and Israel. France and Germany and Italy, as the most active European space countries, have expressed no interest in—in fact opposition to—the issue of anti-satellite weapons.

Interviewer: [Q2] You mentioned earlier that one of the key differentiators for some of these space programs, compared to the US, is the clear government ownership of commercial entities within the commercial sector.

T. Hitchens: Yeah.

Interviewer: [Q2] So, beyond that particular differentiator, are there any other glaring differentiators or differences that we should be aware of between these countries' space programs and how they operate?

T. Hitchens: You mean amongst those countries or do you mean them versus us?

Interviewer: [Q2] Between each other, less with respect to United States but between each other. So, for example, are there any glaring differentiators or differences between the Russian and Chinese space programs and how they operate?

T. Hitchens: Okay. So, certainly in Russia and China everything is government owned. Everything is government owned and/or it's tied to government control. India is largely government controlled but not totally.

The European countries have more commercial-specific interests and even though they have government interests, they have commercial companies and companies that export stuff and do partnerships and things like that. So you find that there's less government interference, or none at all, in those commercial operations in Europe than there is in Russia and China.

So, ultimately, the commercial models are different across all of these countries that your question lists, especially in China since China doesn't have a commercial model. China has "commercial companies"—I'm putting that in quotes—and Russia has "commercial companies"—I'm putting that in quotes as well—while in reality they are not commercial

companies at all. Do you know what I mean? That's kind of the differences amongst those countries if you will.

Interviewer: [Q2] Okay. So, this first bracket of countries you present seem to be the dominant space players from our list.

T. Hitchens: Yeah, they do.

Interviewer: [Q2] So, projecting into the future I guess if you could, do you see any of the countries from our list that you don't consider to currently be in that first bracket eventually getting into that first bracket?

T. Hitchens: Okay so other countries moving into that first bracket. Well certainly India is trying to expand its footprint. The other country trying to expand its footprint is Japan, although it is not entirely clear Japan really knows what it is doing. Japan has a lot of thought processes, and is doing a huge review of all their policies and what they should do in space. Japan has been trying to formulate a plan for how to move forward in the space domain. While Japan hasn't quite gotten there yet, as things move forward, I see them becoming a much bigger force in space than they have been in the past.

I also think we should keep an eye on some of the emerging space powers. Singapore and Brazil in particular are really interesting. Australia has been struggling to figure out where to put its assets as well. I don't really see Australia becoming a major player, but I'd keep an eye on Brazil and Singapore and South Korea as potential larger players in the space domain as things go on.

Interviewer: [Q2] Okay, so looking at this top bracket of countries that you present, I guess including Japan and India as well, how do these countries sort of compare to the US in terms of space power and space capability? Is it the case that the US is just leaps and bounds ahead of all of these other countries in the space domain?

T. Hitchens: The US is leaps and bounds ahead of all countries, every single country, whether it be China or Russia who are next in line. The US is 10 to 20 years ahead in the integration of space operation both into its economic network and its military network depending on country. India, for example, is just moving into satellite communications for banking, for Internet and wireless banking for example, which it is having all sorts of trouble with currently.

Technology wise, I would say that I disagree with the idea that the US is somehow starting to lose the space race—I don't think that's true at all. I would say that in the military arena, both Russia and China are attempting to catch up with the United States, but they are not there yet. China has a lot of ambitions, but they still haven't really integrated space into their operations. Russia has problems, they have money problems. Russia has had money problems since the 1990s. Russia had a very robust space program up until the 1990s and then things started breaking, and they haven't really been replacing things and it's only now that they have really started to invest in trying to reinvigorate their different systems, and, as such, Russia has been focusing on military space as the kind of way to begin to compete with the US.

Interestingly, while in the US we often read about China as a potential adversary in space, China I think is less concentrated on creating systems that would create problems for US space operations than the Russians are. China actually has much broader space ambitions, from their astronauts and their human space programs to being able to bring communication infrastructure to their whole country, etc. So, ultimately, China's portfolio is much broader, but it's also much less focused.

Interviewer: [Q2] So it sounds like the gap between the US and everyone else in the space arena is pretty big or pretty strong.

T. Hitchens: It's pretty big. Though, in certain kinds of technologies, when we look at certain kinds of technologies, that also is not necessarily true. For example, the US is behind even Canada when it

comes to the use of Synthetic Aperture Radar (SAR) satellites because the USG didn't want US commercial providers to operate in this area for a long time, so the US didn't really have a commercial market for SAR satellites. So, other countries are ahead of the US in something like SAR.

Additionally, China has recently made a very major breakthrough in quantum communications from satellites, which is a pretty big deal. China has now demonstrated quantum entanglement from a satellite to the ground, which is kind of the first step in developing a quantum encryption key for secure communication between satellites or just in general for ground to Earth communication. That's a big deal, that was a really huge, ginormous deal.

So, in certain technologies, the United States is behind, but across the board the United States is ahead in the space domain.

Interviewer: [Q2] And you think that overall gap in general is pretty strong?

T. Hitchens: I think the overall gap in general is pretty strong. I think the gap is lessening but I still think it's pretty strong. I mean it used to be that the US was like 30 years ahead of everybody, but some countries are probably only 10 years behind now.

I am going to say that other countries are working very hard to close that gap—a lot of countries—and that's only natural because technology now, certain technology that it took the United States a long time to develop, are now available and so they are out there and once these technologies get out in the free world, people don't have to invest all the upfront capital and the research, they can just buy stuff.

So, the gap is probably more narrow than it has been in the recent past, but I still think there's a pretty significant gap.

Interviewer: [Q2] Okay. One other question. Are any of these of these countries that we listed collaborating and/or cooperating with each other to advance their interests in the space realm? And, on the other end of the spectrum, are any of these countries sort of openly hostile towards each other with respect to their space interests and activity?

T. Hitchens: Well of course the Europeans all work with each other and are all pretty well aware of each other's interests and activities. In Europe, you've got the European Space Agency, and even in the military realm—although they are little more secretively—the Europeans are working together on various aspects of various satellite programs (e.g., Galileo), various ground systems, etc.

The Chinese are very interested in satellite cooperation. They see their satellite capabilities as a form of soft power, and therefore they are doing a lot of marketing in places like Africa and Latin America, and helping other countries own and operate their first satellite or their first satellite systems primarily in the Earth observation arena. The Chinese are very interested in market—they have a capitalist-hybrid communist economy, so they have a lot of interest in playing a bigger role in the world market. China is also working very hard to develop cooperation with the Europeans in space.

The Russians, I don't know. The Russians are just in such a bad space right now across the geopolitical spectrum, so they are kind of currently not really cooperating with anybody other than a little bit of cooperation with India and China overall.

Putting North Korea, which is an outlier problem set here, to this side, I don't think there's actually hostility in space that I'm aware of between these countries. I mean, indeed, I would say at least based off of my interactions internationally, there is a lot of concern amongst other countries, who are not Russia, China, and the United States, about growing hostility between China, Russia, and the United States because they see those geopolitical hostilities and the potential risks of conflict as being detrimental to their own ambitions in space.

[...]

Interviewer: [Q2 indirectly] So, Theresa, we always ask this question at the end of our interviews: Is there anything that I haven't asked you that I should have, or is there any final point you would like to conclude with?

T. Hitchens: Okay, interesting. I have a lot of thoughts on some of the other questions from your full list of questions. I wanted to just briefly address Q3 from your list of questions because I think the framing of this question is really important.

So, what are the motivations of nation-state and non-state actors (e.g., violent extremists, etc.) to contest use of space in times of peace, instability, and conflict? What are the political, military, environmental, or social costs associated with acting on those motivations?

I mean, again, this is a state-by-state question—you have to look at each state individually, different states have different motivations, and that's going to be pretty clear. There are some countries that have motivations for counter-space operations against the United States, and maybe there's more. That's not a surprise. Then maybe India and Israel have shown an interest in counter-space capabilities because they feel threatened by their neighbors and in some ways just want to keep up in general.

I want to address the issue of the non-state actors. I personally don't see non-state actors having any interest in messing with space, so to speak. I just don't see it. I don't think non-state actors have any motivation to do so, I don't think they would want to spend the money, and I don't think it helps them achieve their goals. I think this would be kind of silly.

I actually think this question is kind of a moot question. I don't see any motivations there for non-state actors to contest space.

I also see no motivations, perhaps with the exception of North Korea who is an outlier, on the part of any other states to mess up space in general. In other words, they might contest the use of space in a conflict, particularly in a conflict with the United States. But I don't see them having motivation to do something stupid like launching an EMP. This is because of the fact these countries are investing money in improving their use of space, so there's nothing in it for them, at least in peace time and even crisis stability. In times of conflict, they have motivations and they might have motivation even to do things like creating space debris or creating space weapons if they feel as though they are losing a war. They might have motivations to do that because they have those capabilities, and could see how it would help them win a conflict.

Indeed, with the United States under Trump, this also might not actually be off limits for the US if we were in a conflict. We've said that we don't wish to use space debris creating weapons, that we have no desire to see those kinds of weapons deployed and developed, and that we have no intention of producing those kinds of weapons. But we've never outlined in any doctrinal paper or any policy papers that we have instituted that self-imposed ban on these kinds of technologies—we've not done that. In other words, we have no legal or policy commitments to our pledges.

So, all I'm saying is that I don't see any motivation for anyone, with North Korea being an outlier because who knows what their motivations are, in actually harming space as an environment because there's too much social and economic and military benefit coming from space for anyone to really want to contemplate ruining space for everybody else. I think it's really important that this understanding underlies this question about motivations to contest space.

Interviewer: [Q2 indirectly] So you think that the huge investments that actors are making in the space domain and in their own space programs and capabilities is the key factor deterring contestation and aggression in space?

T. Hitchens: Yeah, I do. I really do. For me, this question of proliferation of technology is sort of a double-edged sword. In some ways, yes it shrinks the gap between US technical capabilities and new technical capabilities of other countries, right? But on the other hand, the more states that are actually invested in the use of space and who see economic development from it and who have put monetary investments in using space, the better because those actors have fewer and fewer motivations to do anything really disruptive in space. These other actors are beginning to grow their own dependencies on the use of space for their own economic development, so they'd be shooting themselves in the foot by causing chaos in space. Ultimately, the more invested you are in space, the less motivation you have to do something really awful in the space domain. It's just common sense.

Jonathan Hung

President (Singapore Space and Technology Association)
23 August 2017

INTERVIEW TRANSCRIPT EXCERPT

J. Hung: [Q2] Sure. But, just to note upfront, Singapore does not have a very significant space program. I mean, Singapore does a lot of regional work but it is mostly for satellites and observation activities. So, I'm not quite sure what kind of responses you are looking for today, but, honestly speaking, we rarely have these kinds of discussions in our region, and definitely not in terms of the difference between commercial ventures and I guess space operations for military purposes. With that said, I'm not quite sure what kind of responses you are looking for but I will try my best.

[...]

J. Hung: [Q2] I am looking at this more from a Singapore perspective, and in Singapore we think about space more from a pure economic point of view...

[...]

Interviewer: [Q2] Okay. Let's move on to the main question that I was hoping we could address, which is about how other actors conceive of space operations for military and commercial purposes. So, how does Singapore, and maybe some other countries and Singapore's region, conceive of space operations for both militarily and commercial purposes?

J. Hung: Well, Singapore is fairly new to space. Commercial space activity has really only been happening now for about 5 years in Singapore. We have a company in Singapore that manufactures commercial satellites for imaging and observation, and this data is sent to other commercial audiences. Ultimately, Singapore looks at space as an opportunity for the country to explore another commercial arena—space is another industry for us. The space arena provides Singapore with an opportunity to create and provide jobs and research, and Singapore is trying to find its niches and some top system applications.

Singapore is not vying to create the biggest space agency in the world. Singapore does not even have a space agency or national space policy. So, again, Singapore's interest in space are purely driven by commercial and economic interests. Companies from the US, from Europe, and from all over the world are starting to set up shop in Singapore, and there are a lot of innovators and startups that are venturing to Singapore as well. Also, given the region, there are increasing observation and communication satellite requirements for Singapore—not the big traditional 2-tonne kind of satellites, but now smaller, smarter, and cheaper satellites. There is a lot of

research going on in Singapore currently about what types of things can be done with small satellites.

Most of Singapore's interests with respect to space are targeted at commercial means, disaster management, and research. So, I think this is Singapore conceives of space operations and planning—commercial and economic interests are really the driver, and its got to stand on its own two feet. Another reason why Singapore is in no hurry to have a space agency is because, like all our other industries in Singapore, the basis of the industry surviving and doing well and is that it has to be commercially sustainable, which is the number one principle in Singapore—the industry cannot be dependent on government funding, etc. There's the possibility that Singapore's government could cut funding, so the commercial backbone has to be very solid, and this how we are building up our space satellite industry in Singapore.

Interviewer: [Q2] So, it sounds like Singapore is primarily a commercial space actor. Given this, plus the fact that it seems as though Singapore has no space agency or national space policy, does Singapore's government do any activity regarding space?

J. Hung: Singapore does not have a space agency nor a national space policy. My organization is a non-profit trade association, so we have corporate members and all that, and we don't define policy but of course we work at all levels of the government. For some of the government agencies, my organization is the conduit to research partners, academic institutions, and commercial companies—we cut across everything. Things in Singapore are very commercial trade driven and research driven.

Interviewer: [Q2] So, what is the relationship like between the government and commercial space entities in Singapore?

J. Hung: There are various government agencies in Singapore that are looking at space in their own way. For example, the primary go-to government contact is the Singapore Economic Development Board. So, our primary space office is under the Singapore Economic Development Board, which is our main inbound investment agency. This is clearly very telling—Singapore has put its primary space office as a subset under its main economic office. This office is looking to attract companies to come to Singapore and leverage the pool of assets, talents, resources, etc. in Singapore and in the region.

So, the relationship between government and commercial in Singapore is very good. If somebody wants to setup some kind of a presence or open up offices in Singapore, the government is happy to talk to them about how it can support their growth. The government supports commercial growth through incentive, talent development, business matching, assistance to aid growth in the region, finding additional business opportunities, etc. The government does its best to help commercial companies grow because the international market for most of these companies is very significant.

So, ultimately, I think the arrangement between commercial and government in Singapore is excellent.

Interviewer: [Q2] Okay. That is refreshing to hear. So, what do you see as the key ambitions and interests of some of Singapore's commercial space entities? You have mentioned that Singapore views the space domain as an opportunity to explore and extend into new areas in pursuit economic and trade interests, so are those the only ambitions or are there any others in addition to that?

J. Hung: I think that's primarily it. And that's also due in some part to the fact that Singapore is pretty small, so the resources that are available have to be used properly. Singapore needs to move up the value chain—the labor-intensive manufacturing is gone and now everybody is going to IOT, so I think we have identified space as an area of interest for necessary development. Singapore is trying to tackle its challenges at all levels, and tapping into the space domain opens up a new market and new industry.

Again, Singapore does not have a space program per se, but, theoretically, every space program needs good industry (i.e., a good aerospace industry, a good electronics industry, a good precision engineering industry, a good information and communications industry, etc.). In most cases, the country's space program helps develop and grow all of these industries. However, in Singapore, it is sort of the other way around—Singapore has a very strong aerospace industry, a very strong electronic sector, a good ICT sector, and its precision engineering strength is not bad. So, Singapore has all of the ingredients, so the commercial sector decided to try space. So, in Singapore, the process was sort of flipped the other way around. It has been a ground-up effort where the commercial side has driven the progress, not the government.

So, the companies in Singapore see this as the next stage of growth. Can you do better in communication? Can you do satellite communications? Can you help improve our telecommunication strength in region? Do you have expertise in imaging and providing good data? These are the types of things that Singapore's commercial sector is interested in. Data analytics today is software driven and algorithm driven, and these are things that Singapore can play a significant role in. And for something like satellite manufacturing, Singapore's companies are not going to just quickly be like Boeing or Airbus or NASA, but the country can work to enrich its advanced computing skills so that it can build better onboard systems and sub-systems that are more powerful, smarter, smaller, and more efficient. So, Singapore is trying to develop its capabilities so that it can extend its portfolio of commercial services for the rest of the world. And some of these are indigenously growth capabilities, while some have been grown in partnership with other audiences, but, ultimately, growing its capabilities is Singapore's main interest.

Singapore is also developing the necessary ecosystem for a national space program by working to build more talent as well. The message is that to be a space expert or enthusiast, you don't just have to study astronautics—a space program takes in people from all sorts of engineering fields, and from other backgrounds as well. So, first and foremost, we want to get more people into STEM, which is a worldwide problem right now. There is a big gap between the current generation and past generations—there are not enough middle managers and a lot of students that are more focused on working at banks because they pay better. So, Singapore is working to push STEM and get more people interested in engineering and sciences. Satellite engineering and operations is a different field, but it excites the youth and there's a lot of good engineering programs in this regard, which gives Singapore something to look forward to. So, Singapore is investing in talent development, and a lot of international space academic research programs are becoming more global so Singapore is encouraging its students to get into these programs and interact with the rest of the world, and Singapore has a lot of partnerships to aid in this effort.

So, there is clear build up in the sense of getting more people to go into S&T. Nobody is going to be an astronaut tomorrow, and if some people do not end up in satellite manufacturing, then that's fine, but at least there will be a bunch of engineers that are well trained in certain parts of this program, which will only help the country as a whole.

So, these are really the primary drivers of why Singapore is interested in space.

Interviewer: [Q2] Okay. You've presented a robust portfolio of space services and ambitions that Singapore seems to be driving towards, so, I'm wondering, are there any areas in particular in which Singapore is investing most heavily, in terms of total investment, in comparison to others? Are there any specific areas where Singapore's commercial space entities are most focused on investing, or is investment generally even across the board?

J. Hung: So, the investment is broad, but it is aimed at small satellites at the point in time. Again, Singapore isn't investing in the big 1-2-tonne telecommunications satellites—if anything, the focus is more on services. But, I think we are investing in areas of analytics—the big data

analytics across all levels, whether it is the space-borne operations in space or the ground segments. Singapore is trying to do more with less. But, overall, the drive is in that direction.

In terms of what particular services Singapore does not have, well, I don't think I could define that because the entire sector in Singapore is continuing to evolve. We are currently looking at Earth observation to get better, faster, and more efficient imagery services, we are working towards better image cleaning solutions, and we are working at getting better at this on the ground. This is definitely in line with smaller satellites, particularly developing better sub-systems and working to provide a more holistic solution to potential customers and for ourselves in the current space ecosystem.

Interviewer: [Q2] Okay. So, if you look at the list of countries that are presented in Q2 on our list, it seems like that Singapore is a pretty unique example because it is a primarily commercial-driven emerging space power.

J. Hung: And that is very much in line with the entire country. I mean, we are ultimately a finance and commercial hub, so I guess that is all in Singapore's DNA, right? Singapore is a small country with a small amount of resources, but it is a very focused country.

There are many aspects of space. And the education component up front is important, and we recognize this in Singapore so we talk to students about all kinds of lunar projects, commercial space transportation, space tourism, etc. We are quite open to all of these kinds of things.

For Singapore, at the end of the day, regardless of the space sector of interest or area of focus regarding space, there has to be some sort of commercial angle in order for Singapore to be seriously invested. Because, otherwise, you never know what might happen tomorrow with government funding, which the government is even very selective with in the first place. If industry can stand on its own two feet and companies can drive commercial sector growth, then this will only help to justify and provide merit to these efforts.

Interviewer: [Q2] Okay. So, given Singapore's clear commercial and economic interests in the space domain, I imagine Singapore is also interested in regional cooperation. Are there any countries in particular that Singapore is cooperating with in an effort to advance its largely commercial and economic space interests? And, on the other side of the spectrum, are there any cases where Singapore's space interests might be sort of in conflict or contest with another country?

J. Hung: I will answer the second part of that question first. I believe we are the smallest of the countries that you have listed in your question, and Singapore does not have a national space program, so Singapore's space interests are probably not likely to conflict with any other country—there is just not very much to contest.

As for the first part of your question, and cooperation with other countries, to my knowledge Singapore does not have any space cooperation with countries such as North Korea and Iran, but if you disregard some of the more sensitive countries, then I think Singapore is very open to cooperation across the board. Singapore has excellent relationships with the US and all of the various European Space Agency (ESA) member states. Singapore does a lot of work with Japan. India launches Singapore's satellites. South Korea worked with Singapore on Singapore's first experimental satellite, and Singapore has a lot of commercial interactions with South Korea as well. As for the other countries on your list, I do not think Singapore has a lot of interaction with Brazil, Ukraine, or Canada, per se—though Canada may be investing a bit. Singapore talks to Australia a lot as well. On the research side, I think the Universities in Singapore talk to everybody else that is also doing research. So, I think Singapore is quite open—our doors are open as long as it is interesting from an academic or commercial point of view. Singapore does not really discount any country, per se.

[...]

Interviewer: [Q2 indirectly] So, we always end these interviews with a general question. Is there anything that I haven't asked you that I should have, or is there any final point that you would like to conclude with?

J. Hung: I think you pretty much covered everything. But, just to conclude, Singapore is pretty agnostic. The space industry is commercially driven, so all of the programs and projects that we weigh and consider, are considered based on its own commercial and economic merit. And is generally how Singapore operates in general—if you were to parallel a lot of these space-focused questions to some of Singapore's other industries, you'd get a lot of the same feedback. Singapore's growth overall has all largely been commercially-driven from the ground-up, and the space sector is no different.

Singapore has a fairly strong oil, gas, and chemical sector and it ranks pretty high globally in maritime trade, so we hope that someday the space sector in Singapore can also reach the same level, and the country is following the same path to do so.

Singapore is open to working with pretty much everyone, as long as there is some commercial interest on both sides—Singapore is interested in fostering win-win partnerships, for sure, and will continue to invest along that path.

Juan Hurtado

Science and Technology Advisor (United States Southern Command)
26 June 2017

WRITTEN RESPONSE

Brazil

Brazil's main interest in space is to support the national development--civilian/commercial purposes. Military benefits are derived and subordinate. Even within the military, support to the development of civilian / commercial capabilities is a key objective.

Small spacecraft (microsatellite, nanosatellite and picosatellite) have a prominent place in their 25-year plan for space modernization. Launch facilities to include the infrastructure (i.e., Alcantara launch site) and launch vehicles have a secondary interest.

They're organized in a way to execute the above strategy for space operations and services. The Brazilian Space Agency (AEB Agencia Espacial Brasileira, HQ in Brasilia) is responsible for the space program in the nation. They develop strategy, vision, policy, roadmaps, budgets, etc. The National Institute for Space Research (INPE Instituto Nacional de Pesquisas Espaciais) conducts the bulk of governmental space research and development under the Ministry of Science and Technology. Their primary interest is civilian applications although they collaborate closely with the military, particularly in the research center (DCTA - Department of Aerospace Science and Technology) located in Sao Jose dos Campos, near Sao Paolo. At this location, the Technological Institute of Aeronautics (ITA Instituto Tecnológico de Aeronautica) a pseudo military academic organization run by the Brazilian Air Force (FAB Fuerza Aerea Brasileira) is key for related education and development. Another important governmental organization is the Center for Space Operations (COPE-P) located in Brasilia under oversight of the FAB. They conduct the space operations for Brazil.

These governmental organizations responsible for the space program, research, education and operations are augmented by the commercial sector and universities. Industry partners includes Visiona Space Technology (satellite manufacturing), Embraer (defense), Telebras (telecommunications), and several start-ups which are being

incubated by the innovation hub in San Jose Dos Campos. Universities with space programs to develop the workforce include the University of Sao Paolo, Rio de Janeiro and other schools throughout the country.

How does Brazil approach space operations and services?

Their approach consists of national and international activities. Organic functions are those that preserve capacity building and safeguard national interests. Brazil is largely dependent on the international support for launch, satellite manufacturing (Brazil has competent capabilities in this area but more development is needed), and orbital mechanics. As an illustrative example of their space capacity consider they only have one astronaut in the history of their space program. All this to say Brazil has capacity in space, certainly more than other nations in the region; however, their program is still in development.

In the area of foreign support, we lost a lot of ground in building an enduring partnership with Brazil due to our space policy guidelines. We were not responsive to their requests for space support during a span of the last 15-years (country-to country bilaterals, working groups, official visits, etc.). Brazil was forced to build alliances with others such as France, and China. In fact, we would have to make a concerted and sustained effort to catch-up and not leave this flank completely uncontested. The Chinese have agreements and presence in key Brazilian space facilities while we're notoriously absent. At this stage, one cost effective option to counter the competitors would be to use / hope industry offers a better choice to the Brazilians. For instance, the American company Planet (Planet Labs) is well positioned and already active in Brazil to provide space-based imaging for a myriad of civilian and military applications such as water security (e.g. planning support for droughts), climate change (NASA data indicates global warming would affect Brazil worse than many regions in the world), power generation from the vast riverine basin found in the Amazon region (topography maps, 3D terrain mapping), agriculture, military basing and security operations (forward bases, special operations, counterdrug operations that take place in remote areas in Brazil space based communications and surveillance are very important).

Is there any difference in how Brazil's commercial ventures (if any) consider security during peace, crisis, and conflict?

Brazil does not see nor define security in our terms. They don't seem overly concerned nor invest heavily in "US security issues" around the world. Brazil is concerned with national development, and issues that affect such development. For our purposes, we should consider how Brazil exports security to our benefit. These areas include military support to the UN peacekeeping operations, humanitarian assistance, disaster response, and counterdrug operations. In this security and stability context, the commercial ventures are not overly active or shown a major difference in their approach.

Group Captain (Indian Air Force ret.) Ajey Lele³⁸

Senior Fellow (Institute for Defence Studies and Analyses, Centre on Strategic Technologies)

25 June 2017

WRITTEN RESPONSE

Amongst the mentioned states for discussion, I have visited PRC, few EU states, South Korea and Israel. At none of these places I have visited any specific space related facilities. However, I had discussed space issues with some officials, scientists, defence personal and academicians from these states. With the experts from the rest of the states too (except North Korea) I have discussed space issues (either in India or at some international forums). All these discussions have been more at an informal level. Hence, the answers given below are based on my own perceptions and information available in open source literature. These answers do not reflect opinion of the India Air Force, Indian Space Research Organization or Government of India.

³⁸ The responses here represent the sole views of Ajey Lele, and are not intended to represent the position of the Indian Air Force, Indian Space Research Organization, or Government of India.

PRC

As it is known, China Great Wall Industry Corporation (CGWIC) is the main agency in China which is the official organ of the government to deal in various commercial activities.

There are various reports in regards to assessment of China's space industry. One from India could be viewed at: <http://www.prnewswire.com/news-releases/china-space-industry-development-analysis-270292311.html>

It has been observed that China is mainly engaging African and Latin American states in the space domain. Also, some small states within South East Asia are engaged by China. Their various arrangements in regards to developing and launching of satellites clearly indicate that the focus is more of a bilateral engagement than immediate commercial gains. This does not mean that they do not have any commercial expectations from their space program however; at least at present the focus appears to be to use their space expertise more for geopolitical and geostrategic purposes.

Recently, Indonesia has signed a contract with China for PALAPA-N1 communication satellite project.

The most recent focus of China has been on its political pet project called One Belt More Road (OBOR) initiative. The 'Road' to Success for the "Silk Road Initiative" is via Aerospace. Please refer to: http://www.idsa.in/idsacomments/silk-road-initiative-via-aerospace_alele_211015

Space is directly under PLA and hence military relevance is obvious. Their space operations and services are directly controlled by military. At the same time it could be possible to collaborate with the CGWIC and other agencies after due procedures.

The BeiDou Satellite navigation system is generating a turnover of more than 30 billion USD per annum for major companies such as CGWIC, China Aerospace Science & Industry Corp and AutoNavi Holdings Ltd. The Beidou satellite navigation system will be able to provide services for countries participating in the Belt and Road Initiative by 2018. Presently, this navigational signal is available for some states outsider China too. However, there is no clarity in regards to availability of this signal to them during crisis and/or conflict situation.

In respect of military usages of space it needs to be understood that China has shown interest towards weaponising the space. They have successfully conducted the ASAT test during 2007 and are known to have capabilities for jamming of satellites. Some of their activities done in space during last few years do indicate that some passive anti-satellite tests being conducted.

Russia

The Russian Federal Space Agency (Roscosmos, RKA), is the government agency responsible for various Russian space related activities. They probably, have more than 100 small and medium companies dealing in space. However, all these companies are state owned. There are major agencies like Russia's state-controlled NPO Energomash with major stakes in space. At the same time few startups are being established in the space arena.

Russia did face problems in space sector almost for a decade after the disintegration of the USSR. For a state like Russia it is obvious that space operations are an integral military operations. It is important to note that till date the US and Russia have succeeded in keeping their space agenda shielded from geopolitical tensions. In spite of terrestrial confrontation they have succeeded in maintaining orbital cooperation. (refer to: <http://www.e-ir.info/2015/04/25/international-space-station-terrestrial-confrontation-to-orbital-cooperation/>). The US agencies would have a better idea in regards to Russian space operations and services particularly the contracts of RD-181 engines with the US would offer more clarity about how their commercial ventures would respond during the period of crisis. Also, their contracts with other states in regards to Gloness navigational rights would indicate the nature of facilities offered during wartime. Russian economy largely depends on their military industrial complex hence for them space sector also have larger commercial significance.

It is important to keep in mind the overall Russia-China relationship. In space sector they are found working jointly on some important projects in deep space and also trying to push PPWT. There is a possibility that in times of crisis both these states could come together and manipulate the activities in the outer space.

Iran

To my mind Iran space program should not be viewed only with a missile bias. In the arena of science and technology Iran is making good progress. They are keen to establish their space program in a respectable fashion. Any space program would have military relevance owing to dual-use nature of technology and same could be true with Iran too. However, their space budget is limited and I do not expect their program to leap-frog in near future but, still could show a steady growth. They could receive some assistance from China in the future in space arena.

North Korea

The country is brazen about their investments in missile and space sector. They are conducted various missile launches and hence do not require to hide behind satellite launches to demonstrate their missile launching capabilities. In this country every activity is state controlled and there is no specific information about any domestic space industry. It is obvious that satellite technology would benefit their ballistic missile agenda. Also, they are expected to invest towards development of various launch vehicles (some testing of engines in underway) to demonstrate their technological capabilities to the outside world.

In regards to commercial activities: there has been a concern about North Korea engaged in the illegal market of purchase/sell of missile parts and it is possible that most of the satellite related components could have been procured illegally.

ESA

For NATO, space is a force enabler/ force multiplier. They have “Allied Joint Doctrine for Air and Space Operations” in place. There are some documents providing assessment of the role and the ability of systems in space in support of European security. As a part of the allied forces along with the US in various recent military operations like Iraq, Afghanistan, Kosovo etc. various armed forces of various European states have depended on satellites significantly. Space has importance for EU for many decades for strategic purposes. There are two EU states which are nuclear weapon states and it is but obvious that there would be considerable amount of dependence on space to keep these forces operational.

Commercial activity related to space in the EU is found happening more as a state based activity than as ESA activity. Private agencies in France, UK, Germany, Italy, Canada etc are in business of space for many years. Various agencies from these states are expected to take state/EU centric positions if the geopolitics demands so. Many of the agencies in these states are basically involved towards designing and manufacturing satellites as well as trading in satellite data. Many of these agencies are well-established and customers are queuing up for their services. Arian Space of France could be a case in point. It is likely that the focus of ESA is more towards investing in space for the commercial purposes.

Japan

Japan’s space agency called JAXA is the main force behind their space program. They also have private agencies like Mitsubishi Heavy Industries and IHI Corp which have a global footprint. During November 2016, Japan’s parliament has enacted two important bills concerning space. It has made it easier for private companies to invest in space. The establishment of the space activity law, specifically allows companies to launch artificial satellites if they meet certain criteria. Among the new market entrants are Interstellar Technologies, Astroscale, PD Aerospace and Canon Electronics. (refer to: <http://asia.nikkei.com/Business/Trends/Japan-s-space-industry-gets-some-new-life>).

On 01 April 2016, Japan has released its fourth Space Basic Plan (Basic Plan 4) which puts in place space policy more as a security policy. This indicates that Japan is increasingly becoming concerned about the security challenges in the region and more and more investing in space technologies for this purpose. In fact, understating the need for monitoring the activities of the unpredictable state like North Korea in its close vicinity Japan has been launching spy satellites since 1999. Japan has launched its first military communications satellite to boost the broadband capacity of its Self Defence Forces during January 2017. Japan is planning to launch a military space force by 2019 that would initially be tasked with protecting satellites from dangerous debris orbiting the Earth. Also, a significant amount of US involvement is expected in various strategic activities undertaken by Japan with respect of space technologies.

Japan's investments in space appear to be both for military and commercial purposes. Japan's security interests and nature of their strategic establishments indicate that they are unlikely to share their space assets with anyone except the US. Hence, their military and commercial activities would go in parallel.

India

For various space-faring states the development of the satellite launch vehicle has been an offshoot their missile agenda however, this was not the case with India. They began their space program with an aim to develop space technologies for the purposes of societal benefits and this agenda continues to remain same even today. At the same time with the liberalization the economic policies (1991) and rapid technological developments India is now also found exploiting its space capability for commercial purposes. Indian space agency, ISRO has its own commercial arm called Antrix which undertake various businesses related activities from launch services to data sharing. Presently, India has established itself in area of providing launch services for small satellites in general and nano-satellites in particular. Private space industry is still in the phase of infancy in India and would require handholding by the state. Some startup companies have started making investments in the space domain but these are early days. There are some small industries already well established and in business for last couple of years, however they specialize in specific jobs for ISRO and their existence is based entirely on the orders from ISRO. A public sector agency called Hindustan Aeronautics Limited (HAL) also undertake structure development (for satellites) work for ISRO. ISRO has plans for engaging private industry to undertake launch activities with a technology transfer agreement with them. India is also keen to develop ground infrastructure for prospective clients (have already done it for Vietnam).

India faces very unique security challenges from cross-border terrorism to having both the adversaries as nuclear weapon states. Also, being a peninsular state, India has large maritime border to monitor. Hence, understating the importance of satellites technologies for the strategic purposes on 29 Sep 13 India's first dedicated defence satellite GSAT-7 was launched for Indian navy. India also has a network of remote sensing satellites which are expected to be dual-use.

At the backdrop of above it could be said that India has reasonable commercial and limited strategic interests in the space. In regards to space operations there is no separate agency for the military and hence their dependence on ISRO is obvious. India's commercial ventures are expected to be more as a service providing activity and during crisis and conflict situation it is expected that depending on the ground situation the decisions could be taken more on case by case basis. India has developed its own regional navigational system and is expected to share this facility with the neighbors. In case of crisis is doesn't look critical for India to switch off such facilities for the non-military users.

South Korea

ROK has larger ambitions in space and is doing and proposing significant financial investments too. However, they have not achieved much success till date apart from establishing themselves as a space-faring nation. Interestingly, the US which has been reluctant to cooperate with ROK fearing that they would use any transfer of technology or knowledge for their missile program has now collaborated with ROK in outer space domain. With the US engagement now, ROK is keen to incorporate advanced technologies of military relevance in space. These are expected to be more of reconnaissance and communications related technologies. They have also developed a new defence doctrine in outer space. Space technologies form an important element in regards any missile defence system and for coming few years this would remain a key focus both for the US and ROK.

ROK is a technologically advanced state and expects that the space industry would gain significant importance in coming years. Number of venture capital firms in space area is showing rapid growth. In coming years this investment is expected to increase however, typical security situation in the region would dictate the situation on ground. The nature of threat from North Korea and characteristic geography of the region may decide of the future of industry in times of crisis.

Israel

They have a limited program and do not look much ambitious in this department. The focus of their program is military in nature apart from some civilian usages.

Dr. Martin Lindsey

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

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: [Q2] Okay, great. That's really helpful. So, now let's move into the main question that I was hoping we could focus on, which has to do with the use of space by US allies, partners, and adversaries. As you can see in the specific question, we have been presented with a number of countries to look at. So, before sort of jumping into this question, I just want to ask you which of the countries from the list you feel most comfortable with or well-suited to talk about?

M. Lindsey: That is a great question. In my interactions, I primarily work with European countries and with Australia and Canada, and specifically through an international group called the Responsive Space Capabilities Research, Development, Test, and Evaluation MOU, which is an MOU that the Air Force International Affairs administers on behalf of DoD. This group includes 10 countries (7 European, the US, Canada, and Australia). So, that's been my primary interaction, and I think this is where I am most comfortable speaking in regards. I do also have a little bit of engagement with Asia Pacific countries, primarily, in addition to Australia, these include New Zealand and Singapore. I haven't engaged much personally with Korea or Japan, even though we have a fairly robust space engagement with those countries, I just don't personally work there. I do know a good bit about Chinese space activities, but that would be a conversation for another forum.

Interviewer: [Q2] Okay. Got it. So, feel free to guide your responses towards those countries you mentioned. So, what are the major, essential things that we should know about each of those countries' space programs and their space interests and their ambitions both with respect to the government and commercial realms?

M. Lindsey: Okay. That's a great question, and one that obviously has a lot of facets to it. My bias and my personal engagements are towards the design of what these countries are doing and interested in doing with respect to small satellite programs. And, it's telling that in the past if you looked at the US investing in large satellites, particularly for things like satellite communication systems, many of these countries' governments, or at least their Ministries of Defense, just didn't have the budget to really meaningfully contribute. So, other than a handful of countries and partnerships (like the Wideband Global SATCOM [WGS] system), we just didn't have a lot of engagement with our allied countries because they didn't always have the capital and the means to participate. But, now, particularly with the smaller European countries and with Australia, we have seen that they've realized that the barriers to get meaningful space capabilities are dropping, so they can now go to space and use small satellites. That's interesting to us at the Combatant Commands because we're very much in pursuit of the resilience in space and ensuring that we have space capabilities in hand, and the persistence that you get from small satellites is something that we see as an easy partnership opportunity with other countries.

So, I would say that's probably been the biggest change that we have seen with a lot of these countries that are now participating in satellite-based solutions outside of the commercial world. Today, a lot of these countries can actually get into the game with their partners.

My perspective in that sense is mostly driven by my interactions with European countries. With respect to some of the Asian countries, I'd recommend talking to Clay Moltz at the Naval Postgraduate School, he's one of the authorities on space policy and what's going on in the Asia Pacific region. I talk to him from time to time and what really strikes me, and he's followed it pretty closely, is kind of the term the "Asian Space Race." I mean, a lot of times we think that countries like China are just focused on the United States, but when it comes to space, the Chinese and [other] Asian countries are very much tied up into the nationalism factor—so, it's

China versus India, China versus Japan, India versus Japan, etc. For example, South Korea sees access to space capabilities as part of its national pride. And, now, this is kind of spreading into Southeast Asia also. So, we are seeing a lot of these “space races” going on in that region now as countries are competing to be the “first Asian country to do X in space.”

Interviewer: [Q2] Okay. So, with the barriers to entry for the space domain sort of declining, at least with respect to small satellites, there are clearly more and more actors now getting involved. So, if we were to think about space actors on a spectrum of space capabilities, I would think that the US would still be out in front of everyone else, is the gap closing? And, if so, which countries are sort of leading the charge of that second wave or second grouping of countries below the US in terms of capacity and capability in the space domain?

M. Lindsey: I think the gap is closing but this isn’t unique to space. The gap is closing because the same globalization and advances in electronics that give us everything we have seen with consumer electronics are also now finding their way to space.

So, I think it’s really more of a bleed over from just the broader technology revolution that we’ve been for the last decade or so, that’s now finding its way into space. I mean, this is primarily being seen now through the commercial sector—it used to be that government drove the direction of space technology, but increasingly it’s the commercial sector that’s driving space technology and the governments are having to become consumers of commercial space technology. I think that is especially true with countries outside the US where there’s a long history of the pursuit of national agencies driving the direction of space technology. So, if you’re the Philippines or you’re Malaysia, most likely the space industry you have is commercial focused, and then the government is trying to figure out how it can take advantage of that.

Interviewer: [Q2] Okay. So, the commercial entities are the ones that are pushing the development and progress in the space domain for a lot of these countries, more so than the governments?

M. Lindsey: Yeah, I think so, or it’s very closely coupled. If you look at some of these countries, many of their industries are driven by the commercial sectors, and you really see that on the space side. For example, Singapore has an electro-optical imagery small satellite up right now, and it is putting up a few more and also developing a small satellite synthetic aperture radar, and this is all being done in a public-private partnership. So, it will be growing commercially and it’s being developed in a public-private partnership with strong government participation.

So, you can see a variety of models—it’s kind of whatever the country chooses to do—but I think the real message is that the barriers to get into space are really falling fast, so countries and entities that just couldn’t contemplate getting involved 10 years ago are now starting to see that they can get in the game.

Interviewer: [Q2] Okay. So, what are the key differences and differentiators between the space programs and space interests of some of these countries that we should be aware, both with respect to government and commercial realms?

M. Lindsey: Sure. So, I can’t speak terribly well to the civil side of space, but I will speak to the national security side and the commercial side of space.

So, you have some of your more traditional players like China where their space industries are tightly coupled with their military. So, every Chinese launch you see, it’s never portrayed as a military launch, right?³⁹ It’s some sort of science and technology launch or commercial launch. But, below the hood, that’s probably not actually the case. So, you have that model.

³⁹ Following the interview, Lindsey provided the following comment (10 October 2017): “China launched 3 satellites 2 weeks ago, and I believe in a first for them, announced at launch that they were RF signals gathering satellites for the military and no further information would be released.”

Then, again, you have a lot of countries that are just getting started like New Zealand or the Philippines, and they are relying a lot on academic contributions to get them started, which is kind of the same path that we started down about 30 years ago with small satellites—it started in academia and took about 20 years to start the transition over to what I’d call real-world application, whether commercial or government. So, these countries are kind of going down that same path that the US went, but I think they’re going to move down that path more quickly than we did just because they now have our lessons learned.

Interviewer: [Q2] Okay. So, you mentioned some collaboration efforts between European countries, the US, Canada, and Australia, but, beyond some of that collaboration, are any of these big countries working together bilaterally in close collaboration when it comes to the space domain? And, on the other hand, do the space interests and space-related actions of any of these countries openly conflict with those of any other countries?

M. Lindsey: I would argue that there’s a lot more cooperation going on in the space domain than competition. I don’t know how you want to define “conflict,” but there’s really not any kind of overt or even covert conflict that I’m aware of right now in space—though, there is competition. But, overall, I think there’s a lot more cooperation going on in space. Again, a lot of that is done multilaterally on the commercial side or bilaterally.

Some examples of multilateral cooperation would be the US has a Five Eyes relationship, right? That relationship spills over into cooperation on technology development, and space technology development, between the five countries in that partnership.

In Asia, the Asian nature is to be more bilateral than multilateral across the board in everything. So, a lot of the relationships in Asia are bilateral in nature—so, you see a lot of times where countries will go to Japan or go to China, or increasingly they’re going to India or European countries, to get their first exposure to development in space. So, you see like, for example, the Chinese will fly country X’s satellite for very low prices, and in return they’ll work out some agreement maybe for ground station access in that country. There are some multilateral space institutions in the Asia Pacific. These are mostly on the civil side of the house or the civil/commercial side. I’m not really aware of, other than the Five Eyes partnership, any real national security-related relationships between countries in the region—though, with the one exception being that USSTRATCOM is working a series of a space situational awareness agreements throughout the world, and these are bilateral agreements with countries that include several countries in the Asia Pacific (e.g., Australia, Japan, Korea).

Interviewer: [Q2] Okay. So, from a longer-term perspective with respect to some of these countries’ space interests and where they see themselves going, while you think things seem to be mostly collaborative at the moment, do you foresee any sort of situation in which some of these countries’ interests might drive things to become more competitive or possibly even conflictual? And, if so, what types of things in particular do you think might be the leading drivers of increased competition and conflict?

M. Lindsey: [Q2] Sure. So, as I mentioned earlier, there are various space races going on in the Asia Pacific region—the big ones being between China and India, and then to a lesser degree between China and Japan, and these are more tied up in nationalism and global prestige—they’re not head-to-head competitions for their own sake. But, having said that, of course there are countries in the region that do have military space capabilities and military counter-space capabilities, so I think it is a logical extension to say that a conflict on the ground can easily extend into the space domain if it involves those countries, and, arguably, a conflict could begin in the space domain and then spill over to the terrestrial side. I mean, certainly leaders in our own country over the past couple of years have been expressing concerns with the risk of that happening and the need to be ready to deal with that.

So, I think that's a real concern, and I think it's a concern for countries throughout the world because there's a recognition that any type of kinetic conflict in space doesn't get limited to the parties that are directly involved; it spills over to everybody that uses that region of space. So, I think countries are concerned about it, and I think a lot of countries are still in a position of knowing that they can't really do much about it directly.

So, is the risk increasing or decreasing? Well, I think it's double-edged. It's increasing from the standpoint that the technology is improving and making it easier to get into space and do things in space where you could do actions that would constitute conflict. On the other hand, I think there's a growing realization that the things that happen in space affect everybody and the risks of escalating a terrestrial conflict go up exponentially because of the increasing dependence on space. So, I think it's double-edged, and, at this point, I'm not sure which direction a lot of countries are going to go in. From observation, again, we see things that disturb us with certain countries, but we'd have to talk somewhere else about that.

Agnieszka Lukaszczyk

Director for EU Policy (Planet)

18 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: [Q2] Okay. Great. So, let's move into the main question that I sent over to you, which is about how other actors conceive of space operations for both military and commercial purposes. So, how do other actors conceive of space operations for military and commercial purposes? And, given your expertise, please feel free to focus on European actors.

A. Lukaszczyk: Well, this is actually quite an interesting question at the moment. For instance, if you had asked that question just a few years ago—I would say 3-5 years ago—you would have seen a clear separation between civil space and military space in Europe. To the point where there would be no kind of cooperation and no collaboration between the two sides. For instance, 5 years ago, a majority of space agencies in Europe—not all, but the majority—were purely civil, and then any sort of space security was dealt with by the military. Also, when you'd look at the European Space Agency (ESA), it was very clearly stated that the ESA was to be used only for civilian purposes, and the EU Space Program was also for civilian purposes. And, back then, the idea of dual use would never really be mentioned, and was a very sensitive topic to discuss. That was all like 5 years ago, and maybe even just 3 years ago as well.

Today, though, the geopolitical situation has changed a lot in Europe, as you know, with the various terrorist attacks—I mean, we just had one yesterday in Barcelona—and also with the refugee crisis and the situation Ukraine, which right next to the borders of the European Union. So, things are getting a little bit uncomfortable. And, all of the sudden, people in the member states of the European Union started discussing that we should not only strengthen our defense capabilities, but we should use the capabilities that we already have for commercial, civil purposes and use them for military purposes. So, all of the sudden, everybody in the EU started to be interested in dual use applications.

So, there are two flagship EU space programs: Galileo and Copernicus but before I get to those, do you know the difference between the European Union Space Program and the European Space Agency (ESA)? I know this can be kind of confusing for foreigners, so do you want me to explain?

Interviewer: [Q2] Yeah, if you want to talk about the differences between the European Union Space Program and the European Space Agency (ESA), that would be really helpful.

A. Lukaszczyk: Okay. I know this can be really confusing, and it is also confusing for people in Europe if they're not really involved, so, let me briefly explain.

Europe is quite complicated, and when you look at the space programs and who does space in Europe, you have kind of three different branches: the individual member states, the EU, and the European Space Agency (ESA).

The first branch is just the individual member states, right? So, you have Germany, the UK, etc., and they will all have some sort of space program or a space agency, or a space office if it's a smaller country. But, they have their national programs or initiatives.

The second branch is the European Space Agency (ESA), which is an intergovernmental organization, and ESA is actually the only space agency in the world that is an international space agency. ESA was set up, I think, around 50 years ago, and it was first set up for just kind of scientific research purposes and then it kind of moved into functioning as an operational space agency, but focused only on civilian aspects.

The third branch is the European Union, and the EU Space Programs. In 2009, the EU passed the Lisbon Treaty, which kind of regulated a lot of different aspects of the European Union. And part of the Lisbon Treaty was an Article—I think it's 186, but I would have to check that—that gave the European Union the competence in space.

Just to make it more confusing, the European Union and the European Space Agency (ESA) are completely independent from each other—just because it's called the European Space Agency doesn't mean that it belongs to the EU. So, ESA is super independent. ESA has its own members, and the EU and ESA differ in their procurement processes, differ in the way they spend money, and differ with respect to a number of factors. ESA is a very separate entity. So, we're still trying to fully figure out how the kind of division of stuff works between the two (the EU and ESA), but, just in a nutshell pretty much, ESA is focusing on space exploration, research, and the kind of technical stuff, whereas the EU is more of a political body, more policy oriented, and more kind of strategic. The difference is also that the EU is the only kind of international organization in the world that has supra national power, right? That means that if the EU passes a directive (i.e., a piece of legislation), then all of the member states need to abide by it—so, the EU can tell member states what to do, whereas ESA doesn't have that sort of power.

So, since 2009, the EU, with that supra national power, has decided to develop Space Programs, and they have developed two flagship programs: 1) Galileo, which is the GNSS program of the European Union, and 2) Copernicus, which is an Earth observation program. The reason I'm talking about this is because originally those two programs were set up as purely civilian, commercial kind of programs, but now, given the geopolitical situation in Europe, the EU has actually adjusted their mandate of these programs.

So, now, Galileo has a huge security and classified component called PRS, and those signals coming through the classified components are solely for the use of the European military. Though, there are also ongoing negotiations between EU with this program and the United States with GPS on how to collaborate and cooperate. As for Copernicus, the Earth observation program, before it was mostly focused on kind of the environmental aspect of Earth observation, but now it has this whole separate security service for Earth observation. So, as you can see, there has been a shift. There has been a change in the mindset and the way people are sort of thinking.

In addition, the European Union is developing two new initiatives. They're currently being called frameworks, not programs yet, because they don't have their own budget line yet. One is just space surveillance and tracking (i.e., SSA), and the other one is GovSatcom and MilSatcom, which

is pretty much telecom for governmental purposes. So, as evident with those programs, the EU is looking at the dual use of the programs, which is quite unique and quite new. Because, like I said, few years ago that wouldn't have even be a question, but now they see this as a necessary thing.

Interviewer: [Q2] Okay. That's really helpful. So, it seems like security is one of the EU's key interests with respect to developing its space programs. But, beyond security, what do you see as the EU's and ESA's key interests and ambitions with respect to space?

A. Lukaszczyk: Well, for sure the new space aspect. This is really interesting. Europe kind of sees that they are behind the United States—the US is producing these “new space companies” that are doing really well, that industry is really flourishing in the US, and, more than that, the US government is actually outsourcing a lot of its activities to the private sector. This, however, is not happening in Europe yet. Europe is very protectionist, they don't really trust the private sector, and any sort of governmental programs or military programs are done in-house—Europe would be very reluctant to give that away to a private sector.

One example is the GovSatcom and MilSatcom initiative. In Europe, we have excellent telecom operators, so anything from SES, Eutelsat, etc., most of them originated or are based in Europe, so in theory they could just meet those security requirements and do the job for European governments, but yet the EU is still very seriously considering actually having its own constellation because it doesn't really want this to be in private hands.

So, I think Europe is not quite as open and ready to collaborate with the private sector and industry as the US is. Now, this is changing, of course, but very slowly. I can tell you, for instance, now I work for Planet and we're getting quite a lot of government contracts. We just got a huge contract with NGA in the US and it's great, and yet something like that in Europe would be almost impossible right now. Nevertheless, they are at least starting to talk about it—they want to attract startups and scale up in Europe to make sure that those startups in Europe actually grow.

There's an interesting statistic that I just discovered recently: the number of space startups that kind of pop up in Europe and the US is quite similar. So, it is not that there are more startups in the US, but the difference is that in the US there's quite a big number of startups that survive and then there's quite a big number of startups that actually grow into something substantial. Whereas in Europe most of the startups actually don't survive after their first 3 years, and for those that do, the majority of them stay as they need, so they stay small and medium in size (i.e., up to ten people, very small companies), and they don't really have the kind of boost to become a big company. One of the reasons for this is because you don't have the venture capitalist approach in Europe that you would in the US.

Interviewer: [Q2] Okay. So, you mentioned some of the collaborations between the US and European commercial entities, but sort of beyond that European-US collaboration, are any of these European actors, both commercial and government, working with any other international actors to cooperate in an effort to advance their interests? And, on the other side of the spectrum, do you see any of these European interests as being openly conflictual with any other international companies or government actors?

A. Lukaszczyk: I think the European companies and national governments, and even the EU and ESA, partake in quite a lot of international cooperation. Obviously, there has been cooperation with the big players (i.e., Russia, China, India, Japan, etc.). Actually, for a while, the EU has halted its cooperation with Russia due to sanctions. Though, that is interesting because while EU cooperation with Russia is kind of on hold, the EU is actually still launching with the Russians every once in a while.

So, there is that sort of cooperation. Especially when it comes to launching, I think, there's a lot of cooperation with Russia and with India in particular. There's a lot of research and semantic

programs done with Japan and India (especially on space applications with India), some with South Korea, and with Canada of course. The EU has also been cooperating with South Africa and Brazil.

There's also been increasing cooperation with Latin America by doing things like exchanging different Earth observation data or that sort of thing, and this kind of cooperation is happening on all three levels—the EU level, the ESA level, and the national level. So, there is quite a bit of that. A lot of time, the cooperation is not really in the exchange of funds of any sort, but rather exchanging information and giving access to data or certain products or services and that sort of thing.

Interviewer: [Q2] Okay. So, I think the EU and the ESA are sort of a unique in comparison to the rest of the countries listed in our question because they represent, as you mentioned, multiple countries rather than just one. So, I'm wondering, if you look within the EU and the ESA at the countries they represent, are all of the countries aligned and in agreement about the organization's stated interests and where investments are being made and the direction the organization is headed, or are there some points of contention between any of the specific countries represented?

A. Lukaszczyk: It's actually a very good question because you would have hoped and you would have thought that they should kind of be aligned since most of the members are the same in both of these entities. But, actually, there's quite a bit of a friction between the EU and the ESA over the turf pretty much because ESA thinks, "We've been there for 50 years. We know space. You guys are just a bunch of bureaucrats and you don't know what you're doing," while the EU thinks, "We have the money. We have the power, and you're just going to have to deal with us being around."

So, a lot of times, actually, the goal and kind of approach is not the same or not ideal; however, one of the good steps made in the right direction was the development of the European Space Strategy. The European Space Strategy was released in last November and it is kind of a big deal because Europe as a whole hasn't had an actual strategy on space or policy or anything like that for a very long time, and they have managed to actually release a strategy that is a strategy for Europe as a whole—the European Union, ESA, and the member states drafted it together. So, if you haven't seen that, I would definitely encourage you to look at that because it gives kind of the direction Europe wants to take in space and its priorities. And those are agreed on by the three players—the EU, member states, and ESA. So that's a very good document that gives a bit of an idea of where this is going.

Now, when you look at the difference also between the EU and ESA, like I said the EU is much more of a political beast, right? So, just the counterparts will be different, too. For instance, giving you an example of collaboration with the US, ESA will work with NASA, right? NASA will be ESA's counterpart in the US. Whereas, the EU will work with the State Department. The State Department would be the EU's counterpart in the US. So, it is just a little bit of a different level of activities.

Interviewer: [Q2 indirectly] Okay. That's really helpful. So, thank you so much for running through those questions with me. I have just one last general question that we always conclude these interviews with. Is there anything that I haven't asked you that I should have, or is there any final point that you would like to conclude with?

A. Lukaszczyk: I don't think there is a specific question that you haven't asked, but I guess I'll just offer some concluding points. Europe is definitely looking at the security questions much more carefully now than it has in the past given the geopolitical situation. And, also, the dual use aspect of space access is definitely something that Europe is now realizing. So, Europe has seen a clear shift with respect to its space interests and activities. And, of course, Europe is a unique actor here—keeping in mind that the multiple players here, which makes things a little bit complicated. It's a

bit complex, but it would be worthwhile to look at the European Space Strategy because I think that would give you a good idea of where Europe is going with its space ambitions.

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7 August 2017

WRITTEN RESPONSE

North Korea

One of the greatest security implications for the United States stems from the political posturing of states within international organizations. The inability of space leaders (U.S., Russia, and China) to do more than create committees provides legitimate cause for states to develop militarized space policies. If international organizations cannot create a status quo, states will ultimately seek to promote their own interests (i.e. nuclear arms race between U.S and the Soviet Union). For example, India (a member of COPUS) cited China's anti-satellite test (ASAT) in 2007 as a reason to develop their own counter-ASAT capability (Vasani 2016). Russian “kamikaze” and “kidnapper” satellites and instances such as India’s ASAT program have understandably generated a growing fear of another space race, albeit with more participants involved. UNOOSA provides the venue for states to come together and regulate the domain of space for all, but it also provides convenient political cover to continue the militarization of space. States can proclaim an active contribution through membership and resolution submittal while pursuing self-serving policies domestically. Even though the UN and EU are organizations that promote the peaceful use of space, they may be utilized and manipulated to diminish U.S. national security. Therefore, the U.S. would be better suited if UN security goals were made to match U.S. security goals.

North Korea’s manipulation of the United Nations international space mandate is an excellent example of successful political maneuvering. In 2006, North Korea conducted a nuclear test without the authorization of the United Nations. This led to international condemnation and the passing of UN Resolution 1718, which prohibited them from conducting any further nuclear or ballistic missile testing (UN Security Council 2006). Three years later in 2009, the DPRK announced they were planning to launch a satellite into orbit. Although this was legal under the international space framework, it was perceived by many as a means for North Korea to continue ballistic missile testing under the guise of a space program. Due to military and space applications utilizing the same missile technology, it was nearly impossible to prove any suspicions.

Despite pushback from the international community, North Korea technically complied with all space launch requirements and attempted an unsuccessful launch in 2009. A new concern was revealed as the rocket used by the North Koreans had the capability of reaching the U.S. On December 12th, 2012, North Korea succeeded in placing a satellite into orbit. International security concerns grew as the North Koreans were able to hone their ballistic capabilities. In February 2016, North Korea again successfully launched a satellite into orbit utilizing the space version of the Taepodong-2 multi-stage missile, known as the Unha-Korean for Galaxy (BBC 2017). These missiles have a maximum estimated range of Australia and parts of the U.S (Alaska). More recently, North Korea successfully launched an intercontinental ballistic missile (ICBM), 2,200 miles into space (Sang-Hun & Sanger, 2017). Although their ability to use the technology to accurately strike is unknown, they are demonstrating they are moving closer to being able to strike as far as the Midwestern United States. The North Korean’s have the guise of their space program to thank for their continued success.

Another concern with North Korea is that they have very little at stake in space and have reduced military capabilities. This combination gives the DPRK a marked advantage in which they could create rudimentary weapons (i.e. bombs intended to create orbital debris) for use in space that has a great impact on their adversary’s space assets with little worry for repercussions to their non-existent space assets (Faith 2017). International condemnation would surely follow, but this has not proven to thwart the DPRK up to this point. Because the DPRK has an unhinged leader at the helm and they have just enough technological capability to be dangerous, they are a

key example. The diffusion of technology has lowered the cost of space activities and has increased the number of actors with the capability to provide space launch and other space services on the open market. This, in turn, provides the adversaries of the U.S. with access to a previously inaccessible domain.

Iran

In July 2017, Iran successfully launched a satellite into orbit upon a Simorgh rocket, also known as the Safir-2 (Moore, 2017). The launch is of not for several different reasons. First, this launch is a reminder that space is becoming more crowded and is not the sole domain of a few prestigious states. As Iran continues to broaden and improve their space capabilities, so to grow the legitimate concern of neighboring states. State sponsored condemnation and overt calls for the complete destruction of Israel and the United States take on a different tone as Iran's missile and space capabilities march towards parity with top-tier states. Second, if Iran is smart, they will take a lesson from North Korea and use their space program as a means to develop their missile capabilities. North Korea was able to improve upon their ICBM technology under the guise of furthering their space program and Iran has the ability to do the same. Honing the ability to launch a rocket carrying a satellite is one step closer to towards developing long-range missiles carrying warheads.

India

India, the world's most populous democracy is another State that has begun to develop a significant space program that has military capabilities. As noted previously, China successfully tested an ASAT missile in 2007, and then again in 2013, prompting concerns in the United States. These apprehensions were not only found in the U.S. Sharing a 3,323-km border with China, India also has a valid geopolitical concern for China's actions within space (Ministry of Home Affairs 2016). Following China's 2007 successful ASAT test, Indian Integrated Defense Staff Chief Lt. General H.S. Lidder stated, "with time, we will get sucked into the military race to protect space assets and inevitable there will be a military contest in space.....space will provide the advantage " (Vasani 2016).

Since 2007, the Indian space program has made great strides in their attempt to develop their own ASAT capabilities to contend with the primary spacefaring states, the U.S., Russia, and China. There has yet to be a successful testing of their ASAT program, leaving China and other states to question its progress or its existence. In addition to their ASAT development, India currently has one of the world's largest space budgets; the Department of Space Research arm had announced a budget of 67 billion rupees (US \$1.3 billion) for the 2012-2013 fiscal year (in comparison FY13 Space budget for Russia \$5.2 billion, U.S. \$17 billion) (Anderson, Conrad, and Gamberini 2014). Also, the India Space Research Organization (ISRO) developed a low-earth orbit satellite expressly designed for military use, to include imagery data retrieval on the Government of Pakistan's military forces and movements, which increases tensions between the nuclear states. This further illustrates the importance of space-based activities and how they influence international relations (Sen 2007).

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INTERVIEW TRANSCRIPT EXCERPT

Interviewer: [Q2] Okay, great. So now I'm hoping we can shift to the second question from our list, which is the question I am hoping we can focus our discussion on today. This question is about use of space by US allies, partners, and adversaries. As you can see from the question, we have been presented with a number of countries to focus on.

So, before we jump into the question, which of these countries do you feel most well-suited and comfortable talking about today?

Col D. Miller: I can talk at the unclassified level about some trends we have seen with respect to China, Russia, North Korea, and somewhat Iran. There's relationships we have with allies I can talk to. And when I say allies, I tend to focus more towards our treaty allies. So certainly, I think we can talk a little bit about the unclassified level of cooperation with some European allies, maybe within NATO, Japan, South Korea, and so on.

I have some level of familiarity with respect to Singapore, Ukraine, and Brazil, but I'm not as up to date on what these countries' vectors or trends are with respect to military space or use of space overall from a national security perspective, so I will likely not focus on them. But I can give you overall trends and if that leads to further discussion or insights, I will follow through on those discussion threads.

Interviewer: [Q2] Perfect. So, my first question is what are the major, central things that we should know about these countries' space programs, their space interests, and their space ambitions both with respect to government and commercial realms? Though, as you noted, please feel free to focus on the government and military realms here.

Col D. Miller: Let's start by thinking of this from a big-picture perspective. The reasons why various nations go to space are not fundamentally different necessarily. The wherewithal these nations have to pursue actually going to space and, as a result, the areas that they focus on will be different. But the basic reasons for going to space haven't changed, and this is certainly the case for the United States in the 60+ years we've been interested in space.

We can trace back—particularly in the Air Force to the first months of the Air Force becoming a separate service—a dedicated focus on going to space, and the reason for this dedicated focus has to do with the physics of the Earth. If you want to see, shoot, move, or communicate over the horizon, there's only so much you can do line of sight with terrestrial-based systems. So, from a military perspective and a national security perspective, particularly back when the US was post-World War II, with the Cold War ramping up, and concerned about missile gaps and things like that, we needed—in the case of one of the first reasons we went to space—to see

over the horizon. And when you're talking about potential adversaries or potential hostile states—at that time the Soviet Union—you have a lot of denied areas. You have a lot of areas where you're not going to be able to fly an aircraft or place a radar. You have a lot of areas where you're not going to be able to do the surveillance and verification you'd need to assure both your own civilian or political population, as well as allies, what the level of security was. So, I don't think that that is fundamentally any different than why, say, the UK or Australia or Canada or any other very strong partners of ours is interested in space, because they recognize that adversaries or potential adversaries or just nations in general don't want you flying over their territory or basing terrestrial-based surveillance systems. If you want to provide some level of security as to the intent and capability sets of potential security challenges on the horizon, you're going to need a way to get that information—space provides a way to do that and has historically been relatively secure from adversary influence or denial.

As you can see, the most visible manifestation now, certainly commercially, is in remote sensing and navigation to communicate and navigate over the horizon. The Europeans obviously have their own global positioning or position navigation and timing efforts that they're pursuing. The Russians have theirs. The Chinese have theirs. The need to provide the ability for not just people in their Armed Forces, but for everybody for commercial civil use as well as national security missions. Hence, the requirement to be able to navigate and move over the horizon drives you into certain areas of operation or new domains, and those tend to be, like I said, remote sensing and satellite communications. You're not going to be able to string fiber and wire everywhere across the globe—there's, number one, security reasons why people wouldn't let you do that, but also it just doesn't make sense monetarily. Therefore, actors tend to go to space to ensure global communications as well. So, as you can see, I don't think that those space mission sets we have pursued over the past 60+ years have fundamentally changed really.

In the Defense Department, we typically lump those mission sets from a national security perspective under the term “force enhancement.” That those capability sets (intelligence, surveillance and reconnaissance; position navigation and timing for GPS; military satellite communications; etc.) allow our military forces, our national security forces, to fight better. What do I mean when I say fight better? Well, right now, and this may be up to debate to some, but from my experience it's not, the United States in particular is able to see more, fight more accurately, fight quicker, and fight with fewer casualties than we ever have been—meaning fewer casualties for us as well as fewer casualties from collateral damage. And the principle reasons we're able to do this so effectively are the capabilities I just described to you that we derive from space. We know where the adversaries are. We can mass quickly if needed. We can communicate over the horizon and fight in large formations on a scale that, frankly, nobody has ever seen before. We can do all of this so efficiently that our decision loop for targeting is often inside a potential adversary's decision loop, and we can assess how we've done and ensure we minimize civilian casualties as well as threats to US forces or allied forces on a level that we have never been on before. That's why the focus in recent years has been so much on protecting our space capabilities in the United States.

Over the past 25 years since Desert Storm, when we first really started to see this in earnest, adversaries have started to seek the ability to 1) obtain their own capability to do what the US is doing and 2) look to deny that competitive advantage that the US or allies have if a security challenge arises.

So, if you look at any of those nation states that you have listed in your question, I bet you they want to be able to communicate over the horizon. I bet you they'd want to have, from a security standpoint, indications and warning of threatened to their state because, ultimately, they have a lot of security concerns. Maybe they have adversaries or potential adversaries in their region contesting, or at least concerned about, airspace in the ocean areas off their coast. Those are all things that they're interested in, so I imagine the things that they want to derive from space are

those same capability sets that anybody does. From a military standpoint, you say they want to: see, shoot, move, and communicate over the horizon. But if you're a civilian, obviously, it's not necessary to shoot over the horizon, instead those other capability steps are fundamental reasons for their interest in space, and certain things have developed certain levels of expertise. I think you can see that these other actors are able to invest in certain aspects of that to allow them to be pre-eminent, in some sense, or at least globally competitive.

For example, some British firms are really good at building small satellites. As technologies have improved, and as the need for bigger sensor and/or communications packages has been reduced to smaller requirements, you start to see things like Surrey Satellite Technology, which is an example of a whole lot of capability in a very small satellite. Different states or different companies have different strengths that certainly play to the base that they have, typically within their own government, but on an international scale they can certainly sell those to anybody.

Interviewer: [Q2] At a more country-specific level, how do these countries' space interests and investments differ in comparison to each other? What are the key differentiators between these countries' interests and investments in the space realm?

Col D. Miller: I don't know that I'm capable of answering that question for any other country. Though, I think, obviously, a lot goes into that—each of these countries has to make its own very specific calculations. Undoubtedly, factors like geography, the environment, and the country's specific neighbors are important. Certainly, the country's history matters as well—what has happened and the country's perspective on things is driven by that history.

Ultimately, a country's interests will drive what it incentivizes within its own commercial or civil industries in order to support its specific development efforts. I don't think this general process is different for any particular nation, but it certainly explains maybe why a given nation or a consortium of nations would invest in certain things versus others.

Interviewer: [Q2] Okay. So, are there any glaringly obvious differences in the types of things, materials, and/or activities that some of these countries have been investing in or focusing on in the space domain?

Col D. Miller: Of late, I think there's pretty good documented unclassified evidence—and you could look at the reports of the Defense Intelligence Agency or the Department of Defense releases for more details—that the Russians and the Chinese have invested heavily in all of those force enhancement capabilities that I described to you earlier. Whether it's remote sensing, navigation and timing, communications, etc., both Russia and China have been investing heavily in order to improve their military capabilities. Russia and China are doing so for different reasons, because they're at different stages in their development, but they've invested certainly heavily in those.

China and Russia have also invested heavily, particularly lately in the last decade or so, in counter-space capabilities. So, China and Russia are investing in the capability to deny, disrupt, defeat, degrade US or allied space capabilities, in particular, in an effort to deny us the advantage that we would have if we ever got into a security challenge or security problem. There's pretty good documented evidence to support this—in particular, there's a recent Russian military power report that either the DIA or the DoD produced in the last couple months, and there's an annual report we do on the PRC. A lot of Russia's and China's capability sets are linked between both space and cyber, so you'll see commonalities in their investment portfolios.

In terms of our allies, it's no secret that we have partnered with allies to invest in certain capability sets. We've partnered with some allies for investments in satellite communications, for example. Australians have made investments in things like wide-band global satellite communications.

We, as the United States military, look to ensure interoperability of our military weapons systems with our allies. So, it's not a very good coalition force if the equipment and capabilities can't talk

to each other. So, as we move forward with our NATO allies or others, we like to ensure that our capabilities are interoperable (i.e., the capability to process and receive remote sensing information, the capability to leverage different navigation and timing communications, etc.). Making sure that we are interoperable between ourselves and our allies is a priority for us—it's obviously on a different scale with different allies, but that's something that you'd want to do to bring a lot of credibility to the coalition or the allied military force you're trying to generate.

These are the types of investments that I've seen. But, like I said, I'm not super qualified to comment on something like where Japan's commercial space industry is going. I really can't do that. What you can see is a lot of nations that have the capability to launch satellite capabilities—the Japanese have the capability, the Indians have the capability, the French have the capability, etc. Likewise, the Russians and Chinese obviously have that capability as well. That's not a cheap enterprise—it depends on what you're trying to launch, but in general that is not a cheap enterprise—but having the capability to do your own launch and reconstitution if needed, or certainly generation of capability, is part of the consideration for classification as a "space faring nation" from a national security perspective.

Why does that matter? Well, in order to do that, you've made investments in launch vehicle delivery to orbit, typically ballistic missile technology or missile technology overall whether liquid or solid fuel; you've made investments in navigation; and you've made investments in technology for operations in orbit, batteries, etc., and you've made investments in ground infrastructure and launch range capability.

So, there's industries that all support nations that operate in, through, and from space, and in order to sustain yourself as a credible nation state doing that, you'd need investments in all those industries.

Interviewer: [Q2] So, beyond the US cooperation with its partners and allies in the space domain, are any of these other countries working together with each other, or maybe not directly working together but sort of cooperating indirectly, to expand capabilities and capacity in pursuit of space interests?

Col D. Miller: Well, it sure seems widely reported that the European Union and the European Space Agency obviously consolidate investments from Western European nations, right? Their efforts focused on their version of the global positioning system or weather satellites and things like that. This is obviously an example of cooperation that we've seen, and this cooperation is over and above whatever other cooperation the EU and European Space Agency have had individually with different allied nations—in particular, US allied nations.

In terms of other nation states, I'm not sure to what extent they're cooperating from a space perspective. There are certainly recent indicators of military cooperation. Whether it's a recent reporting of the Russian and Chinese exercises or others that would make you assume that there is some level of cooperation if for nothing else from a communications perspective. But I don't have any evidence of that and I certainly couldn't speak to it. You'd have to assume that though—if you don't have cooperation or the capability to talk over the horizon, you're a force that's limited to 12 miles in contact. So, you've got to assume that there's some way for them to communicate. Right now, we take advantage of and almost take for granted the wide proliferation of civil and commercial capability that can be leveraged for some of those communications. But still, they're still space communications and we still need them.

Interviewer: [Q2] If you were to envision a spectrum of state space capability and capacity, how do you see various space-faring countries being positioned on the spectrum? The US is clearly at the top of this spectrum, but how would other countries be broken down across the spectrum? Additionally, with the advances in technology seemingly lowering the barriers to entry and barriers to compete in the space domain, is the gap between the US and everyone else on the

spectrum beginning to decrease? If so, what countries do you see as being at the forefront of that second wave leading the charge in closing the gap between the US and everyone else?

Col D. Miller: Well, I don't have specific numbers or figures on investment trends to say which nations are ramping up or not.

I guess my perspective on this question—and it's just my perspective—is that it certainly seems like, based off of what we are seeing, that there is substantial investment being made on the part of some nations, the Russians and Chinese in particular, to advance their military space programs. This advancement is evident given increased investment levels, but also given efforts to reorganize their military forces. The development of technology is not just a force enhancement, but also an enhancement to the capabilities required for countering US space capabilities. Those are two areas that seem to be receiving substantial investments that we know about and have been well-reported at the unclassified level over the past 4 or 5 years.

I can't really speak to trends of other allies. I think we seem to rely on and incorporate our allied partners in both development as well as operation of space capabilities, and if it were up to me this would be strengthened. For example, I'd like more allied Air Force personnel operating space based infrared systems, etc. I'd like more coordination with Australia, the United Kingdom, Canada, and other allies. And I think those discussions will be underway, if they're not already, about what that force needs to look like for the future. This is a natural part of our alliance.

I don't foresee any significant drop, if that's the question, in allied participation. I don't see any evidence of that. In fact, I would see that actually to be growing. If you look at the space situational awareness data-sharing relationships that the USSTRATCOM has made between France and Germany and so on, I think you'd see that they are trying to expand those partnerships with like-minded nations to ensure that we have a responsible use of space for everybody and that we minimize any risk of conflict where possible through strengthened alliances and cooperation.

Interviewer: [Q2 indirectly] Okay great. I promised you that this discussion would only be 30-minutes and we are approaching that half-hour mark right now. So, I just want to conclude by asking one last general question. Is there anything that I haven't asked you that you think I should have? Or is there any final point that you'd like to conclude with as closing remarks?

Col D. Miller: I guess the only point I would add is one to help provide some additional context. There's been a lot of interest lately in having discussions about 1) what trends we're seeing in terms of space, 2) the implications of those trends to US national security, and 3) what the US needs to do in order to ensure that it maintain a competitive advantage for the American men and women who are in uniform.

Several years ago there was a lot of hesitation to talk about space as a war fighting domain. In fact, I think you'd probably hear from some leaders that they probably couldn't even use that terminology some years ago. And I don't think at all that the Department or the Air Force, in particular, is looking for conflict in space, but my concern after doing this business now for 24-years is that I don't know that the American people or even some in the military appreciate the unique advantage that they derive from space. This advantage simply cannot be provided by terrestrial means—there's no aircraft that's going to replace space because there are denied areas and there's no radar or suite of radars that's going to be close enough to replace the capabilities you have from space, particularly in terms of geospatial accuracy over the horizon. All of these systems need to be developed to be complementary....all are necessary and neither alone is sufficient.

So, if you value the speed, precision, and force protection, as well as the limitation in casualties that we derive from space, then you need to make investments in order to protect and defend it. I think the sooner we start to have that discussion about what that needs to be and to what

extent we want to do that, which I think needs to be a national discussion, not just a military discussion, I think the better off we will be. There is only so much that we're going to be able to protect and defend with the current architecture and environment that we have right now. A lot of these systems are years to acquisition cycles. It has been 20-years since I first came here to Buckley Air Force Base as a Captain, but it's the same weapons system that we were acquiring then that is being fielded now. It is capable and needs upgrades, but it's basically the same thing. The assumptions about the need to protect and defend at that time were minimal to none. It was largely a "benign environment."

So, as you get to your report and start focusing on those questions, I think that there needs to be a sort of strategic level discussion on what is the advantage that the US derives from space? And how much do you value that? Let's end the confusion and have a discussion on whether it can be replaced or what other mitigation strategies can be put in place, and then make a determination of where we need to go in the future. But we can't keep studying this and debating it for the reasons I tried to describe to you today at the unclassified level. The pace of development for counter-space activity is significant and if we don't get our act together quick enough, my concern is that if it does come time for a conflict—frankly, we're already in levels of small, but persistent conflict everywhere—then some of the things that I described to you before just may not be there on a scale that they are today. And the ultimate end state cost of not having that advantage we derive from space is, to put it plainly...casualties, period. That's what it is. Either civilian casualties or US forces. So, I think that we really need to start having that discussion about what the advantage you derive from space is and how much we want to protect it in the future.

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WRITTEN RESPONSE

The Military/Commercial Nexus of the Chinese Space Programme

Abstract

The scope of this paper is limited. It will explore how China's space operations are conceived, outline some civilian and military activities, and examine whether there are differences in these programmes during peacetime and conflict. The authors believe that China's space agencies and strategic ambition cannot be reduced to those of the People's Liberation Army (PLA), and that achieving scientific 'firsts' is part and parcel of China's strategic vision as a global power. However, Chinese activities carry challenges for the United States (US), chiefly in technological advancements that can be utilised toward C4ISR dominance. Despite this real challenge, China also has legitimate research and scientific interests in space, for which it has found international partners who are ready to collaborate.

Key Points

- The US must understand and monitor Chinese space policy through the prism of wider PLA reform and modernisation.
- Greater understanding is needed of non-kinetic threats in space, which China continues to develop.

- The US should take note that Chinese space policy is not singularly premised on PLA ambitions, but also has legitimate scientific interests. These will have secondary effects on China's soft-power (e.g. replacing GPS with BDS).
- China will continue to work with international partners. The US may do well to consider re-examining the current ban on collaboration with China, or risk exclusion from future initiatives.
- The US should focus on leading the discussion on Outer Space Treaty reform, reclaiming its leading role in international space cooperation.

Introduction

The publication in December 2016 of China's Space White Paper⁴⁰ by the State Council, the country's chief administrative authority, shed light on Beijing's space policies. It outlined China's achievements and offered a five-year outlook on future activities. In doing so, it also raised key questions regarding its role as a space power, as well as how it viewed peaceful space exploration versus its securitisation.

The scope of this paper is limited. It will explore how space operations are conceived, outline some civilian and military activities, and examine whether there are differences in these programmes during peacetime and conflict. The authors believe that China's space agencies and strategic ambition cannot be reduced to those of the People's Liberation Army (PLA), and that achieving scientific 'firsts' is part and parcel of China's strategic vision as a global power. However, Chinese activities carry challenges for the United States (US), chiefly in technological advancements that can be utilised toward C4ISR dominance.

How Space Operations are Conceived

Since its first satellite launch in 1970, China has become a major player in the space domain and significant resources have been allocated to narrowing the capability gap between China and the US. China's actions are often rooted in a long-term strategic vision that requires programmatic planning and a supporting organisational structure.

Space Policy

There is likely a Leading Small Group (LSG) on Space that provides a consultative framework for the development of space policy.⁴¹ LSGs help streamline thinking across Party, Government and Military leadership.⁴² The members of the SLG are likely to be senior officials of the CCP, the PLA, and the government, including relevant ministries (e.g. Foreign Affairs; Industry and Information Technology; Finance).⁴³ The State Council (hereafter SC), has ultimate authority given its funding portfolio and also issues the 5-year space plan (Space White Paper).

Space Agencies: Industry, International Cooperation

The structure of actors quickly descends into a maze of organisations. Within the SC, the State Administration on Science, Technology and Industry for National Defence (SASTIND), which is subordinate to the Ministry of Industry and Information Technology (MIIT), coordinates and manages China's space activities (defence and aerospace industry) through development, procurement and supply. It also issues space and defence industry regulations and monitors their implementation, and is charged with R&D funding allocation.

Within SASTIND lies the China National Space Administration (CNSA), which formally defines national space policies, administers the civilian space programmes and manages the development of national space science, technology and industry. It also serves as the international face of China's space programme and works with foreign space agencies. The China Aerospace Science and Technology Corporation (CASC), composed of multiple research institutes and their subsidiaries, focuses on the "research, design, manufacture and launch of space systems such as launch vehicles, satellites and manned spaceships as well as strategic and tactical missiles, and

⁴⁰ http://english.gov.cn/archive/white_paper/2016/12/28/content_281475527159496.htm

⁴¹ Aliberti, M. (2015). *When China Goes to the Moon...* Springer International Publishing.

⁴² Jessica Batke and Matthias Stepan, "Party, State and Individual Leaders: The Who's Who of China's Leading Small Groups", MERICS, <https://www.merics.org/en/merics-analysis/china-mapping/the-whos-who-of-chinas-leading-small-groups/>

⁴³ Aliberti, M. (2015). *When China Goes to the Moon...* Springer International Publishing. p. 9

also provides international commercial satellite launch service”.⁴⁴ In 1999, the China Aerospace Science Industry Corporation (CASIC) was created as an off-shoot of CASC. CASIC is a state-owned and state-funded entity composed of five research institutes, two research and production bases, six publicly listed companies, and over 620 enterprises.⁴⁵ It focuses on missile development and aerospace products, which include the design and building of satellites and guidance systems.⁴⁶

The PLA and Space

Space forms a vital part of the PLA’s holistic approach to offensive and defensive military strategy. This is reflected in Xi Jinping’s organisational reform of the PLA, a process that was endorsed in 2013 at the 18th Party Congress, and kicked-off in 2015 with an aim to be completed by 2020.

The 2015 Defence White Paper termed outer space a “commanding height for international strategic competition”, for which China seeks to develop what President Xi Jinping called “a new-type combat force”.⁴⁷ The objective is to transform the PLA into a modern force capable of information dominance through fighting and winning “informationised local wars”, or “regional conflicts defined by real-time, data-networked command”.⁴⁸ The Central Military Commission (CMC) reorganisation included the creation of the Strategic Support Force (SSF), bringing together space, cyber and electronic warfare (EW) capabilities by unifying units formerly scattered across the former General Armaments Department (GAD) and the General Staff Department (GSD).

The organisational streamlining of space, cyber and EW commands reflects the nexus upon which modern Chinese warfare will rely; namely, C4ISR (Command, control, communications, computers, intelligence, surveillance, and reconnaissance). Herein lies China’s greatest strategic asset and weakness. The PLA therefore seeks information dominance capabilities in space, while developing capabilities to deny or degrade the capabilities of others.

Examples of Chinese Space Operations and Services

Military

The PLA has been testing numerous military space-based and land-based space technologies. In January 2007, China successfully tested a ground-launched direct ascent anti-satellite (ASAT) weapon system against a defunct FY-1C weather satellite in high-orbit. The test was unprecedented and drew widespread criticism for its creation of space debris. Nevertheless, this ASAT test indicated that Beijing sought and tested technology that in wartime could be used against satellites of adversaries.

Other ASAT technology includes co-orbital systems that are prepositioned in space and could manoeuvre to neutralise other satellite systems. In July 2013, China launched a rocket carrying three satellites (CX-3, Shiyang-7 (SY 7), SJ-15), one of which is equipped with a robotic arm. As Anthony Cordesman notes, non-kinetic co-orbital satellites have the advantage of being less likely to entail uncontrolled escalation and debris creation, and can pass as dual-use vehicles.⁴⁹ Microsats are in this sense equally an area to watch.

Further technological advancements are being made in the area of ‘soft-kill’ neutralising technology in a bid to advance and defend its own C4ISR capabilities, while diminishing that of others. US Department of Defence reports have noted that China has been developing directed-energy weapons, such as lasers and high-powered microwaves, as well as radio-frequency weapons that could be used to jam communications systems. These systems could be employed on missiles, ground-based and space-based assets.

⁴⁴ <http://english.spacechina.com/n16421/n17138/n17229/c127066/content.html>

⁴⁵ <http://english.casic.cn/n189298/n189314/index.html>

⁴⁶ <http://www.nti.org/learn/facilities/63/>

⁴⁷ <http://www.reuters.com/article/us-china-military-idUSKCN0V714B>

⁴⁸ Office of the Secretary of Defence (2017), *Annual Report to Congress: Military and Security Developments Involving the People’s Republic of China*.

⁴⁹ Anthony H. Cordesman, “Chinese Space Strategy and Developments”, CSIS Working Draft Paper (2016), p. 25. See: https://csis-prod.s3.amazonaws.com/s3fs-public/publication/160819_Chinese_Space_Strategy_Developments.pdf

Another area which warrants further consideration is the possibility of intercepting satellites through the open microwave antenna, thereby potentially seizing command and control, as well as accessing their information (such as imagery).⁵⁰

Civilian/Commercial

China desires to position itself as a great power that is at the forefront of humanity's exploration of space. Indeed, future activities listed in the Space White Paper included missions to the Moon and Mars, asteroid exploration/exploitation, and a variety of scientific missions, the creation of the global BeiDou Navigation Satellite System (BDS) to rival GPS⁵¹, as well as assessing the implications of space debris and utilising the increasing range of satellite applications.

A key development was the June 2016 inauguration of a new launch site on Hainan Island. The Wenchang site, China's 'Cape Canaveral', was the origin of the debuts of both the Long March 7 and Long March 5 rockets. Closer to the Equator, it is more suitable for reaching geostationary orbit and is also accessible for sea transportation of rocket stages and payloads. However, this location is also representative of China's non-military space operations and includes plans to increase tourism, which suggests that China is actively attempting to open up its commercial space activities.

A keystone scientific experiment is the 2016 Micius satellite⁵², a Chinese and Austrian joint endeavour, to test the use of quantum key distribution by using the properties of entangled photons to transmit a key that cannot be cracked. On 10 August 2017, the Micius sent the first ever 'hack-proof' messages to Earth⁵³, paving the way for an un-hackable communications network. These same properties also mean that any attempt to intercept or decode a transmission will be noticed. While the Chinese lead researcher noted that the mission had "started a worldwide quantum space race"⁵⁴, the future application of this technology extends beyond national security and includes a global quantum internet with commercial benefits to a range of stakeholders.

Like on Micius, China continues to collaborate with foreign countries. A recent experiment designed to test the effects of space radiation on DNA reached the International Space Station (ISS) in June 2017 aboard a Dragon cargo spacecraft, and is the first Chinese experiment to do so. Operating through the private company NanoRacks, rather than NASA, ensured sanctions compliance as no technology was transferred between NASA and China. These experiments potentially open the door to further cooperation with the US and others in areas of mutual benefit. They also point to the blurred lines that result from the increased partnerships between national space programmes and commercial space satellite manufacturers and launch providers.

Transformation of technological assets from peacetime to conflict: Implications for the US

The rate of development of China in its uses of space points toward the acceleration in its capabilities, with civilian and military implications. Indeed, as a 2015 report by the US-China Economic and Security Review Commission stated, "Chinese analysts assess that the employment of space-based C4ISR capabilities by potential adversaries, especially the United States, require the PLA to develop capabilities to attack space systems".⁵⁵ China's increasing presence in space will impact how the US utilises the space domain, however, this scenario carries both challenges and potential opportunities for US space policy.

Opportunities

Firstly, for all of China's advances it still lags behind US capabilities; case in point is the July 2017 Long March 5 rocket launch failure, and the potential knock-on effects to the Chang'e lunar mission and overall launch

⁵⁰ https://csis-prod.s3.amazonaws.com/s3fs-public/publication/160819_Chinese_Space_Strategy_Developments.pdf

⁵¹ http://english.gov.cn/archive/white_paper/2016/06/17/content_281475373666770.htm

⁵² See: <http://www.bbc.co.uk/news/world-asia-china-37091833>

⁵³ <http://www.bbc.co.uk/news/technology-40885723>

⁵⁴ <http://www.bbc.co.uk/news/science-environment-40294795>

⁵⁵ US-China Economic and Security Review Commission (2015), 'China Dream, Space Dream: China's Progress in Space Technologies and Implications for the United States', p. 8. See: https://www.uscc.gov/sites/default/files/Research/China%20Dream%20Space%20Dream_Report.pdf

programme. Moreover, while China has made strides in manned spaceflight, its practical experience remains limited.

This capability gap, coupled with declarations by the new US Administration over greater prioritisation of space policy,⁵⁶ offers the government (NASA and the military) and commercial (particularly those private enterprises that hold government contracts) sector the opportunity to take advantage of a favourable policy and regulatory environment and continue to play a leading role in space.

Secondly, while China has sought to promote greater innovation in the commercial domain, it remains to be seen to what extent it will attempt to break into this market, both in terms of providing launch facilities and its own use of commercial technologies. Companies around the world, including in China, are seeking to capitalise on the global space industry's predicted worth of US\$640 billion by 2030⁵⁷. Decreasing production costs of, for example, CubeSats allow for more actors to access space. Nevertheless, the US remains at the forefront for launch developments for these satellites and more traditional heavy payloads, as was exemplified through the SpaceX breakthroughs in reusable launch capabilities which lower the cost of launches (highlighted by its new contract with the US Air Force to launch the X-37B spaceplane). Domestically, indigenous US companies are still best placed to be contracted by the US military, and countries lacking launch capabilities will continue to see the US as a key launch service provider along with China, India and Russia. Russia has long been a major launch service provider and there is little evidence it does not intend to carry on in this guise, as highlighted by its launch in July 2017 of 73 satellites on a single rocket⁵⁸, and its recent launch of a US satellite⁵⁹. However, 2016 was the first year since 2004 that Russia did not hold the top spot in number of launches globally, falling behind both the US and China, who jointly led the standings⁶⁰. Similarly, despite being the only country that regularly launches humans into space, the Russian national space programme has increasingly been met with trouble.⁶¹

Finally, the US must capitalise on its history of international space cooperation, and potentially re-examine its ban on cooperation with China. The growing collaboration between China and other space actors through political and scientific partnerships will be essential for the development of policies and technologies that address shared challenges, such as orbital debris, that are currently not addressed in international regulations.

This creates an opportunity for the US to take a leadership role in future negotiations on international regulatory frameworks on space. Including China in such work not only positions the US at the forefront of negotiations, but can also help ensure that any Chinese developments do not adversely affect US space assets.

Challenges

China's technological advancements that carry dual-use capabilities pose a potential threat. The utility of a satellite equipped with a grappling arm to remove space debris, under the auspices of China acting as a responsible global power is obvious. But the ability to remove an adversary's assets in space during times of tension would not be unimaginable. Such a scenario can be likened to the case of China, acting 'for the sake of international safety', capturing a US UAV/underwater drone in the South China Sea.⁶² Such an event, if seen in space, would lead to questions over attribution and intent. For example, if a Chinese satellite were to remove another state's functioning satellite from orbit as the result of an outward attempt to clear a potentially dangerous piece of equipment, this could be seen as an act of aggression. Without a proper regulatory framework over conduct in space, both the securitisation of space and the destabilisation of nations' C4ISR capabilities on Earth is a growing reality.

China's international cooperation within the space sector poses a second challenge. As China moves forward in a number of key technological areas, this could have implications on preferential partnerships being made with

⁵⁶ <http://www.cbsnews.com/news/pence-vows-to-make-space-great-again/>

⁵⁷ Jamie Reed, presentation to the UK Space 2017 Conference, Manchester, 30 May 2017

⁵⁸ <http://spacenews.com/soyuz-launches-73-satellites/>

⁵⁹ http://news.xinhuanet.com/english/2017-06/08/c_136350780.htm

⁶⁰ <http://spaceflight101.com/2016-space-launch-statistics/>

⁶¹ http://www.slate.com/articles/technology/future_tense/2017/03/russia_s_space_program_is_in_trouble.html

⁶² <http://www.aljazeera.com/news/2016/12/china-negotiations-seized-underwater-drone-161217135305893.html>

China over the US. Similarly, the refusal of the US to work with China could potentially lead to future exclusion from international partnerships that work towards confronting global challenges faced by all parties. This is as much a challenge to US public diplomacy and soft power as a leader in science and technology, as it is to the US benefitting from the resulting technologies. Furthermore, with a potential decommissioning of the ISS, the future of a single Chinese-built space station may necessitate international cooperation with Beijing in space.

Finally, Chinese leadership in technological advancements (quantum communication) and rival technology (BDS versus GPS), are cornerstones of Chinese public diplomacy and soft power. While the US has historically held a leading position as the international frontrunner in science and space, it is clear that China is capitalising on its space programme as part of its narrative of a global power.

Final Assessment

The ambitious nature of China's space programme, both in military and commercial terms, should not be underestimated. The challenge to US supremacy in the space domain is growing. While China certainly has legitimate objectives in space that are unrelated to defence, the potential for dual-use technology poses a clear challenge for the US. However, caution is needed when assessing the extent to which this will inhibit US use of space. In times of peace, China is seen to be developing its civilian and military technology. Although ASAT tests and dual-use technology could be aimed at degrading US assets in space and on Earth, their outright use would cause severe harm to the soft power that China currently seeks to amass as a rising global peaceful power. The most likely threat therefore comes through soft-kill technologies and the cyber domain, which seek to degrade US C4ISR capabilities on Earth.

Furthermore, it should not be forgotten that China's space assets face the same threats, such as extreme space weather and debris, as all other space users. Many of these hazards can only be mitigated through international cooperation and the agreed need to protect space as a global commons, a view that China likely shares. Working with China on regulating space beyond the existing Outer Space Treaty will be essential to shaping the future leadership role of the US in space.

This year marks the 50th anniversary of the Outer Space Treaty, leading many of its signatories, and other space actors, to question its efficacy and relevance. Since its establishment, the number of space actors and industry sectors has hugely increased, deepening the level of reliance on space activities. This has introduced a wider set of questions regarding space usage that were not applicable when only the US and Russia were active participants, including aspects of law relating to technology and the exploitation of space (e.g. asteroid mining). It is vital that any update to the Treaty ensures these issues are taken into account and continues to guarantee that all signatories uphold its principles to prevent conflict and promote peaceful space exploration. Given that any future conflict between great powers will likely include a space element, the US can prepare and should continue to monitor the space policy of China and place emphasis on its own technological capabilities. However, ultimately, it must not lose sight of the importance of its leadership position in the international political arena. Retaining American soft power and leadership in space will be as essential as its technological capabilities in meeting China's growing role in space.

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WRITTEN RESPONSE

Israel

Israel has a long tradition of space activity developing, operating and launching satellites into space. As a small country, **Israel enhances its power through space in ways otherwise not possible**. This opportunity is accompanied by significant challenges, especially in maintaining the qualitative gap and preserving Israel's position

at the forefront of technology, as well as securing the space environment. The significance of space in Israel's strategic conception shapes Israel's perspective on space security.

Having an indigenous national space capability is part of Israel's national security strategy. As a traditional space-faring nation and **a sophisticated producer and user of space technologies and applications**, Israel attributes great importance to securing the space environment for peaceful uses for all nations.

Looking back thirty years, the overall space activity of Israel is much broader than national security activity. In the 1990s Israel commercialized its space activity. It has a robust commercial space industry, alongside a strong scientific sector.

Israel's approach towards space and space security emerges primarily from its position in the regional and global systems. As a small and threatened country, Israel strives to secure and assure its national security, as well as achieve a lofty position, especially in its region.

Israel's need to relate to a broad circle of states which surround it, beyond its immediate neighbors, and its national and security interests demand an orientation towards space. As a small country, Israel suffers from an acute lack of resources. For these reasons, the country manifests **a pragmatic approach to space power, aimed to satisfy national security needs**. Generally, these consist of the capability to reach distant threats from an intelligence and operational point of view. This mainly involves early warning, intelligence, deterrence, and self-reliance in advanced technologies.

National space capabilities and infrastructure for military and civilian applications are perceived as force multipliers boosting Israel's technological advantage, which allows it to enhance military capabilities. These capabilities also contribute to a number of non-military fields. This, in turn, enables the country to increase its level of national security and strengthen its status in the region. Hence, a strong state-of-the-art space program is highly important to Israel's national security. Nonetheless, **Israel's limited resources dictate that it must concentrate on those fields that are critical**. Therefore, Israel seeks a presence in space and regional dominance in space in niche areas: Earth Observation (i.e. lightweight satellites, high resolution electro-optic and SAR), low-Earth orbit (LEO) launch capability, and Communications. Israel does not undertake to build all systems entirely on its own. It has, for example, no navigation or weather systems, and has no manned mission, etc. However, Israel seeks to cooperate with international partners on projects of this nature, as well as scientific projects.

Israel's narrow borders constitute a lack of strategic depth, and have posed existential threats which necessitated a search for solutions to avoid the elements of strategic surprise and sudden attack. For these reasons, Israel's security doctrine demands advanced intelligence capabilities for early warning; as well as combat capabilities for a rapid transfer of battle away from Israel's population centers to enemy territory. **The orientation towards space assists Israel in coping with the challenges presented by the lack of strategic depth.**

Satellite-derived intelligence information is considered to be a great equalizer in strategic terms, because it increases transparency among states and diminishes the sense of uncertainty, thus reducing the risk of surprise. In Israel's strategic thinking the Israeli space program is recognized as a critical component of its independent intelligence capability. The issue of Israel's **self sufficiency** is a complex one. Israel is far from being totally self-reliant; it depends on American political support in international forum and economic aid. Nevertheless, in the field of intelligence, Israel has a great deal of autonomy.

Israel perceives space as a global commons and therefore aspires to contribute to a secure and sustainable space environment. Israel acknowledges the worldwide use of space for supporting terrestrial military activity, as well as defending, and deterring harmful actions, against space systems. Nevertheless, it seeks greater international collaboration and cooperation, especially among democratic space-faring nations, in maintaining space as a peaceful environment for the benefit of all.

Israel enjoys and suffers from a growing reliance on space systems for its critical national infrastructure. For this reason, it is concerned about the growing global trend of space militarization. Such threats, if realized, could lead to Israel losing its current relative advantages in the realm of space. Therefore, **Israel is looking for ways to protect its satellites and achieve a sustainable space environment.**

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8 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: [Q2] Okay. Great. So, let's move on to the main question that I was hoping we could focus on, which is about how other actors conceive of space operations for both military and commercial purposes. So, how do you see other actors, like China, as conceiving of their space operations for military and commercial purposes? And, as you can see, the question lists a number of countries to address but, given your expertise, please feel free to focus on China and maybe any other country you're comfortable with speaking to.

K. Pollpeter: Sure. My comments here will be limited to China. So, I think, broadly speaking, China has a space program to increase what it calls its comprehensive national power. So, this is sort of the basket of everything that makes a country powerful: its military might, its economic power, its diplomatic power, its cultural power. The Chinese are really big on assigning numbers to each of these categories and in ranking countries and things like that, and this is a very sort of subjective way of approaching things but generally when the Chinese look at their space program, they try and justify a certain space program—whether it's their satellite navigation system (BeiDou) or human space flight or lunar exploration, what have you—by trying to check the boxes for all aspects of comprehensive national power.

So, in that sense, the Chinese try to have their space program hit on all cylinders—they want to sort of work towards something so that it's not just a purely military effort and it's not purely commercial effort, but you'll see a lot of things combined to achieve multiple objectives. Here you'll get to one big difference between US and China, which is that the Chinese space program is inherently dual use. It's a military and civilian program in one. They don't have a NASA that is a purely civilian organization. There is no separation.

So, when the Chinese go to build some sort of space system, it's within the mind that it will serve multiple uses (i.e., military and civilian), if possible. Of course, there's always going to be some outliers (i.e. Mars exploration will probably have less military use than another satellite), but going into it, it's always thought of as sort of this dual use program where one satellite will serve multiple applications. Where in the US, we may have certain satellites that are civilian-focused or commercial-focused, in China it's very much centered on this dual use system, and I think part of that is because in a world of limited resources and technological know-how and engineering talent, it makes sense not to divide up your R&D capabilities like that because then you're going to end up shorting either the civilian side or the military side—keeping it together makes a lot more sense for the Chinese.

Interviewer: [Q2] Okay. So, you mentioned an overriding Chinese ambition to increase national power, and it seems like the focus and action of anything China does regarding space is focused around increasing Chinese national power. So, I'm wondering, what sort of specific actions has China

taken regarding in relation to the space domain and space capability that have been most effective in sort of achieving this objective of increasing Chinese national power?

K. Pollpeter: Oh, wow. It's hard to pin down any single one that has been the most dramatic. I mean, China's space program since 2000 has just basically hit on all cylinders. The only type of satellite that it doesn't have is a ballistic missile early warning satellite—though, there is some speculation in the Western press that they already have some but every time I try and track down where they got that from, it ends up at a dead end.

So, it's hard to pick out any one example. Certainly human space flight catches a lot of attention. It's a big engineering feat that the Chinese are able to send humans up into space, and they haven't lost anybody up in space yet. So, that goes to sort of the political aspect of it—the pride and prestige part of space power.

In the mid-1990s, China was really the poster boy for how not to do space launches, as they lost a number of launchers and satellites and nobody would place their satellites on a Chinese rocket. I think at one point, China was doing one launch a year. However, China has really turned around its launch capability—the Chinese are now doing 15-20 launches a year, they have a reliability rating now that is at international standards, and they have gone from just having a handful of satellites up in space to having I think close to around 200 satellites in space.

The Chinese went from having a very limited remote-sensing capability, to now having 5 types of remote-sensing satellites anywhere from I think about .72 meter resolution all the way up to 250 meter resolutions and they can do hyperspectral, electro-optical, multi-spectral, synthetic aperture radar, electronic intelligence, etc.

The Chinese also now have counter-space weapons to deny an adversary's use of space.

So, there are a lot of things that you can point to. I'm not sure there's any one real indicator—it goes almost across the board.

Please let me know if you want me to stop. If not, I can keep going.

Interviewer: [Q2] Please go ahead and continue.

K. Pollpeter: Okay. In a military sense, since the late 1990s China has been studying what we termed “network-centric warfare,” which was a concept put out by the Office of Force Transformation under Admiral Cebrowski back in the late 1990s. So, the Chinese did a lot of research on “network-centric warfare” and finally in 2015 it came out in their Defense white paper as “system-versus-system operations.” So, “system-versus-system operations” is a take on warfare where modern warfare like that fought by the United States is not fought on platform-versus-platform—rather, it's really a contest of systems versus the other guy's systems. And really what's driving this is the PLA, or the Chinese Communist Party I should say, have observed this coming on for some time and have realized that a ground war is no longer their main concern. They're no longer really concerned with the Russians coming over to the boarder. What they are more concerned about is what's happening out in the ocean with the US, and they stated that their main threats now are coming from the maritime domain.

So, in order to do that—in order to defend yourself from those maritime threats—you need the ability to conduct long-range strikes against an opponent's ships or against their bases. And if you need to do that, then you need some sort of C4ISR architecture to support those types of operations. So, if you look at, what does it take for China to locate, track, and target a US aircraft carrier? There are many different ways you can do this (e.g., over-the-horizon radar, aircraft, etc.), but you can certainly think of space as being useful in that regards. So, for example, let's say China was thinking about conducting missile strikes against Guam. You'd want to know where things are after you conduct the strikes, you want to do battle damage assessments, etc.

So, in effect, the PLA has realized what the US military has realized: that the farther from your shores you go, the more important space becomes.

Then, the other side of system-versus-system operations is that you need to be able to take out the other person's eyes and ears. So, this gets into asymmetric warfare aspects (i.e., area denial, anti-access area denial, etc.), but if you look in Chinese writings, they say that even if system-versus-system warfare is inherently asymmetric in that even if you have two countries that are of equal capability, the battle is not so much determined by the strengths of either side—rather, it's determined by their weaknesses and the ability to exploit those weaknesses. So, that's where things like counter-space weapons come into play.

Interviewer: [Q2] Okay. You mentioned that China is sort of firing on all cylinders with respect to the space domain, with maybe just a slight deficiency with respect ICBM defense and warning. So, if you were to look at China's overall investment with regard to the space domain and space activities, and if you were to think about this total investment broken down into a pie chart, would you see any sort of noticeable areas where they're investing significantly more or significant less than other areas, or is Chinese investment generally pretty even across the board of space-related investment areas?

K. Pollpeter: Sure. So, the Chinese budget is tremendously opaque. Estimates on the budget run anywhere from \$2 billion to about \$8 billion a year. Anyway you cut it up, they're not spending as much as the US, so it's really hard in budgetary terms to determine what may be a priority.

Policy-wise, what I've seen is that C4ISR satellites, remote-sensing communication, and these types of things are the priority. Something like human space flight and lunar exploration will rank second, and then third will be sort of more science-related assets (i.e., space weather, looking at the Sun, missions to Mars, etc.). And counter-space isn't even mentioned.

Interviewer: [Q2] Okay. So, I'm wondering what the relationship is like between the commercial space sector and government space sector in China. You noted the Chinese interest in dual use systems, so what kind of relationship does the Chinese government have with what we would technically classify as commercial space entities in China? And, are the Chinese space companies, which we might consider to be commercial entities in the US, independent actors, or are they all government-owned or partially government-owned?

K. Pollpeter: Yeah, so this is tricky. The tricky thing is that all the major players in China's space program are government-owned. There are two main state-owned enterprises that are involved in China's space program, and they're doing most of the work.

There are some others, though. There's this new ExPace company—who's name seems to be a play on SpaceX—that has been promoted as China's commercial launch company, but when you start scratching at the surface it seems to be the case that it's really government-owned.

So, a lot of what I've seen in China is not really commercial in the sense of the way that we think of commercial space—the companies are really government-owned or at least heavily invested in by the government. There is one company—the name is escaping me right now—that is associated with the Jilin series of satellites, which may be commercially operated but I'd have to take a closer look at that. But, regardless, by and large once you start scratching the surface, most of these Chinese companies are either owned by state-level corporations or provincial-level corporations.

There's this talk about leveraging—doing like the US has done to leverage commercial capabilities—but I have yet to see that happen in China in the way that we think of it here in the US.

Interviewer: [Q2] Yeah. That's sort of what we've been hearing. So, is China cooperating with any other countries in support of its space interest? And, I guess on the other side of the spectrum as well,

do any of China's space interests and ambitions openly conflict with any other specific countries that you can think of?

K. Pollpeter: So, China has had a longstanding relationship with Russia. Though, trying to find out exactly what they're doing is more difficult, maybe in part because I don't know Russian. But certainly in the Chinese press, you'll see that they'll sign memorandums of understanding in space cooperation but then it's never really fully revealed what they're doing.

China has also gone to Ukraine. I know China has been working on launch vehicle technologies with Ukraine.

China also has what seems like a growing cooperation with countries in Europe. Their space robotic arm has been developed in conjunction with Germany. The University of Strathclyde has been hosting Chinese researchers on space technologies. German astronauts are learning Chinese. France has been doing some work with China on space weather.

So, as China becomes more capable, these other countries in Europe—though, China has been cooperating with Russia and Ukraine for some time—are finding that they would like to do more cooperation with China. But, then also, it's also a way to curry favor with China—if certain countries are cooperating with them on sort of high prestige space technologies, it might open up the way for China to think more positively about certain countries and do more trade and investment with them.

What was the last part of your question about competition?

Interviewer: [Q2] On the other side of the spectrum, do any of China's space interests and ambitions openly conflict with any other specific countries that you can think of?

K. Pollpeter: I don't know if it's openly conflictual, except in the counter-space realm, which is obviously somewhat conflictual with the United States. But, in other areas, it's more about like Europe says, "Hey US, we still love you. We're still going to cooperate with you in space, but China's up and coming so we want to cooperate with the Chinese too." So, at what point does that become a zero-sum game? Is it going to be win-win-win for everybody, or does there come a point where countries only have so much money to spend, so they have to figure out who's the best partner. And, if maybe some of that money will be going towards China instead of the US, then how does the US react? So, in that sort of sense, it could eventually create conflicts or at least trouble for the United States.

Interviewer: [Q2] Okay. Great. So, I have just one last general question that we always conclude these interviews with. Is there anything that I haven't asked you that I should have, or is there any final point that you would like to conclude with?

K. Pollpeter: I think that I've hit most of the main points. China's coming on strong.

Though, one last thing, I guess, is that one thing that I'm not seeing is as China becomes more invested in space, what I'm not seeing in Chinese writings—now, maybe they're talking about it in Beijing and we just don't see it—is that it seems that they're not talking about something like, "Hey, as we become more invested in space, we're taking on some of the same vulnerabilities that the US has." So, in Chinese writing, we do see discussions about, "Hey, the US uses space for 80% of its communications and 70-90% of its remote-sensing for intelligence gathering. So, obviously for the US this is a great strength, but it's also a vulnerability, so if a conflict were to arise, it would be great if we could take it out." What you don't see then is the flipside, such as, "Hey, if we're building all these satellites and we're becoming more dependent on space, shouldn't we be thinking about doing things differently? What happens to us if there's a space war?"

There's just sort of this natural assumption that war will eventually go up into space, that things will just happen, and China will just fight through it. There's no talk about, "Hey, maybe we

should reconsider some of these things.” There’s nobody in the arms control community saying, “Hey, we’re taking on the same sort of vulnerabilities, maybe we should talk about some sort of code of conduct or something similar in space.”

And, in fact, both Russia and China have been really sort of opposed to a code of conduct in space. So, this really seems to be at odds with their self-interest, and its sort of interesting from the way I look at it that you don’t see this discussion happening in Chinese writings.

Interviewer: [Q2] How do you think an increased recognition of that vulnerability would impact Chinese action?

K. Pollpeter: Well, I would think that if you look at their counter-space capabilities, they look to be developing capabilities that go from the ground all the way up to your geosynchronous orbit. The testing of a capability that could knock out satellites up in GEO, that debris will be up there forever. So, it really seems to have gone past the deterrence aspect into sort of more of a war-fighting capability.

So, you would think that they would begin dialing back some of that but it doesn’t seem to be happening. You would think that they wouldn’t need to develop all these capabilities—maybe that they’d be going more after the soft sort of kills, or maybe that they would be concerned about, again, developing some sort of code of conduct rather than sticking to this arms control treaty that they’ve been cosponsoring with Russia, which has gone nowhere. So, this is all really interesting to me.

Victoria Samson

Washington Office Director (Secure World Foundation)
22 August 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: [Q2] That’s interesting. I didn’t know that a country like India doesn’t have a national space policy. So, this actually segues nicely into the next question I was hoping to ask you. This question has a lot of parts, but it’s about how US allies, partners, and adversaries conceive of space operations for military and commercial purposes. So, I’m wondering if you could talk about this, how do other actors conceive of their space operations both with respect to the military realm and the commercial realm? And, as you can see, this question lists out a number of countries to address, but feel free to focus in on whichever countries from that list you feel most well-suited and comfortable with speaking to.

V. Samson: Sure. Let me just start with India since I just brought it up. India went to space for developmental purposes. It was peaceful, or, I should say, non-military—peaceful use of space is another example of a contentious space term, because there isn’t a lot of agreement about whether it means non-aggressive or non-military. Either way, India was basically using space for civil, national development capabilities for decades.

But over the past decade or so, there have been a couple of changes. First, I think the Indian military has recognized that there are definite interests for them to utilize space, particularly since they have areas of conflict in mountainous regions where it’s difficult to communicate and do imagery otherwise. Space is pretty helpful for that. But also, like a lot of countries, India is very worried about China, and when China had its 2007 ASAT test, it was kind of a wakeup call for many actors, and India immediately thought, “okay, maybe we should have something as well.”

As an aside, India and China are really interesting. India is super interested in China, whereas China seems to be barely interested in India. That's a bit of an exaggeration, but I think in terms of security and space issues, India is not really on China's radar.

Anyways, India's space program is typically run through the Indian Space Research Organization (ISRO), which is a civilian entity, but more and more their Ministry of Defence (MoD) has been getting involved in space and satellites, and they actually have two national security satellites now out of about 24-26 total Indian satellites. And they're starting to have a lot of dual purpose type capabilities (e.g., an ISRO satellite provides services that the Indian military uses).

As well, India traditionally has not had a solid independent commercial space sector. They do have a commercial wing of ISRO that is called Antrix, and they're the ones that develop a lot of the commercial capabilities in India. But Antrix is funded by the Indian government, so it's not truly, I would argue, a commercial sector. Antrix just recently announced that they were going to start seeking subcontractors completely independent of the government, so I think India is slowly getting an independent commercial sector. India has a huge small satellite community and is really interested in the new space-type stuff—there is a lot of interesting technological research coming out of India these days.

And, like I said, India is finally gearing up to the fact that there are national security interests that they can have in space, so they need to figure out what sort of space capability they need. Additionally, India has a missile defense program that they've been working on for some time, and they're using it as a way in which to develop an anti-satellite capability without actually testing an anti-satellite weapon. Currently, there are tons of quotes from Indian officials—I think more for the domestic audience than anything else—saying, “look, India wants peace in space. India doesn't want a conflict in space, but if anything should happen, then we have an ASAT capability done and dusted.” I'd argue that this is probably optimistic on their part, but it is what it is.

So, it's interesting to see kind of how India's space operations have evolved over the past couple of years. But, like I said before, India doesn't have a national space policy. Supposedly, they've been working on one that's in draft form, but it's hard to get it through their government. India's Parliament doesn't really have committees like we have here in Congress. Indian Parliamentary efforts depend upon individual members to push things through, and I don't know that they have any strong supporters of getting a national space policy out. And I've been told by some military people that India actually likes not having a national space policy because it gives them a lot of room and flexibility to maneuver—if you haven't been told what to do, you could do whatever you want, right?

Interviewer: [Q2] Great. Can you talk about any of the other countries that are listed in this question?

V. Samson: Sure. Russia is interesting because, going back to the Cold War, the Soviet Union did not want to acknowledge any kind of commercial activity—they didn't want space to be used for commercial activities. I think this was largely because they felt that the United States would have a leg up on them because the United States could have US national space activities and then commercial activities, and that would kind of give us a leg up. When you look back to when the Outer Space Treaty was written, there were a lot of arguments over whether or not commercial activities should even be allowed in space. The United States was able to prevail on that issue, so that was a victory in our time. But that has changed because I think the Russians are looking at current circumstances and realizing that oil prices aren't what they used to be, so they need other outside sources of funding, and they've also had a few restrictions elsewhere due to other activities, so they're looking for new ways to use the space domain as a tool for making money.

ROSCOSMOS is weird because it was the Russian Space Agency, but then they shut it down and renamed it, and they also made a commercial sector also named ROSCOSMOS. Honestly, it's very hard to understand what the difference is, as well. I don't think the Russians actually have a

national space policy either. They have a couple competing documents, and I'm not sure which one is uppermost—a few years ago, I tried to actually track down what exactly Russia's national space policy is, and I had no success. I think that's kind of indicative of their confusion regarding where they want to go in space and where they want to go as a country. I always say that NASA kind of has a crisis because they don't really know what they're supposed to be doing or what the *raison d'être* is, but Russia's space program truly does not know what it's supposed to be doing—they're just kind of hanging on, hopefully not exploding too many rockets while they're doing it.

The one positive thing Russia has right now with respect to its space operations is that they're the ones taking people up to the International Space Station, and they have a lock on this. But, Russia is looking at other things regarding space operations. There has been a rise of Precision Navigation and Timing (PNT) satellite constellations around the world, and Russia is interested in this. Of course, the US has GPS; the Chinese have Beidou, which is doing pretty well; the Europeans have their own version called Galileo; and Russia has GLONASS. Russia is really trying to make GLONASS a thing that people use, but it's hard because they don't have exactly the right coverage, the satellites tend to malfunction, and it just doesn't have the broad use that GPS has. This is changing, though—a lot of the newer cellphones now have chips for both GPS and GLONASS when you buy them, but GLONASS is clearly not as widespread.

So, I think Russia is trying to follow the US's lead, actually, in terms of how we've diversified our space capabilities, but they're having a hard time doing it because I just don't think there's a lot of leadership. It seems that Russia is just fearful of being left behind and being perceived as being weak.

I know Russia does have some new space actors, but, to be honest, our organization has had a very difficult time reaching out to the Russian space community. We know that people that show up at COPUOS—a couple of them are very good technicians and experts on the issues—but it's hard to get a beat on what the Russian space policy makers are thinking just because of language differences, visas, and just general difficulties between our two countries' relationships.

Interviewer: [Q2] Okay. What about North Korea?

V. Samson: Well, this is obvious, but North Korea doesn't really have a commercial sector. I'm sure you guys have heard a lot about North Korea lately. Supposedly North Korea has launched some satellites, but these don't really seem to do much more than maybe broadcast a tune, if they can actually broadcast it.

However, North Korea is absolutely using its space launch capabilities to further its missile launch capabilities. I don't know that North Korea would necessarily sell those capabilities, so it's not like they're doing this in the sense of commercial operations or interests. I think they're more using these capabilities and operations to further their interests regarding security concerns more than anything else.

Interviewer: So, how would you define North Korea's key ambitions and interests with respect to the space domain?

V. Samson: I think North Korea's ambitions and interests are portrayed by the way in which it has developed its missile capabilities. North Korea isn't like other countries where economies are reliant upon space—North Korea isn't reliant on space. I think the leadership's interests revolve around regime continuity, and I'd imagine that drives whatever policy they decide to do. So, I think that any research into the North Korean space program has to look at the underlying issues. North Korea isn't going to do space for science's sake or for development's sake or for STEM promotion's sake—they aren't going to do anything like that. They're going to focus on national security concerns, and there are always national security interests.

Having said that, because North Korea doesn't have space assets at the level of pretty much anyone else, I know a lot of people often point to North Korea as being the actor most likely to launch a nuke or do an EMP or wipe out a lot of satellites. However, I don't see them doing that, largely because I think it would be so hugely escalatory—it would require a regime-ending response, and they are aware of that. I don't think they would be able to target missiles by doing an ASAT operation, and I don't think they have the guidance or situational awareness strength to be able to do that either. They have not mentioned counterspace in public documents. But that doesn't mean there aren't other things they could try and do, though, to make people concerned. I just think that they're focused too heavily on their nuclear program and missile program to really develop an ASAT capability because it is rocket science and it is complicated, and they're doing a lot of work there that depends upon getting access to other people's technology. So, I think North Korea is limited in terms of what their indigenous science and technology can accomplish.

Interviewer: [Q2] So, for the sake of time, I'll just ask you one more question about this particular question. If you were to look at these countries on a spectrum of space power, how would you rank or group these countries across that spectrum? Presumably the US is at the top, but where would these other countries fall?

V. Samson: So, I would approach this by using groupings.

I think the first group would pretty clearly be the US, Russia, and China. With respect to something like total number of satellites, I think the US and Russia are pretty close. The Chinese are not quite on the exact same level as the US and Russia—China is probably a few years behind—but given what China has been able to accomplish and how much money they're putting into their space program, they're pretty close. So, I would rank the US, Russia, and China together in one grouping.

Then, the next level down, I would classify in terms of countries that utilize space a lot, have a space launch capability, and have a strong space policy. So, in this grouping, I am thinking of the countries of the European Space Agency (ESA), Japan, India, and Canada. Though I don't think Canada can launch its own satellites, I do think that they are kind of on par with the US friends and families.

Then, the third level down, I would classify countries that are kind of one-offs. In this grouping, I am thinking of Israel and South Korea, both of which can launch their own satellites. Israel, in particular, has a pretty strong space program, and it's been militarized. The South Koreans, not so much, so they're maybe a tier below that. Brazil is also probably on par with South Korea.

Then, below all of those I just mentioned, I think would be most of the other countries in your list. So, you'd have Australia, Singapore, and Ukraine. They're each different, but they're countries that use space, recognize space as being important, and each have their own space interests and capabilities; however, they're definitely in the fourth level.

Brent Sherwood

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

13 July 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: [Q2] You mentioned earlier that with respect to the planetary exploration sector, there are not really any perceived threats because the barrier to entry is so high and no one else is really operating in this domain.

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

Interviewer: [Q2] Okay. So, if you were to look at the actors operating in the planetary exploration sector on a spectrum, you'd think that the US is pretty far ahead of everybody else, right?

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

Interviewer: [Q2] Okay. So, who are the other key actors in the planetary exploration and mission domain, and would they fall along this spectrum in comparison to the US?

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

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

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

Interviewer: [Q2] Okay. So, you mentioned that Russia is sort of dropping off because of some resource constraints and also some failures, but do you see a situation where maybe some of the bigger actors that you mentioned, like maybe China or India, start to sort of close the gap with the US in terms of planetary mission capabilities? And, if so, as this gap starts closing, could there be a situation where some points of conflict or aggression begin to arise between the US and say a more empowered China in the planetary missions and exploration domain?

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

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

drilling fluids from the drilling operation. Because of this, Russia has taken multiple measures since then, but to this day there is a scientific argument about the validity of their results.

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

[...]

Interviewer: [Q2 indirectly] Hi Brent. I have a quick, more policy focused question for you regarding the relationship between the commercial space sector and the civil space sector. Can you talk a little about some of the key impediments or hindrances to cooperation between various commercial space sectors and the military or defensive space sectors? Are there any particular areas of contention that you are aware of?

B. Sherwood: Well, nothing really comes to mind because I don't know anything about military space, so I don't know what kind of impediments there might be that would be amenable to solutions that we use in the civil sector. You know, certainly we have all the usual contractual stuff, which is kind of onerous but just something that has to be dealt with.

Though, I'm a big fan of collaborative partnerships, like public-private partnership kind of things. Collaborative partnerships work very well in Japan, by the way, and it's being demonstrated to work in lots of sectors here in the US. But, it's kind of a new thing for civil space, and I don't know if there is a possibility for those kinds of things in military space or not. It's just not my field, so I don't know.

ViaSat, Inc.

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15 August 2017

WRITTEN RESPONSE

Many of the entities identified, for example the People's Republic of China, Russia, Iran, North Korea, India and others, are not known to have a culture of openness and trust and as such may find it difficult to enable

commercial or private sector innovation in space operations to serve military and commercial purposes. In the case of significant commercial or private sector investments a culture of openness and trust is paramount to increasing the rate of technology and capability innovation and development.

Exponential technology growth can only be gained by enabling and leveraging innovation, not directing it, or attempting to manage and control it. This is a fundamental trait of American businesses and the American way of life. Clearly there is great risk in openness and a need for trust to affirm aligned purposes, therefore it is important that leadership approaches these efforts with an “Eyes-on, Hands-off” approach, creating and maintaining an operational ecosystem but allowing individual organizations to operate independently.

Dr. Brian Weeden

Director of Program Planning (Secure World Foundation)
31 July 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: [Q2] Okay. Great. So, now let’s move beyond the definition questions into some of the other questions I was hoping we could address. Q2 from our list is about how other actors conceive of space operations for military and commercial purposes. So, I am wondering if you can talk a bit about how, from your perspective, other actors conceive of space operations for both military and commercial purposes. This question, as presented in our list of questions, lays out several countries to address, but please feel free to talk about whichever countries you are most comfortable with speaking to.

B. Weeden: Sure. So, backing up a little, first I’ll talk about the tiers and categories of space-faring states and users. This is something that I have actually written about before. To put it broadly, we at the Secure World Foundation had a line of scholarly research over the last several years trying to inform the approaches we take towards space governance and space sustainability, and we basically started off by drawing from other domains. As much as people like to think the space domain is special, it isn’t really in most cases. So, part of what we did was, we looked at the work of Elinor Ostrom, who won the Nobel Prize in Economics in 2009. In particular, we looked at Ostrom’s work on sustainable management of common pool resources (CPRs).

So, what are common pool resources. Well, everyone is familiar with the tragedy of the commons, which says basically, if nobody owns a particular thing, there is a tendency to overuse it, which means, it gets destroyed. What Ostrom points out is that the traditional tragedy there is the only way to preserve that thing, is to either privatize it (i.e., break it up into little chunks and fence it off) or to bring in a leviathan that is some government or administrator to dictate how to use it. However, either one of those options destroys the commonness of it.

So, Ostrom looked at common pool resources. For example, if you call the ocean a global commons, then common pool resources are things like fishing grounds or oil reserves under the ocean—the sorts of things that are subsets of this broader commons that you can kind of use to extract resources. Ostrom found that there are dozens of cases where people have found a way to use common pool resources sustainably, and she created a list of principles that occur across those cases.

So, as part of our research at the Secure World Foundation, we have tried to look at the things that work across all other common pool resources around the world—whether they are fisheries, watersheds, oil patches, forests, etc.—and think about how they might apply to space.

So, in relation to your question, we have tried to identify different tiers of stakeholders in the space world. Our first cut was that we identified 3 levels: 1) space-faring states (i.e., countries

that can do it all), 2) space-capable states (i.e., countries that can do some things in space but not everything), and 3) space users (i.e., basically anyone that uses space data, services, or applications in their daily life, whether it be countries, companies, individual citizens, etc.). We then went into a lower level of analysis where we broke these 3 levels down according to 4 different variables: 1) level of engagement (i.e., are they directly involved—actually flying a satellite—or are they indirectly involved—just using the data from a satellite?), 2) spectrum of engagement (i.e., are they just operating in one space sector, or are they operating in multiple space sectors?), 3) dependence on space (i.e., do they just use space because they like it, or is space actually a core interest?), 4) prioritization (i.e., how do they prioritize space relative to their peers and relative to other issues?). We put together a full paper on this, and I will send it to you.

As far as the specific countries you have listed in your question, my sense is that there was some sort of a categorization between the three bulleted groupings of countries that are presented in the question. In the first group, you have China, Russia, Iran, and North Korea, which all seem to fit into the adversary category. In the second group, you have Europe, Japan, India, South Korea, and Israel; and in the third group, you have Canada, Brazil, Australia, Singapore, and Ukraine. My guess is that for the second and third groupings, one grouping is meant to be the allies category and the other grouping is meant to be the partners category; however, I couldn't really tell which grouping was meant to be which category.

Part of the issue and difference here is that the US has different relationships with countries in space than they might have with those same countries outside of space. Let's take South Korea for example. Obviously, the US has a treaty alliance with South Korea stemming from the Korean conflicts, but in the space world, there is not really that big of a relationship there between the US and South Korea. Vice versa, we have Australia and Canada. The US has strong relationships with Australia and Canada in other domains (e.g., in Afghanistan where the US, Canada, and Australia have been fighting side-by-side), but it's only very recently that the US has had a strong space relationship, or a stronger space relationship, with Australia and Canada. Then, you have a country like India, which the US is kind of forging new relationships with on both fronts.

So, in general, the way I would recommend approaching this is by starting first starting with the US, and then building circles of trust outwards from the US. So, in that first circle of trust, you probably would include the Five Eyes (Canada, Australia, the UK, and New Zealand), though New Zealand is not really doing a whole lot in space. Over the last 5 or 6 years, there have been a lot of discussions about building a Five Eyes space relationship—these discussions started out under the rubric of the Combined Space Operation Center (CSPOC), which was exercised at one of the frequent war games around 2010, but are now under the rubric of the Combined Space Operations Concept (CSPO). The idea there is that each of the Five Eyes countries is going to have a national space integration cell (i.e., JSPOC, CANSPOC, AUSSPOC, etc.), and the CSPO is a set of CONOPS for how those national operations interact with each other, recording aerospace operations. So, you have the US with the Five Eyes, and that concept of operations is underway. There have also been discussions about expanding space operations and space situational awareness (SSA) data sharing outwards to the next circle of trust, which would probably include Germany, France, and Japan. After that, the next circle of trust outward would likely include all of the countries that the US has signed a space situational awareness (SSA) data sharing agreement with, so this would include South Korea, India, UAE, and several others.

So, going back to your question regarding how these countries conceive of space operations.

There are a couple of countries, such as Australia, Canada, and the UK, that the US has a few decades of history with in space. Canada was originally part of space because of NORAD, and it was a big part of the NORAD early warning network, which was not only for aircrafts but also for satellites. Eventually, though, that US-Canada space-centric relationship went away—in large part because Canada said no to Strategic Defense Initiative (SDI) missile defense and Canada kind

of said no to the Iraq war as well, which led to Canada kind of being kicked out of the US space world for a decent amount of time. Australia has historically been home to a lot of ground assets in support of the NRO's mission, but that was a closely held national secret until fairly recently—Australia's public was certainly not aware of this. In general, though, Australia hasn't really had a big role in space. Going back to Canada for a second, Canada's entire space budget is something around \$400 million—that's miniscule compared to the US.

So, in looking at all of the other countries on your list, by and large they have done something small in space—mostly with allies or partners—and are now starting to realize that they need to expand what they are doing. So, Canada has been working on a national space policy for the last couple of years, and now has a satellite named Sapphire in orbit, which contributes to the US space surveillance network. Australia is dumping a whole bunch of money into revitalizing its space industry and is developing a new space policy. South Korea is trying to figure out what it wants to do in space. Japan has recently gone from interpreting “peaceful use of space” as meaning non-military, to changing its constitution so now Japan can have military space activities, so Japan is trying to figure out what all of that means. Japan's actions are probably being driven largely by what it is observing from China and North Korea.

So, all of these countries have had some sort of role in space but are now going through the transition where they are trying to expand what they are doing in space and sort of redefine stuff in large part to add a military and national security component into their space interests. Though, some of these countries are further along than others in figuring out what that all means.

Interviewer: [Q2] Great. So, I think we could talk for hours about this question because there are so many components, but I'd like to ask you just one quick follow up. You mentioned the work you have done to categorize stakeholders in the space world into 3 different tiers: space-faring states, space-capable states, and space users. So, I'm wondering, if you take a look at the specific countries presented in Q2 from our list, how would you classify each country within your 3 tiers?

B. Weeden: Sure. So, for the space-faring states tier, the obvious ones that I would include are the US, Russia, and China.

Then, also in that first tier, I would put the European Union. Though, that depends on if you consider the European Union to be a unitary actor or not. If you do consider the European Union to be a unitary actor, then I think you put it in that first tier (space-faring states) as well, but if you do not, and you are looking at France, Germany, and Italy as all separate actors, then I would probably classify each of these individually as in the second tier (space-capable states). So, for example, France has some decent military space capabilities here and there, but nothing global, nothing sustained, and it doesn't really do a whole lot on human space flight.

I would say that Iran and North Korea are clearly in the second tier (space-capable states) because they do some stuff in space. Clearly, North Korea and Iran both have launched satellites, they have active ballistic missile programs and space launch programs, and they have nascent satellite development programs that are good but not the best. Overall, though, Iran and North Korea really don't have a huge robust presence in space. Iran has a little bit more robust space presence than North Korea. Iran, before the revolution, was heavily active in the international space community and heavily active in the scientific space community, but that has been curtailed somewhat post-revolution.

Then, I'd say you have a bunch of countries that are kind of on the bubble and looking to think about transitioning from kind of a tier 2 (space-capable states) actor or tier 1 (space-faring states) actor. India is one of these countries. India has been involved in space for decades, and it has some very good capabilities, but historically India has said that the purpose of the Indian space program is to provide socio-economic benefits to India's public. So, historically, the major focus of India's space program has been on remote sensing and monitoring of Earth's resources (e.g., agriculture, land use, forest use, etc.) and some other scientific- and application-driven

things. But, now, over the last ten years, India has started to shift to other things. India is now actively looking at prestige programs, sending probes to the Moon and looking to go to Mars, human space flight, and national security applications—India has launched its first national security satellite, is using dual-use satellites for national activities, and is even thinking about things like counter space anti-satellite capabilities. So, India is definitely on that bubble between tier 2 (space-capable states) and tier 1 (space-faring states).

So, most of the countries listed in your question are in that tier 2 (space-capable states) classification.

As for tier 3 (space users) actors, there's a lot of countries that could be considered a space user. Pretty much every country uses space to some degree. Though, what is interesting is that more and more of those space users are starting to become active members in space. It's much easier for actors to get a satellite up into space than it used to be. Today, upwards of about 60 or more countries have at least one satellite in orbit or have launched a satellite that has orbited.

So, over time, I would say that everyone is kind of moving up the tiers, but as far as that top tier of fully space-faring states that can do everything in space, I would say right now the list is the US, Russia and China.

Notably, Russia was kind of on the bubble of slipping into tier 2, and China is kind of in the middle of that transition from tier 2 to tier 1—China is in the process of building out its military and national security space applications.

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24 July 2017

INTERVIEW TRANSCRIPT EXCERPT

Interviewer: [Q2] Okay yeah that is very helpful, so moving right along to question two. How does each entity in the following categories conceive of space operations for military and commercial purposes? How do they approach space operations and services? Is there any difference in how their commercial ventures (if any) consider security during peace, crisis and conflict? We selected the third or the second option I believe and I suppose you can speak more exclusively on Canada. Is that right?

C. Weeden: The first thing I would state as someone who was in the Canadian Military and worked with the US on space issues, the Five Eyes community is very close. It is what we understand and believe is kind of the closest allied community in space, especially with Canada's history of being in the North American Aerospace Defense Command and being one of the first close-knit bi-national commands to track satellites, Canada has been a very close ally for many decades and providing space situational awareness services back then as well, and today. Those five nations have key space relationships plus Germany, Japan, France, and others.

When I was working inside Cheyenne Mountain tracking satellites, I was the deputy sensor manager under Air Force Space Command but in the NORAD billet. So that's how close-knit Canada and the US have become in space. Today, Canadians are serving in the JSpOC on the Watch Center and other missions of course for the missile warning mission due to the NORAD relationship.

As a close ally, Canada from the 1990s actually has evolved when it comes to the use of space for defense purposes. The 1990s is when the last defense space policy was released. It had a very

ardent no-military use of space kind of vibe to it. That was the culture in that timeframe. Since then I believe Canada has done a 180, in how they rely and use space for critical national security. There's a recognition even in the most recent Canadian defense policy, which I'm happy to send everyone, to bring space into national security aspects for Canada.

Those specific items where space is the most important is in support of the Arctic operations. Canada has one of the longest coastlines in the world and highly relies on radar satellite data and AIS (Automatic Identification System), and also communications.

Canada has also, I told you, a legacy in NORAD for space situational awareness. Canada had three Baker-Nunn telescopes across the country from the 1960s to the 1980s. Today the Canadian Armed Forces has a dedicated satellite orbiting to provide space situational awareness into the NORAD and JSpOC missions, through to the Space Situational Network. For communications, increasingly narrow and wideband communications are critical to support Arctic operations. That's in a nutshell from my time in the Canadian military how space has evolved and what kind of capabilities the Canadian government is looking to move forward on.

[...]

Interviewer: [Q2 indirectly] Okay. Okay, we'll keep it moving along again. I want to rephrase this question just a little bit. Now we know most of the commercial satellite industry is based in the US, but looking outside of North America, what would you say are the nations that are poised to expand their own commercial satellite industry for military purposes?

C. Weeden: I think in the SatCom-satellite communications environment, Latin America is utilizing commercial SatCom, I understand, for defense purposes. The Middle East, potentially it could be a place that is looking to leverage more commercial or encourage commercial satellite SatCom to be launched and therefore opening the doors towards utilizing it. Oh, one thing about Canada, going back there, Canada is well equipped to do public-private partnerships in creating commercial satellite capabilities. That's something that the rest of the world may be engaged in as well.

Interviewer: [Q2 indirectly] Okay. Okay, great. How are the components of the commercial space industry allocated outside of the US? Now, speaking specifically in the satellite industry, I noted from the SIA report that there's a page talking about manufacturing broken down by country and region. Could you expand on that a little bit?

C. Weeden: Sure. Let me get to the manufacturing page (p. 19), let me bring that up.

As you can tell, it's primarily the US and Europe for manufacturing of commercial satellites. Obviously, China has their own capability to build. Those that have invested in global navigation are usually the nations that have a keen interest in it. It's an expensive program that doesn't necessarily have a business case. Japan, India, China, Russia, and Europe, they all have their own national global navigation systems or regional navigations systems as it may be.

Startups can be associated mainly to Earth observation, but we're seeing more Internet communications services/broadband as well. It's not necessarily which countries have types of market interest, it's where the new startups are making their homes and looking to serve the global community.