HEARING ON CHINA IN SPACE: A STRATEGIC COMPETITION?

HEARING

BEFORE THE

U.S.-CHINA ECONOMIC AND SECURITY REVIEW COMMISSION

ONE HUNDRED SIXTEENTH CONGRESS
FIRST SESSION

THURSDAY, APRIL 25, 2019

Printed for use of the
United States-China Economic and Security Review Commission
Available via the World Wide Web: www.uscc.gov

UNITED STATES-CHINA ECONOMIC AND SECURITY REVIEW COMMISSION

WASHINGTON: 2019

U.S.-CHINA ECONOMIC AND SECURITY REVIEW COMMISSION

CAROLYN BARTHOLOMEW, *CHAIRMAN*
ROBIN CLEVELAND, *VICE CHAIRMAN*

Commissioners:
HON. CARTE P. GOODWIN
ROY D. KAMPHAUSEN
THEA MEI LEE
KENNETH LEWIS
MICHAEL A. MCDEVITT
HON. JAMES M. TALENT
MICHAEL R. WESSEL

The Commission was created on October 30, 2000 by the Floyd D. Spence National Defense Authorization Act for 2001 § 1238, Public Law No. 106-398, 114 STAT. 1654A-334 (2000) (codified at 22 U.S.C. § 7002 (2001), as amended by the Treasury and General Government Appropriations Act for 2002 § 645 (regarding employment status of staff) & § 648 (regarding changing annual report due date from March to June), Public Law No. 107-67, 115 STAT. 514 (Nov. 12, 2001); as amended by Division P of the "Consolidated Appropriations Resolution, 2003," Pub L. No. 108-7 (Feb. 20, 2003) (regarding Commission name change, terms of Commissioners, and responsibilities of the Commission); as amended by Public Law No. 109-108 (H.R. 2862) (Nov. 22, 2005) (regarding responsibilities of Commission and applicability of FACA); as amended by Division J of the "Consolidated Appropriations Act, 2008," Public Law Nol. 110-161 (December 26, 2007) (regarding responsibilities of the Commission, and changing the Annual Report due date from June to December); as amended by the Carl Levin and Howard P. "Buck" McKeon National Defense Authorization Act for Fiscal Year 2015, P.L. 113-291 (December 19, 2014) (regarding responsibilities of the Commission).

The Commission's full charter is available at www.uscc.gov.

May 13, 2019

The Honorable Chuck Grassley
President Pro Tempore of the Senate, Washington, DC 20510
The Honorable Nancy Pelosi
Speaker of the House of Representatives, Washington, DC 20515

Dear Senator Grassley and Speaker Pelosi:

We are writing to notify you of the Commission's April 25, 2019 public hearing on "China in Space: A Strategic Competition?." The Floyd D. Spence National Defense Authorization Act for 2001 § 1238, Pub. L. No. 106-398 (as amended by the Carl Levin and Howard P. "Buck" McKeon National Defense Authorization Act for Fiscal Year 2015 § 1259b, Pub. L. No. 113-291) provides the basis for this hearing.

At the hearing, the Commissioners received testimony from the following witnesses: General James Cartwright, USMC (Ret.), Inaugural Chairholder, Harold Brown Chair, Center for Strategic and International Studies; William Roper, Ph.D., Assistant Secretary of the Air Force for Acquisition, Technology, and Logistics; Todd Harrison, Director, Aerospace Security Project and Defense Budget Analysis, Center for Strategic and International Studies; Brian Weeden, Ph.D., Director of Program Planning, Secure World Foundation; Namrata Goswami, Ph.D., Senior Independent Analyst; Lorand Laskai, Visiting Researcher, Georgetown Center for Security and Emerging Technology; Michael Gold, J.D., Vice-President, Regulatory and Policy, Maxar Technologies; Kevin J. Wolf, J.D., Partner, Akin Gump Strauss Hauer & Feld; Kevin Pollpeter, Senior Research Scientist, CNA; Mark Stokes, Executive Director, Project 2049 Institute; and Jonathan Ray, Research Director, Special Programs Division, SOS International LLC. This hearing examined the implications for the United States of a commercial, scientific, diplomatic, and military strategic competition with China. The hearing began with two individual panels comprising a strategic planning perspective on competition with China in space and a current Administration official's assessment of the balance of power in space and China's current space-based surveillance capabilities, respectively. The first full panel examined China's pursuit of global space leadership, focusing on China's international space partnerships, its views on international law in space, and its exploration ambitions. The second panel addressed the role of military-civil fusion in China's space ambitions, including the role of military-civil fusion in context of China's national space goals, U.S. competition with Chinese companies in the international satellite industry, and the adequacy of U.S. export controls. Finally, the third panel examined China's military space activities, focusing on its national military space goals and doctrine, its military space and counterspace capabilities, and the intersection of cyber and space in China's strategy and operations.

The full transcript of the hearing, prepared statements, and supporting documents are posted to the Commission's website, www.uscc.gov. Members and the staff of the Commission are available to provide more detailed briefings. We hope these materials will be helpful to the Congress as it continues its assessment of U.S.-China relations and their impact on U.S. security.

The Commission will examine in greater depth these issues and the others in our statutory mandate this year. Our 2019 Annual Report will be submitted to Congress in November 2019. Should you have any questions, please do not hesitate to have your staff contact one of us or our Congressional Liaison, Leslie Tisdale Reagan, at 202-624-1496 or lreagan@uscc.gov.

Sincerely yours,

Carolyn Bartholomew
Chairman

Robin Cleveland
Vice Chairman

cc: Members of Congress and Congressional Staff

CONTENTS

THURSDAY, APRIL 25, 2019

CHINA IN SPACE: A STRATEGIC COMPETITION?

Strategic Perspective

Administration Perspective

Panel I: China's Pursuit of Global Space Leadership

Panel II: Military-Civil Fusion in China's Space Ambitions

Panel III: China's Military Space Activities

ANSWERS TO QUESTIONS SUBMITTED FOR THE RECORD

CHINA IN SPACE: A STRATEGIC COMPETITION?

THURSDAY, APRIL 25, 2019

U.S.-CHINA ECONOMIC AND SECURITY REVIEW COMMISSION

Washington, DC

The Commission met in Room 419 of Dirksen Senate Office Building, Washington, DC at 9:50 a.m., Chairman Carolyn Bartholomew and Commissioner Michael McDevitt (Hearing Co-Chairs) presiding.

OPENING STATEMENT OF CHAIRMAN BARTHOLOMEW HEARING CO-CHAIR

CHAIRMAN BARTHOLOMEW: All right. We're going to go ahead and get started this morning. Good morning. Welcome to the fourth hearing of the U.S.-China Economic and Security Review Commission's 2019 annual report cycle.

Our hearing today will examine China's ambition to become an international leader in space, what the Central Government's most recent white paper on space released by the State Council in 2016 terms "a space power in all respects." Beijing aspires to lead international space-related innovation and exploration.

In a recent example of China's desire and its ability to realize its goals in space, this January, China's lunar exploration program successfully landed a robotic probe on the Moon's far side, a technological feat never before achieved by any country.

China has also nearly completed its own position, navigation, and timing satellite network known as BeiDou, which will serve to increase China's influence in countries participating in its Belt and Road Initiative and decrease China's dependence on the U.S.-maintained Global Positioning System.

These developments, along with ambitious plans for future milestones, such as a long-term space station, a research station on the lunar surface, and reusable spacecraft, show that China is serious about becoming a space power and is willing to commit the political will and funds necessary to achieve this goal.

It's our honor today to welcome two distinguished public servants, General Cartwright, and Assistant Secretary of the Air Force, Dr. Roper. We look forward to hearing them discuss the strategic perspective on competition with China in space, as well as steps the Department of Defense is currently taking to prepare for an era of heightened competition in space. Their perspectives will contribute to the discussion about what China's intentions as a space power might be and how the United States must prepare to respond.

Following Dr. Roper, a panel of experts will address China's pursuit of global space leadership.

China's space program, no longer constrained by poor infrastructure and less advanced technology, has advanced by leaps and bounds since its first crewed space flight in 2003. Beijing continues to meet important milestones in its ambitious agenda for exploration and

exploitation of space.

It is troubling that the Chinese government has begun comparing its interests in space to its expansive territorial claims on Earth. As one Chinese senior space official put it, "if we regard space as the Earth, then the Moon is the Senkaku Islands and Mars is the Spratly Islands or reefs." This official further warned that not exploring these celestial bodies may result in a failure to protect China's so-called space rights and interests.

Comparing the Moon and Mars to China's disputed territorial claims in the East and South China Seas, what Beijing includes among its core interests, suggests that China may be coming to view space as a new front for its expansionist ambitions, potentially including views of sovereignty in space that would violate the 1967 Outer Space Treaty, to which China is a party.

The United States must not be complacent in the face of what may become a long-term, highly consequential economic and strategic competition. We look forward to hearing about these important topics from the experts we have today.

Before we begin, I would like to thank the Senate Foreign Relations Committee for helping to secure today's hearing venue. And I'll now turn to the co-chair of today's Commission hearing, Admiral Mike McDevitt, for his opening remarks.

PREPARED STATEMENT OF CHAIRMAN BARTHOLOMEW
HEARING CO-CHAIR

Good morning, and welcome to the fourth hearing of the U.S.-China Economic and Security Review Commission's 2019 Annual Report cycle.

Our hearing today will examine China's ambition to become an international leader in space, what the central government's most recent white paper on space, released by the State Council in 2016, terms a "space power in all respects." Beijing aspires to lead international space-related innovation and exploration. In a recent example of China's desire and ability to realize its goals in space, this January China's Lunar Exploration Program successfully landed a robotic probe on the moon's far side—a technological feat never before achieved by any country. China has also nearly completed its own position, navigation, and timing satellite network, known as Beidou, which will serve to increase China's influence in countries participating in its Belt and Road Initiative and decrease China's dependence on the U.S.-maintained Global Positioning System.

These developments, along with ambitious plans for future milestones—such as a long-term space station, a research station on the lunar surface, and reusable spacecraft—show that China is serious about becoming a space power and is willing to commit the political will and funds necessary to achieve this goal. It is our honor to welcome two distinguished public servants, General Cartwright and Assistant Secretary of the Air Force, Dr. Roper. We look forward to hearing them discuss the strategic perspective on competition with China in space as well as steps the Department of Defense is currently taking to prepare for an era of heightened competition in space. Their perspectives will contribute to the discussion about what China's intentions as a space power might be and how the United States must prepare to respond..

Following Dr. Roper, a panel of experts will address China's pursuit of global space leadership. China's space program, no longer constrained by poor infrastructure and less advanced technology, has advanced by leaps and bounds since its first crewed spaceflight in 2003. Beijing continues to meet important milestones in its ambitious agenda for exploration and exploitation of space.

It is troubling that the Chinese government has begun comparing its interests in space to its expansive territorial claims on Earth. As one senior Chinese space official put it, "If we regard space as the Earth, then the Moon is the Senkaku Islands and Mars is the Spratly Islands or reefs." This official further warned that not exploring these celestial bodies may result in a failure to protect China's so-called "space rights and interests." Comparing the Moon and Mars to China's disputed territorial claims in the East and South China seas—what Beijing includes among its "core interests"—suggests that China may be coming to view space as a new front for its expansionist ambitions, potentially including views of sovereignty in space that would violate the 1967 Outer Space Treaty, to which China is a party. The United States must not be complacent in the face of what may become a long-term, highly consequential economic and strategic competition.

We look forward to hearing about these important topics from the experts we have here today. Before we begin. I would like to thank the Senate Foreign Relations Committee for helping to

secure today's hearing venue.

I will now turn to the co-chair of today's Commission hearing, Admiral Michael McDevitt, for his opening remarks.

OPENING STATEMENT OF COMMISSIONER MCDEVITT
HEARING CO-CHAIR

COMMISSIONER MCDEVITT: Thank you very much, Chairman Bartholomew. I would also like to welcome our panelists and guests to the hearing.

I must say, I've spent years studying China's maritime rights and interests. But, until I started preparing for this panel, I didn't know that they also had space rights and interests.

To repeat, China is determined to become a leading space power, which requires continuing to boost its innovation capabilities both in its civilian and military sectors.

The People's Liberation Army is closely involved in most, if not every, aspect of China's space program, from helping to formulate and execute national space goals, overseeing China's human space flight program.

Coverage of China's space program must treat seriously the implications of the reality that, in many cases, the boundaries between military and civil silos of China's program are thin, if they exist at all.

Our second panel today, to jump ahead a bit, will address the application of what China calls its military-civil fusion strategy in its space sector. Military-civil fusion is a strategic concept designed to harness the civilian sector's innovation to power China's military and technological modernization with the goal of leapfrogging the United States in becoming a technical powerhouse.

Space has been designated as an especially important sector for military-civil fusion. And the impacts of this campaign on China's burgeoning commercial space sector, itself a recipient of generous government support and protection, will be crucial as China's companies increasingly seek to compete in the international marketplace. Military-civil fusion is especially worthy of attention due to its continued reliance on technology.

The PLA views the space and cyber domains as closely connected in strategy. And, for this reason, China stood up a new Strategic Support Force in 2015, a new military service responsible for most of the military's space warfare mission, in addition to cyber, electronic, and psychological warfare.

It will be crucial for the United States to base its strategic planning on a sufficient understanding of the importance that the PLA ascribes to the Strategic Support Force, or otherwise known as the SSF, and its associated missions.

So, again, I thank all of you for attending today. And I'd like to remind you to mark your calendars for our next hearing -- I make commercials -- which will take place on June 7 and will address trade, artificial intelligence, and new materials.

With that, let me turn back to Commissioner Bartholomew to introduce General Cartwright.

PREPARED STATEMENT OF COMMISSIONER MCDEVITT
HEARING CO-CHAIR

Thank you, Chairman Bartholomew. I also would like to welcome our panelists and guests to our hearing.

As the Chairman said, China is determined to become a leading space power, which requires continuing to boost its innovation capabilities, both in its civilian and military sectors. The People's Liberation Army is closely involved in most if not every aspect of China's space program, from helping formulate and execute national space goals to overseeing China's human spaceflight program. Coverage of China's space program must treat seriously the implications of the reality that in many cases the boundaries between the military and civil silos of China's program are thin, if they exist at all.

Our second panel today will address the application of what China calls its "military-civil fusion" strategy to its space sector. Military-civil fusion, a strategic concept designed to harness civilian sector innovation to power China's military and technological modernization with the goal of leapfrogging the United States and becoming a technological powerhouse. Space has been designated as an especially important sector for military-civil fusion, and the impacts of this campaign on China's burgeoning commercial space sector—itself a recipient of generous government support and protection—will be crucial as Chinese companies increasingly seek to compete in the international marketplace. Military-civil fusion is especially worthy of attention due to its continued reliance on technology transfer, by hook or by crook, to fuel China's industrial and military growth.

Our third and final panel today will examine China's military space and counterspace activities. Since its direct-ascent kinetic antisatellite test in 2007, which was responsible for a large amount of all space debris currently in Earth's orbit, China has continued to invest in a variety of offensive antisatellite capabilities. Indeed, China's counterspace arsenal contains many options: earlier this month, Acting Secretary of Defense Patrick Shanahan said China "has exercised and continues to develop" jamming capabilities; is deploying directed-energy counterspace weapons; has deployed an operational ground-based antisatellite missile system; and is prepared to use cyberattacks against U.S. space systems.

The People's Liberation Army views the space and cyber domains as closely connected in strategy, and for this reason China stood up the new Strategic Support Force in 2015, a new military service responsible for most of the military's space warfare mission in addition to cyber, electronic, and psychological warfare. It will be critical for the United States to base its strategic planning on a sufficient understanding of the importance the People's Liberation Army ascribes to the SSF and its associated missions.

Again, thank you all for attending today, and I'd like to remind you to mark your calendars for our next hearing, which will take place on June 7 and will address trade, artificial intelligence, and new materials.

With that, let us begin with the testimonies.

STRATEGIC PERSPECTIVE INTRODUCTION BY CHAIRMAN BARTHOLOMEW

CHAIRMAN BARTHOLOMEW: Great. Thank you very much. Again, it's my honor to introduce today General James Cartwright, retired from the U.S. Marine Corps and currently serving as the inaugural holder of the Harold Brown Chair in Defense Policy Studies for the Center for Strategic and International Studies.

Unique among Marines, General Cartwright served as Commander, U.S. Strategic Command, before being nominated and appointed as the eighth Vice Chairman of the Joint Chiefs of Staff, the nation's second highest military officer. General Cartwright served his four-year tenure as Vice Chairman across two presidential administrations and constant military operations against diverse and evolving enemies.

General Cartwright graduated with distinction from the Air Command and Staff College, received a master of arts in national security and strategic studies from the Naval War College, completed a fellowship with MIT, and was honored with a Naval War College Distinguished Graduate Leadership Award.

General Cartwright, welcome. We look forward to hearing your testimony. Thank you for appearing today.

OPENING STATEMENT BY GENERAL JAMES CARTWRIGHT, USMC (RET.), INAUGURAL CHAIRHOLDER, HAROLD BROWN CHAIR, CENTER FOR STRATEGIC AND INTERNATIONAL STUDIES

GEN. CARTWRIGHT: Thank you to the co-chairs and to the members of the panel. And it shouldn't go without saying, but the dedication that you have demonstrated to this issue and the time that you have given to it, you know, you deserve a great amount of thanks. And I certainly would pile on with that.

I did not prepare a formal statement because I think this time is really for you. But I would like to just kind of go back in context briefly, and, as the Commander of Strategic Command, give you my perspective at that time on where we were heading and what might be important attributes of a construct of deterrence in space.

And I still believe that the nation is, quite frankly, trying to articulate a coherent deterrence strategy that includes space. And so I will start there and just a few brief comments on that and then turn it back to you.

To me, the problem statement here is that, much as you have said, the space domain is by many termed crowded and contested now -- contested being the operative word that has been added in the last several years.

It is clearly critical to national security -- space, that is -- and domestic activities. And the concern that we have probably most frequently is that it is highly vulnerable to denial operations.

So, from a STRATCOM perspective, at the time, we then focused in on how would you create a more effective deterrence architecture for not only today but where you see space moving in the future. And you have alluded to that in conversation about moving to the Moon, moving to Mars, moving into outer space.

How do you start to think about deterrence in those areas? How do you start to think about bringing it in such that the deterrence you build today does not preclude the deterrence you need tomorrow?

And I think that's critical. And that's kind of the job of the commander to sit down and get his smartest people to put their head to this.

And we had three attributes of deterrence that, military vocabulary here, but have been tried and true through the years.

The first is that it has to be credible. You have to have capabilities and capacity to impose your will. That's just essential. If your adversary doesn't believe that, you don't have a deterrence strategy.

You must demonstrate through policy, training, and exercises the regimes in which you will exercise your capabilities. You must demonstrate that so that people understand what they are, and they are not magic, and they understand the consequences, because you are trying to raise the cost of any anomalous behavior on the part of anyone in space.

And then third is that you must demonstrate the will to exercise these capabilities. And that is generally in the regime of policy, things like declaratory policy, et cetera, that are essential in stating what we believe ought to be the new norms and regimes for operating in space.

So, those three things were what drove us at STRATCOM. Where we ended up was with three attributes that we thought provided us with measures of merit, provided us with a pathway forward, provided us with capabilities that we felt would enhance the national capabilities, not only now but as we move to the future.

The pattern of threes is just my Marine math. That's all I can go up to is three.

But the first one is resilience, the construct of resilience. And the keys that we focused in the resilience space were really the disaggregation of the architecture such that the cost of launching ASAT-type capabilities would be astronomical and infeasible. So, remove the objective from the adversary, remove the high-value single targets, and disaggregate in a way that would impose cost on anyone who wanted to attack them. Okay? So that was number one.

That is now starting to be applied, not only in the national security sector but in the commercial sector as you look at the different companies that are talking about 4,000 satellites in a particular orbit for communications, et cetera.

The disaggregation means that any attack on that is likely to fail, be more expensive than the impact of the cost, and then also that the recovery time would be substantially less than having a single asset doing that work on orbit. So, that's the construct under resilience. And so the work that we did was to start to understand the technical requirements of moving to these more resilient architectures.

The second activity that we thought was absolutely essential here was to revitalize and rebuild the command and control systems. Admiral, much like at sea, the idea of big space, little bullet, it doesn't work anymore. I mean, it is so crowded up there that deconfliction, rules of the road, things like that are absolutely essential.

To do that, you must have a robust and highly precise surveillance system to know where everything is and where it's going, and to be able to say that clearly and to not have any ambiguity such that there are assets moving around where they shouldn't be moving around, impeding on sovereign footprints, whether they be physical or electronic, et cetera.

We must be able to ascertain that at a high degree of precision. And we are moving in that direction. I think that's on a good path. It will be expensive. It will be expensive. But it is probably the most important thing that we need to do, because we need to understand who's doing what in space. There's just no way around it.

The third one is cross-domain integration. Cross-domain integration. In other words -- these are my words, nobody else's -- the idea of Space Command as it existed prior to moving to STRATCOM was an entity that was unto itself. It was not beholden to the ground, to the air regimes, to the naval regimes. It just existed to itself. It had its own vocabulary. It had its own security system. And nobody knew what was behind those green doors. Therefore, it was very hard to integrate and/or defend. Okay?

Moving it out was an effort on the operational side to open up that capability to the services in the DoD construct, to our allies and friends, and to the commercial sector who needed to be able to transit space, okay, whether it be electronically or otherwise.

But the integration of space as we move forward is probably one of the key issues. And it is an organizational issue. And we have to align roles, missions, authorities, incentive structures such that they are not so different than the other domains of air, land, sea, that they cannot be integrated by a combatant commander into a coherent strategy. Okay? If they have a different vocabulary, if they build all of their stuff unto themselves and don't work across the seam, it's bad.

To me, that's probably one of the most important today issues. We have to get Space Command, whatever we call it, the service side of this, the train and equip side of this, authorized to do the work it needs to do to build the force.

We have to have an operational counterpart to that, which right now is STRATCOM. Maybe it will become another combatant commander, but it is the operational employer of that

force, okay, integrated with other capabilities.

To not do that is bad, A. B, I'm a Marine, okay? The integration of amphibious, to go from sea to land across that domain divide, was absolutely essential in our coherent strategies of all the world wars and everything since.

This is very much the same for the Air Force in air and space. We cannot allow them to become disaggregated from each other. They must be coherent. The Air Force Secretary must have the power to impose that these two domains work together through budget controls. And the Congress must have the same power.

This is absolutely essential. If you don't get this right, we can't have a coherent strategy or deterrence construct. I'm thumping the table on that. But it's really important. I don't care about belt buckles. I don't care about patches and colors of uniform. These things are what matter. They really do matter and make a big difference.

The last point that I'll make was that there were many things that the Director of NASA and my counterpart, as both STRATCOM and then as the Vice Chairman, and I worried about was that we are not paying attention to cislunar space.

Cislunar space is the space where the intersection, in particular around the Moon and its orbits, the intersection of Earth's gravity and the Moon's gravity. It is the gateway to the Moon. It is the gateway to space. It is the high ground from which you can observe all of Earth's orbits. Not knowing what's going on there, not having a good command and control architecture at that point, will tremendously disadvantage us as we go to the future.

I have to say that, for both Dr. Griffin and myself, we probably preached to the wind at that time. But I do believe that people are beginning to realize how important those zones are out there and how we would follow a normal pattern.

Normally, NASA goes out and explores. They build a rudimentary communications and navigation system that gets them from point A to point B. National security follows on and builds out that architecture to a greater scale to allow it to happen with greater resilience. And then eventually the commercial sector comes in.

We're at that transition. The national security apparatus must start to build that out. They are doing it. Everything I see is there. But it is very important to understand the advantage that you have from that high ground. That is critical, from a national security standpoint, from a military standpoint.

I look forward to your questions. I'll do my best. I'm old and I'm retired and I'm flunking retirement. But I'm here to help. Thank you.

PREPARED STATEMENT BY GENERAL JAMES CARTWRIGHT, USMC (RET.), INAUGURAL CHAIRHOLDER, HAROLD BROWN CHAIR, CENTER FOR STRATEGIC AND INTERNATIONAL STUDIES

26 April 2016
General (ret) James Cartwright, CSIS
Testimony before the US-China Economic and Security Review Commission
Strategic Competition with China in Space

For this submission, I have drawn heavily on the "The Center for Strategic and International Studies, Space Threat Assessment 2019" which provides a reasonably comprehensive, unclassified assessment of both the threat and actions being undertaken by our main competitors, with an excellent review of the Chinese capabilities and potential areas of investment. The assessment portrays the clear intent of the Chinese to obtain maximum leverage in the space and cyberspace domains. The assessment's opening pages highlight an excerpt from the 2018 NATIONAL DEFESE STRATEGY, UNITED STATES DEPARTMENT OF DEFENSE; "New threats to commercial and military uses of space are emerging, while increasing connectivity of all aspects of life, business, government and economic infrastructure creates significant vulnerabilities. During conflict, attacks against our critical defense, government, and economic infrastructure must be anticipated."

Air, space and cyberspace have become the strategic high ground for U.S. national, and economic security. Assured presence and passage yield the greatest current and future competitive advantage with both friendly and hostile competitors.

Unique to these domains, in both the physical and non-physical instantiations, are the significant amount of autonomy, robotics, and artificial intelligence necessary to effectively compete. Most activities occur at the speed of light, or extremely high velocities, with decision cycles that exceed the capabilities of the human mind to process.

Commercial and national security interests in the space domain today, are focused from geosynchronous orbits inward toward Earth. Technology is re-opening lunar space, which is rapidly gaining critical commercial and security roles. Both lunar space and the intersection of the lunar and Earth's gravities, provide a gateway to outer space destinations and exploration, and a venue to construct basing and support infrastructure with a far lower gravity well for launch and recovery from as compared to Earth. This area is also a platform with a unique vantage point from which to conduct remote sensing and other operations associated with Earth's orbital fields, e.g. geosynchronous, medium earth orbit, low earth orbits. The national security implications of lunar space will continue to grow in importance as our space exploration and commercial interests grow.

China is demonstrating a focused and long term interest in both the national security and commercial implications of the space domain. China's investments in autonomy, robotics, and artificial intelligence have been, and likely will remain, significant. China's work in quantum communications and other advanced processing constructs set the stage for significant breakout capabilities. While these breakout capabilities have yet to be realized, they merit close scrutiny.

China's investment and exploration of remote proximity operations in space is another venue worthy of close scrutiny. These operations open the opportunity to conduct rendezvous, docking, servicing and other logistical support operations in space. However, these same operations facilitate all forms of space-based weapon employment. Absent a set of international norms and regimes, that are adhered to, and a robust space surveillance capability, these proximity operations can represent a significant threat.

The United States has entered a period of accelerated advancement in space launch and delivery operations, autonomy, robotics and artificial intelligence. Most significant among these is the

introduction of reusability, which is already dramatically reducing cost, while increasing space access to much broader national security and commercial markets, for the U.S., its friends and allies. Current investment in increased payload capacity and faster turnaround time between launches all seem to be well within reach of U.S. commercial and national security customers.

U.S. space investments since the beginning of the century are revitalizing U.S. capabilities and capacity for space operations, in both the commercial and national security venues. Most significant, I believe, and referred to previously, is in the area of reusability, for launch, on orbit, and recovery operations from Earth. This has dramatically increased access, reduced cost, and broadened the opportunity for further competition across all space-based functionality.

Increased capabilities and capacity made possible by advances in autonomy and robotics are also fueling broader operational capabilities. Current R&D efforts with clusters of small satellite architectures are demonstrating increased capacity, resiliency, and survivability. There are no silver bullets; all things can be attacked, disabled, and/or destroyed. The movement toward small satellites and cluster architectures are a significant step in reducing the impact of any hostile action.

Increased capabilities in surveillance of space-based assets will be essential in understanding and correctly characterizing the activities of space-based assets. Newer, dedicated assets are under development to meet this critical function of surveillance and characterization. The cost of a robust capability will be high but must not be underestimated in its value.

Plans for returning to the lunar surface, for basing both on orbit and on the surface, and for expanding the sensing and communications architectures on and around this strategic gateway will be critical in expanding space exploration and defending our home planet space. Understanding the value of this is just now beginning to gain acknowledgement.

The emerging Department of Defense organizational construct for space and the intense focus on how DoD organizes for space are appropriate and necessary. Getting the organizational construct right merits considerable thought and debate. Today, the services are organized around the physical domains – air, land, and sea. The combatant commands are organized geographically and integrate the service domain capabilities for combat in a cross domain integrated strategy. The color of uniforms, unit patches, and headquarters location are irrelevant. We must have space and cyberspace service organizations that are accountable for all train and equip functions. We must have a domain-centric service construct that can be integrated with any and all other domains, via the combatant commands, to conduct combat operations on behalf of the nation.

Artificial intelligence and proximity operations are capabilities essential in any space endeavor, especially security. Proximity operations were touched on earlier. Artificial intelligence is and will be essential in space operations. These two areas require additional policy, resource and testing. At its core, artificial intelligence is best applied in an environment driven by a high degree of robotics, automation and one in which there is a clear strategic imperative for the acquisition of data. Applying artificial intelligence to space-based sensing, processing, storing and disseminating data is a natural fit. Applying artificial intelligence to space operations will require a reference architecture in order to support enterprise level operations for the DOD. In the commercial sector, the efforts of Tesla and

Amazon offer insight into the scale and the distribution of functions necessary to run enterprise level AI. NSA and NRO are the closest government counterparts, principally because of their significant data capture, processing, dissemination and warehousing. We need the right architecture and the right organizational roles and missions construct to successfully field an enterprise-level AI effort for space. Second, and more foundational, AI based lethality is the only realistic way to conduct combat and combat support operations in and through the space and cyberspace domains. How we do this remains a realistic policy void. Use of computational devices to complete fire control chains is not new. How we do it in domains where humans cannot be physically present, and/or cannot comprehend the necessary inputs to functionally complete the fire control loop is going to be challenging for our culture. Policy work and education in this area has to be accelerated, if we are to defend and compete in space and cyberspace.

In order to realize and leverage the potential of space, it is clear that expanding the utility of space beyond the purview of national security will increase resources and research and development efforts. We need policies and incentive structures that favor public/private cooperation. Allowing the full force of our commercial, academic, and government enterprises to participate in the nation's space endeavors will be essential in realizing the potential of space for the nation.

CHAIRMAN BARTHOLOMEW: Thanks very much. We'll start with Admiral McDevitt.

COMMISSIONER MCDEVITT: I'm older and I'm still flunking retirement.

This notion of cislunar space, if I'm saying it correctly, as I read it, the short excerpt you had submitted from the space report that CSIS did recently, I must say, if you could educate me a little bit, or educate us, on why is it so important.

And I was particularly taken as I went through the testimonies and readings that were provided in preparation for this hearing, the Chinese are talking about it, too. And so there is, obviously, the potential for competition there.

And so, if your comments were essentially talking into the wind, are the Chinese ruminations about this key portion of space, are they being taken seriously? And should we worry about it?

GEN. CARTWRIGHT: The cislunar space would include all of the orbits that would be lunar orbits. Okay? It includes the Moon. And it tends to intersect with Earth at where the gravity fields kind of null out. So, between the Moon and the Earth. Okay? And I'm not a technical person. Somebody's probably having a heart attack as I'm saying this, you know, that he's saying it wrong.

But what that affords is that -- one of the more difficult things here for sustained operations in space is to be able to get replenishment, new capabilities, but scaled to orbit.

All of Earth's orbits are observable from this point, number one. Number two, if you start to build capacity on the lunar surface, which is likely in support of beyond-Earth operations, coming out of the Moon's gravity well is hundreds of times cheaper than coming out of Earth's gravity well. So that's critical.

It is a strategic high point in which, at that intersection, you can sit with communications, sensing, et cetera, to manage the flow, because you really can't get any place else without going through those spots. So it is the hill over the valley. And you've got to have it.

That line of communications is like a sea line, sea strait. Everybody has to go through there. And so understanding what's happening there is critical, number one.

Number two, the observation from the Moon looking down on Earth's orbits, so to speak, is a very different perspective. And if it's very cheap to either leave the Moon's surface or the Moon's orbit and get to GEO and MEO and LEO in the orbits, that drops down the price, the cost of entry, and raises the potential for scale of mass in applying either denial operations to orbits or threatening operations. And so it is a critical point.

And the reverse slope, so to speak, is the back side of the Moon. And so, from an operational standpoint, that's the way we look at it.

Are those things all real yet? No. But you can see the race that's on and the priorities that are on -- NASA just moved their timeline up substantially -- how important this is.

COMMISSIONER MCDEVITT: And the China part of it, have you paid attention or been looking at what they are doing in this area as part of the space domain?

GEN. CARTWRIGHT: When I was the STRATCOM commander and Dr. Griffin was NASA, we were friends with our Chinese counterparts, to say the least. Okay? And we were working with them in partnership to understand what it would take to get back to the Moon, et cetera.

We understood in those dialogues with my military counterparts that it had strategic

significance, that there was no way any spacefaring nation could get to space and beyond Earth's orbits without working in those areas. And so it was critical.

The question at that time was how we might partner to do this work or how we might work independently but share. And those constructs may have fallen apart, it appears, to some extent. And the dialogue, I think, is probably wanting again, also.

CHAIRMAN BARTHOLOMEW: Commissioner Wessel?

COMMISSIONER WESSEL: Excuse me. Thank you, General. We're glad to host you. You hosted us a number of years ago out at STRATCOM and appreciate all that you have shared with us over the years.

Let me, if I can, look a little more at the near term as we focus increasingly -- and you know better than I -- on the informationized warfighter who is dependent on GPS, who's dependent on drone feeds, you know, everything else that is needed in that domain.

China has looked at both space and cyberspace as their asymmetric strengths or the ability to deter, deny our capabilities. China is, with their ASAT test, with a number of other space-based activities they've been engaged in, appears to be accelerating their -- filling out their asymmetric policies.

How would you rate China in terms of denying us of the capabilities that our warfighters depend on? And including I'd put, you know, nuclear command and control. Are we at -- do we have multiple capabilities, or are we at risk with single points of denial?

GEN. CARTWRIGHT: My assessment is from the outside looking in. Anytime that you take quality over quantity as a purist approach you eventually get down to the one ship on each coast. And it's never in the right place at the right time.

In that construct, denial is pretty easy. You can either do it by destroying a single asset. You can do it by operating where that asset isn't. So, you pick your place and the time of conflict. So you are highly vulnerable. And that was the assessment when I was at STRATCOM.

The intent of the adversary is much harder to read. But in deterrence theory, you try to remove as many of the opportunities so that you basically herd your adversary to a known approach. Okay?

So, if you take away land-based ASAT because it's just not feasible because of the number of assets up there. You know, you're expending $300 million against, you know, a $10 million asset and it doesn't make any sense and even its loss doesn't really affect the system, is where you want to move. That's the objective.

And we are starting to do that aggressively. The commercial sector is moving even more aggressively than the Department of Defense, quite frankly. Not that the Department isn't trying and moving in that direction. But they've got some exquisite assets up there for which they do not yet have a strategy to move to a disaggregated architecture. They are moving in that direction, though.

So, to me, that's where you want to start to think about the issue.

COMMISSIONER WESSEL: And do you have an assessment of that sort of vulnerability period?

GEN. CARTWRIGHT: Yeah. My sense is that we've probably got another three to five years in that vulnerability period. It will probably be longer for certain things, certain capabilities.

But to the extent that -- and I tried to make it clear in the paper, too, is that I'm not looking for the perfect solution. I never lived in that world of there's a perfect solution for

anything here.

So the expectation is you will be attacked. The question is how high a price is your adversary willing to pay, and then how long can they impose that on you in a temporal sense.

So, if I have a Humvee running around the battlefield, I generally think that an adversary could take it out for a period of 30 days max. And then I'll have either a new one or a repaired one back on the field.

The measure of merit in space now needs to come down from months to days to hours. And disaggregation will allow you to do that. Reuse will allow you to do that in a major way. And we are way ahead in reuse. They are aspiring to it. But you've seen how magical it is to watch reuse going on.

And to think if -- let me put it in this context. To think about an architecture today and a commercial sector that would have 2- to 4,000 assets in multiple planes, okay, that if you knocked out 50 of them it really wouldn't notice because the AI in that system moves those comms around at the speed of light. Okay?

But when you start to think about the future of something like that, then you're talking about every week you would have to launch somewhere between 50 and 80 satellites to replenish. Without reuse, that's not feasible. You cannot get to mass without reuse, without those constructs.

Now, there are other approaches, propulsion approaches and what not. But you can see it, and the commercial sector has really stepped up to that. And DoD is, you know, likely to take advantage of that, hopefully sooner rather than later. But we've got to get past some cultural challenges in that same vein.

COMMISSIONER WESSEL: Thank you.

GEN. CARTWRIGHT: Yes, sir.

CHAIRMAN BARTHOLOMEW: All right. I'm going to take the prerogative of the Chair. A lot of interesting ideas that you raise, General Cartwright.

I guess that I would start with, first, of course, acknowledging the terrible damage that STRATCOM has gotten recently from the weather and the importance of supporting the people who live and work there with resources and with moral support and everything.

But since your time at STRATCOM -- you said about sort of the dialogue that you had going on -- are you surprised at the progress that the Chinese have made in their space activities?

My experience over, I would say, the first 20 years that I was doing China policy is people in the military, our military, were consistently surprised at the progress that the Chinese military was making.

And I wondered, you know, sort of if you can go back to the perspective of looking forward from where you are and then looking back, are they where you thought that they would be or have they made more progress?

GEN. CARTWRIGHT: Like all things, it's uneven.

CHAIRMAN BARTHOLOMEW: Yeah.

GEN. CARTWRIGHT: I would say, for the most part, we're a little bit in denial, my community. More than surprised, we were in denial too long.

We, during my time at STRATCOM, you know, supported by some of you, moved aggressively into reuse, moved aggressively into disaggregation, et cetera. And then the country took a hiatus for probably six to eight years. Not any one person, just priorities that were out there and needed to be addressed.

We lost ground, quite frankly. And we are still in what, if I can do this, what Bob Gates

often termed, you know, we're trapped by this notion of the extreme, perfect platform, you know, the art of the exquisite.

And it's very difficult to move the industrial complex off of that. The commercial sector has fortunately led the way because the dollars and cents and the diminishing returns of that approach are where we are.

I mean, we're building a new platform that doesn't jump any higher, run any farther, carry anything more, and we triple the price. And so the diminishing returns is there. We have to start to push that.

I think culturally now the security apparatus has become more attuned to the imperative because of what the Chinese have done and how they have moved, more than it was totally surprised. I mean, it was kind of a, oh darn, we shouldn't have been not paying attention here. That's my opinion.

CHAIRMAN BARTHOLOMEW: All right. And then my second question is you raised the issue of the importance of cross-domain integration. And I was wondering if you could talk a little bit about your assessment of China's success or ability to do cross-domain integration, particularly in light of their military restructuring.

GEN. CARTWRIGHT: Yeah. They are -- first, cross-domain integration, in my terms, is the idea that a commander has at his beckon in any construct multiple ways to come at the adversary. And even if it occurs on land or in the sea or in space, using the other domains as maneuver space to outflank, so to speak, your adversary is essential.

In order to do that, you must have a command and control system that crosses that. So, unlike what we experienced oftentimes in past conflicts here recently, we could not put an Army division on the flank of a Marine division or vice versa because the two didn't have radios that could talk to each other. This is the credit card from the island when we're trying to get people out, I mean, to call on AT&T.

It is the responsibility of the service secretary who oversees that transition to ensure that the comms, that the command and control apparatus, crosses that domain. That's kind of point number one.

Point number two is the technologies that interface there. So, to the extent -- I will talk the word fires. It doesn't necessarily mean kinetic. It can mean non-kinetic. It can mean persuasion, any number of things. But fires have to be coordinated and have to pass across those domains as if they weren't there.

And if you come from orbital speed into the atmosphere, that's a big transition. Okay? It's a big transition for a physical asset. It's a big transition for a electronic spectrum asset. Okay? And you have to be able to do that, and somebody has to be sure that that's going to be the case. And so that's the criticality that I see.

And it's really not as -- there are very high technical issues. Heat management, thermal management systems and wave form management systems, et cetera, are critical. But it's probably for us more of a command and control issue.

When I look at my Chinese counterparts doing these same things, they're thinking about it from an organizational construct. And they are putting kind of like issues together, because they want to coordinate them and they know that they'll cross through each other. But they've not yet cracked the code on integrated operations. That's not pejorative to them. It's just that they haven't had the experience.

I spent some time in the field with a Chinese organization, military organization. And while I witnessed the use of some of the most exquisite capabilities, I'd seen rifles and pistols

and things like that, something as simple as how do you get out of a vehicle with a rifle barrel that's longer than the door opening totally has escaped.

I mean, but we've been working and at war for so long these things are just second nature to us. So that's a major advantage. And it's a hard one to overcome for them. I mean, all the technology and all the money in the world does not buy you that expertise.

CHAIRMAN BARTHOLOMEW: All right. Thank you. Commissioner Lewis?

COMMISSIONER LEWIS: General Cartwright, thank you so much for coming today and helping educate all of us. Like Commissioner McDevitt said before, we really didn't know about the space program that China is doing until we got involved with this hearing today.

I have two kind of questions for you. And one has to do with the Wall Street Journal article from yesterday that there are export controls that prohibit sale of satellites but they're able to rent the satellites instead. Is this a fallacy, because you said before about intent? The head of a Hong Kong company said he has deep affinity for the United States, but he's also a Chinese patriot. So does that mean that Hong Kong companies owe greater allegiance to China than they do to the United States? It seems, based on what he said, that they do. That's the number one question about the Wall Street Journal article.

The second is the recommendations that you were making before, what are the forces that oppose those recommendations that have to be overcome to put your recommendations into effect?

GEN. CARTWRIGHT: On the construct of communication satellites -- and these are commercial satellites being used and leased and rented and bought and sometimes operated depending on what type of satellite it is by the Chinese -- to the extent that those assets remain sovereign U.S. assets owned by a company, whatever it is, means that they are subject to U.S. law. And they are subject to U.S. norms and regimes.

And so when I look at an asset that is potentially being used just to move goods, services, et cetera, back and forth, the upside is that if we say, "just say no," okay, then we might hold onto the technology for, say, 18 more months before they just go off and do it themselves.

To do what -- when I was a kid, there were two strategies that the U.S. was looking at in the construct of the Cold War approaching. One was mutually assured destruction and the other one was entanglement. We have -- Kissinger has taken us, took us down the path of entanglement. And we have remained in that.

There are some really strong upsides to not bringing American business out of China, to not constrain American business in China, to allow commercial interests, but to protect them from the standpoint of the sovereignty and the intellectual property laws, et cetera that we have.

Should they be reviewed in this context because space -- I hate to say any place is different, but space is a little bit unique in these areas. They should be looked at. Okay? But denial of these would probably put us in a difficult position commercially. And you can witness this with any number of companies now that are being questioned about their loyalty to the United States in doing work.

But by the same token, when they drive our cars, when they use our phones, when they, et cetera, they become part of us. And the price then to stop that is a deterrent price that holds back conflict.

So you have to take the good and the bad here. I think it is worth the ex-sum side of the equation to look at do we have this right, do we have the protection of intellectual property in a digital world right? I think most people would say not yet. We need to keep working that.

But I wouldn't do it in the construct of competition with China and trying to exclude

them. I think that that might take us down a path that would be more like mutually assured destruction. And I don't really want to go that way again. That's my opinion.

COMMISSIONER LEWIS: What are the forces that oppose the recommendations you're making?

GEN. CARTWRIGHT: I think it's more along the lines of, are the resources available? We are starting to make this much more resource-friendly by reuse constructs. Okay.

Number two, I don't know. I drove tanks. I drove ships. I drove planes, whatever it is. These space things, why are they getting money? I want my new shiny other thing. What's the right balance?

At the strategic level, you have three kinds of forces: special, general purpose, and strategic. We have swung heavily to special forces. That pendulum is now starting to adjust back. And the cost of reconstituting the strategic forces is significant, particularly if we try to reconstitute them in kind. We have to think about what are our strategic capabilities. Space is one of them. Okay?

The resources that we put in -- I'm going to irritate people here a little bit. But the idea of the canonical triad is, you know, an idea of threes. Okay? But the idea here is that if you did it and thought about it from a point of cyber, of space, in other words, of domains of operation and maneuver, you get to a very different point in where the strategic architecture ought to be. And we have to start thinking about that.

It's easy to go back and do what you did. That's easy. For any leader, moving the institution to the future and the unknown is really what you get your pay for. And that's the difficult part here, because trying to forecast the future is almost -- you're almost assured to be wrong in some way.

CHAIRMAN BARTHOLOMEW: All right. I think we're actually ending right on time.

General Cartwright, thank you very much. We appreciate getting the wisdom of your views. And we very well may be back in touch with you with additional questions. Thank you so much for appearing today.

GEN. CARTWRIGHT: Thank you to the committee for doing this.

ADMINISTRATION PERSPECTIVE INTRODUCTION BY COMMISSIONER MCDEVITT

COMMISSIONER MCDEVITT: Our next witness today will testify about how the Department of Defense is preparing for an era of heightened competition in space between the United States and China.

Dr. Will Roper is the Assistant Secretary of the Air Force for Acquisition, Technology, and Logistics, ATL. In this position, Dr. Roper serves as the principal advisor to the Secretary and the Chief of Staff of the Air Force for research and development, test, production, and modernization efforts in the Air Force.

In addition to his Air Force responsibility, he also is the Service Acquisition Executive for the Joint Strike Fighter Program. Prior to his current position, Dr. Roper was the founding director of the Pentagon's Strategic Capabilities Office.

Dr. Roper completed his bachelor's and master's of science, both in physics, at Georgia Tech and received his doctorate in mathematics from Oxford University.

Dr. Roper, we're delighted that you're with us here today, and please begin.

OPENING STATEMENT BY WILLIAM ROPER, PH.D., ASSISTANT SECRETARY OF THE AIR FORCE FOR ACQUISITION, TECHNOLOGY, AND LOGISTICS

DR. ROPER: Thank you very much for the introduction, Chairman Bartholomew, Vice Chairman Cleveland. And thank you to all of the commissioners for taking on this very important topic. You have my written statement. I asked that it be read into the record. But I'm not going to read it to you today. I trust that you've read it. And we're going to have a great discussion.

We really do need to focus on space. And I'm glad that we're having the discussion of the seriousness of having a strategy. I got here based on space-based information today. I imagine many of you navigated here as well, because all of our lives are increasingly connected to this important domain.

And, more importantly, many investment firms are saying that more and more economic development is going to move to space. Some are saying one trillion by the year 2040. Others are going as high as three trillion. But with that much economic investment going into space, we have to treat it as a national security concern.

We've made great strides starting to think about space as a warfighting domain, as a contested domain where we will have to compete militarily while we compete economically. But we have to keep this domain safe and secure for all to see the prosperity that space offers.

So I look forward to your questions today. And thank you again for being willing to serve in this capacity.

PREPARED STATEMENT BY WILLIAM ROPER, PH.D., ASSISTANT SECRETARY OF THE AIR FORCE FOR ACQUISITION, TECHNOLOGY, AND LOGISTICS ADMINISTRATION PANEL QUESTION AND ANSWER

Testimony before the U.S. – China Economic and Security Review Commission

Hearing on "China in Space: A Strategic Competition?"

Statement of: William B. Roper, Jr.
Assistant Secretary of the Air Force
(Acquisition, Technology & Logistics)

Good morning and thank you, Chairman Bartholomew, Vice Chairman Cleveland, and members of the Commission, for the invitation to speak on this important topic. Throughout recorded history—and likely even before then—mankind has been inextricably linked to information from space. The waxing and waning of sun paths and moon phases provided critical information about seasons and time, and the stars, navigation over great and treacherous distances. What was once a seasonal, monthly, or daily connection is now nearly continuous. Satellites furnish time to within nanoseconds and position within meters, as well as 24-7 communication, imagery, weather, entertainment, and much more. Many of us likely got here today because our lives are connected to space.

The world space economy is currently valued at over $385 billion. At least 666 intelligence satellites from 38 countries monitor the globe; 790 communications satellites from 45 countries move critical data; 121 navigation satellites from six countries connect point As to point Bs; and 303 scientific satellites from 38 countries push the frontiers of learning. Of these, the United States accounts for 353, 391, 31, and 94 respectively—a 46 percent eagle's share if you do the math.

Having experienced nearly 7 percent annual growth for a decade, top investment firms predict over a trillion dollar space industry by 2040 with some going a high as 3 trillion. With space-based broadband, cheaper reusable rockets, and space tourism nearly here, and energy, mining, and transportation looking increasingly possible, our national interests—and treasure—are increasingly migrating to space and, correspondingly, our national security concerns.

Countries like China have already demonstrated their intention to escalate hostilities into space. First conducting a debris-forming anti-satellite test in 2007, China is developing antisatellite missiles and lasers that will be fully operational within a few years. Having opened this Pandora's Box, cyber, jamming, high-power microwave, and space-based weapons cannot be ruled out as future threats, especially when Kepler's laws make critical asset locations uncomfortably predictable.

With so much riding on industrializing space, it is naive to assume conflict will not reach escape velocity. Why fight a nation's stealth fighters, aircraft carriers, or brigade combat teams if you can defeat satellites that guide their maneuver, communications, and weapons? Why fight their military at all if their critical economic veins flow through space?

We can look the other way from our terrestrial comfort zone no longer. Wars will extend into space until a new theory of deterrence supplants the apparent advantages hostilities in space can provide. Consequently, the Air Force is developing options—and the training, manning, and equipping to use them—so that space is never our nation's Achilles' heel; rather, our strong shield protecting a new industrial revolution and all its exciting possibilities.

This is the hope emerging from Pandora's Box. The Air Force has maintained the world's most cutting-edge lethal force for over 70 years with systems known and unknown. We have been pioneers in uncontested space, providing GPS to the world, monitoring space debris to keep commercial satellites safe, detecting ballistic missile launches to defend our friends, allies, and the American people. Now that our gloves have been forced off, we are combining our warfighting and space know-how to contend with the threats we will likely face.

This Commission is tasked to address whether we are in a strategic competition with China in space. I hope you conclude "yes." Given growing global financial interests—concurrent with China's present militarization of the Final Frontier—we must not be late to recognize the importance of new thoughts, policies, technologies, and coalitions to overcome future challenges to global development and exploration in space. As part of what must be a national approach, our present Air Force budget reflects the seriousness of keeping space safe and secure for all.

The Air Force's space budget request is $14 billion—17 percent larger than last year's. But it isn't just larger—it incorporates speedy acquisition authorities, faster contracting approaches, and strategic industry partnerships to compete against emerging space threats—over decades if need be—to keep this domain safe for worldwide exploration and economic development. Our eyes are on the threat; our ears, on the warfighters' needs; and our foot, on the development accelerator.

Though much of our space strategy and capabilities are classified, I can share some highlights in three areas: space warfighters, fast acquisitions, and industry base expansions.

Space Warfighter

Everything we do is about the warfighter: those current and those in future. The Air Force is building multi-domain Airmen to fight as part of a joint force. Just like cyber, no scenario of conflict decouples from space, so our warfighters must be fluent with every Service, every adversary, and every contingency. Our recent budget request funds advanced force development, adding 19 weeks of space warfighter courses, a U.S. Space Command to conduct operations, and initial planning efforts for a U.S. Space Force.

From our Chief of Staff to our warfighters on the operations floor, multi-domain operations are driving new requirements and closer relationships with acquisition. The highlight of this budget is the Advanced Battle Management System. Envisioned as a family-of-systems replacement for the aging JSTARS, this capability will cut across all facets of the Air Force—air, space, and cyberspace—trailblazing a path for how we design and use future distributed systems.

With so many new challenges driving new approaches to space-based capabilities, it is no wonder a faster, smarter acquisition system is a top priority for our Service Secretary.

Fast Acquisitions

Restoring a competitive mindset to how we design, manufacture, and sustain war-winning systems has taken deep root in our new space programs. New authorities and close partnership with our warfighters have revved our acquisition engine, removing 92.75 years of unnecessary schedule on our Century quest to reach 100—21.5 of it comes from space. Stealing time back from our adversaries and giving it to space warfighters is a paradigm that must become the norm. Thankfully, we have talented space operators and acquisition professionals itching for the change, and this past year, we empowered them to affect it.

First, we reorganized the Space and Missile Center, adding three new Program Executive Officers—our highest acquisition positions—with delegated authority to speed decision velocity. They aggressively applied Section 804 authorities and Tailored 5000 approaches to accelerate new satellite programs. Next-Gen Missile Warning is on track to deliver 3.5 years early. Protected

Tactical Enterprise Service is fielding on carrier strike groups 1.5 years ahead of schedule. Our strategic, tactical, and polar SATCOM programs combine for 8 years of acceleration—and the latter received the Department's top acquisition award for proposing a U.S. payload on a Norwegian satellite, saving time and money. Not just fast, smart too.

Second, we stood up our second software factory in an Air Force-wide shift to agile software development. Like our Boston-based Kessel Run, named from Star Wars, Los Angeles now has Kobayashi Maru, named after Star Trek's impossible training scenario that Kirk hacked to win. Inspired by this, Kobayashi Maru is hacking space command and control with developers and operators working side by side, pushing code to warfighters in months, not years. Having delivered their first increment to Air Force Space Command, we are excited to see more space programs shift to agile software development. We are also glad our naming convention is balanced between the Star Wars and Star Trek universes. Hopefully, the gods of "nerd-dom" will smile on our new software motto: "May our Force live long and prosper."

Third, we are focused on contracting reform. Prototype contract awards at the Space and Missile Center are down to 90 days—twice as fast as historical norms—and contingency contracting to provide overhead support to California's battle against deadly wildfires completed in 8 hours. These steps are part of longer journey to bring down times for all contract types. We must have speed when our nation needs it.

Fourth, to accelerate classified capabilities, we stood up the Space Rapid Capabilities Office and initiated three classified programs that continue in this budget. Patterned after the awesome office that manages our X-37 spaceplane, this new Program Executive Office brings our space total to five, increasing decision speed while developing the aces our space warfighters need up their sleeves.

Fifth, we have expanded external partnerships with DARPA and the Strategic Capabilities Office on disaggregated Low Earth Orbit constellations and new classified systems. Lowering risk on high-payoff technologies helps us leapfrog the valley of death and, hopefully, future threats. Our door is always open for new partnerships where we see the potential for speed and delivering for the warfighter.

Expanding Industrial Partnerships.
As we accelerate programs, we are also looking ahead at the long-term health of our partnerships with traditional defense companies and commercial ones too. We cannot compete over time—nor build the joint force we need—without a sustainable strategy for both types. We are calling on subject matter experts, and panels like this one, to help us get this complex issue right. But we are not waiting around to move out on steps we think will help.

One step is increasing competitive prototyping. Space programs like Next Gen Missile Warning, Enhanced Strategic SATCOM, and Protected Tactical SATCOM are using prototyping so that market entrants can compete with incumbents, induce better prices, and leave behind a stronger industry base for future programs. This strategic thinking needs to be everywhere and all the time in acquisition. Until opportunities to design, build, and launch critical satellites occur more frequently and routinely, we must plant seeds in programs to bear future fruit.

Another step is pursuing collaborative development partnerships when defense and commercial interests align. Launch Service is a fantastic example of Defense spending spurring a new commercial launch industry that meets national security requirements. We are also beginning collaboration with industry on how truly operationally-responsive space might work. These examples are encouraging but need to become more commonplace. With so many services moving to space, the trend of dual-use capability partnerships should continue and expand.

A third step is significantly accelerating how we do business with space startups and commercial tech providers. Currently, awarding a contract in months is a flash for the government. For startups living hand-to-mouth, it is an eternity. As a result, we are not competing for the best space ideas in the accelerating tech ecosystem.

Orbiting our challenges to reach escape velocity should be easy, rewarding, and hopefully a bit cool. Instead, startups face an amusement park sign: "You must be this tall to ride the ride." I am excited we are finally taking it down.

On March 6-7, we held our inaugural Air Force Pitch Day in New York. We invited small businesses from across the country to pitch their ideas, and our venture team had 51 of them on one-page contracts, worth $8.75 million, in less than 15 minutes each. The fastest was done in three! This took place during a fantastic week of 242 small business awards, many of which were space-related.

With $660 million in small business innovation dollars available annually, we are an ideal space investment partner: our money is non-dilutive; our company equity requirements, nil; our return on investment expectations, conservative; our resources, significant; our payment speed, lightning; and our mission, nothing less than inspiring. With the Pitch Day authority now delegated to the field and our next event being an Air Force Space Pitch Day—we expect big things from small business dollars in future.

Conclusions

The Air Force is taking a big first step towards dealing with future challenges we face in space. With Pandora's Box open, the Air Force has moved out on designing defendable space, accelerating how we buy it, and training to use it in multi-domain conflicts. With so many space-related technologies on the cusp of maturity, the future is a deck of wildcards, where hands are difficult to predict. To compete and win, we have to be fast, work with our entire industry base, and have a few aces up our sleeves.

With recent budget initiatives, we have made a good start, but we must follow through with many more to be the security guarantor of a coalition strategy to compete and win in space. Like many, I hope for Great Cooperation—vice Great Competition—with China on many fronts. However, it appears a distant star in current skies. Until present constellations change, we must respect how much of our lives—like our forebearers—connect to space, but unlike them we must prepare to defend it to keep its future bright.

ADMINISTRATION PERSPECTIVE QUESTION AND ANSWER

CHAIRMAN BARTHOLOMEW: All right. I'll start. I think that sort of the challenge for all of us is, how do you get to a balance between protecting the security and allowing people access to all of these innovations? As you say, I mean, most of us got here using Lyft or driving with GPS or something like that.

How do you address that issue of the balance between protecting our national security and allowing these commercial activities to go forward? And then we have all of these questions, of course, with China's participation in these systems.

DR. ROPER: Madam Chairwoman, it's a tough time for space, because we live in an era today where there is so much technology that's available for innovation, which is very different than the scenario we were in in the Cold War, where most technology was being generated inside of governments. We were facing a competitor in the Soviet Union that we were economically isolated from. And the strategy for keeping national security was really based on technology exclusivity and being able to manifest technologies the other side didn't have in new military systems. And we used those to create deterrence and then ultimately win the Cold War.

We don't have deterrents, currently, in space. And I'm glad we're finally able to talk about space as a warfighting domain. That is the biggest change I've seen in the Pentagon in years.

There's too much economic viability. Too much military enablement runs through space. Why would you want to fight the Joint Strike Fighter if you can fight the satellites that support it getting where it needs to be? Why would you want to fight a carrier strike group if you can take out satellites that help it navigate?

So, now that we're able to talk about warfighting in space, we can talk about applying technologies that are available to create what will hopefully be a new deterrence model in space that is done in a coalition fashion.

We have had multiple international partners and allies reach out and have wanted to be part of space development with us. Heretofore, we have done space development as U.S.-only. We have a classification called NOFORN, no foreign nationals. We're now using the term YESFORN. We want to start with a coalition approach.

But we're going to have to move quickly, because the technologies that are going to change space are not going to be developed inside government laboratories. Some of them will. But a lot of them are going to come from commercial development.

And so we're going to have to adopt a DuPont model where time to market is how we keep our security. And anyone that can help us get to market quickly and share the burden for security in space, we've got to build those bridges now, because hopefully we can convince everyone in the world that it's just not worth fighting a war in space, that in a war in space everyone loses.

So let's keep it a peaceful domain for exploration and for economic development and prosperity and take off the table those potential benefits that I've previously mentioned.

CHAIRMAN BARTHOLOMEW: Dr. Roper, do you think that the Chinese view of space and the use of space parallels the view that you're putting out there about keeping it peaceful, using it sort of cooperatively?

DR. ROPER: I would hope so in future, Madam Chairwoman. Right now I don't believe that's the case.

We've seen China continue to develop weapons that are going to make space a contested

warfighting domain. Their ASAT test back in 2007 caught everyone off-guard. It created a lot of orbital debris that we now track to keep our satellites and commercial satellites and foreign satellites safe. And they've recently demonstrated their willingness to do directed energy programs against satellites.

And I understand their strategy. So, the world knows, based on our operations in the Middle East, how empowering space capabilities connected to terrestrial and air capabilities and sea capabilities are. The ability to navigate and put weapons precisely on target and do that anywhere in the globe is a huge enabler for our military and for our allies and partners.

So, if I were in their shoes, I'd be doing the same thing. Why fight the pointy end of the spear when I can catch the spear-maker, the thing that enables that spear? And so I understand why navigation and GPS and communications are things that China would see an advantage to being able to hold at risk.

And so our countermove to that is designing the next generation of systems that are able to defend themselves, that have tricks up their sleeves so that they're not things that are hoping that space will be a peaceful domain. They are things that anticipate it won't be and are able to take corrective actions and keep themselves operating.

CHAIRMAN BARTHOLOMEW: So, again, Dr. Roper, one of the challenges is the components of this technology that you are talking about are often manufactured in China. How do we maintain a technological edge when we are sometimes dependent on components for the very equipment that would be giving us a technological edge?

DR. ROPER: It's a fantastic question, something -- it's also very different than the Cold War. Supply chain is globalized. It doesn't appear that we can reverse that. We are very focused on trusted supply chains in the Department so that we can build and manufacture things that we need for critical assets, especially military assets.

But I also see an opportunity for us to pivot to new design models where we do fault-tolerant designs, where we distribute the design across multiple components of the supply chain.

Some of our rocket providers today, rather than having one mission computer they have four. And then every one of those computers has two processing chips, both different. And that spreads out the vulnerability across multiple components. And so you flip from a model where you're basically building a perimeter around your supply chain and saying "you can't get in and therefore I'm secure" to one where you say "you have to compromise the entire worldwide supply chain to hold me at risk."

We need to pursue both. We are not ready to downselect to one model or the other. But in order to work with this burgeoning economic ecosystem that's driven by that global supply chain, we would be unwise not to have a model that lives in that camp.

COMMISSIONER MCDEVITT: I know. Everybody has suddenly got their arm in the air. But Commissioner Lewis is next on my queue.

COMMISSIONER LEWIS: There's obviously a conflict between the Commerce Department that wants to aid the commerce of the United States, and Hong Kong plays a role here. As I mentioned to General Cartwright, there's a statement by the chair of a Hong Kong company who says "I have great affinity for America, but I'm a patriot of China."

Does this mean that the laws that we now have in effect to limit exports belongs in the Commerce Department as opposed to an agency of government that has a broader perspective than the Commerce Department?

And I think you may have read the Wall Street Journal article from yesterday. And they can't buy things, but they're renting our abilities. Do you think we need to change the laws that

are in effect today?

DR. ROPER: I think we will have to change many laws to be competitive in this century. So, the CFIUS laws that were grown in the last century are simply not as relevant in this century. And the administration has taken steps forward to implement the FIRRMA reforms.

But I think this is going to be the first step in what will have to be a continual evolution of the laws and regulations that make sure that the U.S. and our allies and partners are competitive and that give us access to that global supply chain while trying to create a level playing field.

I think the conundrum that we have is that the model that worked so successfully in the Cold War was really based on having an economy that's separated from the competitor. And now we don't. We're really going to have to be able to work with everyone in a way that makes sense for the level of trust we put in the partner.

And so I see the change we're going to have to make, in the Air Force particularly, is being a very good investor, the investor of choice in U.S. innovators. And we've made really great strides this year in working with commercial startups, being able to put them on contract and pay them the same day they pitch an idea to us, because we don't want them to go to someone that may be bringing in foreign investment. We want, if you've got an idea that's going to change the game in space, come to us first. We are your partner of choice.

And that works really well right now under current laws with U.S. companies. And we want to prefer them. But we certainly don't want to have a wall between us and international ideas, because if they don't come to us they'll probably go to China. So, all roads need to be downhill to the U.S.

And we do have the resources, the creativity, and the people to create a revolution of innovation in space. And I think we've taken a good step. But a step's not a journey. It's a long journey.

COMMISSIONER LEWIS: Is China the only competitor we have or is Russia also a competitor?

DR. ROPER: I believe Russia is, as well. I typically will say China because this commission is focused on it. But we're going to have to deal with worldwide competition in space, especially threats to space security.

Nations that may not be able to afford stealth fighters, nuclear submarines, carrier strike groups, brigade combat teams, may find it very advantageous to develop weapons that are meant to hold their enablers at risk.

It's even broader than that, though. Those countries would be looking at cyber and gray zone operations. There are just a lot of domains of warfare in this century that appear to be the place that you would start, that take less time, money, and effort to get into the game.

And so we're going to have to worry about more threats, I expect, than just China and Russia. But right now they are the two that are foremost on my mind.

COMMISSIONER MCDEVITT: Just so everybody knows, Dr. Roper has a hard depart time at 11:00. So I wanted to get the rest of the questions in.

I have first Commissioner Wessel, then Commissioner Talent, then Commissioner Lee, then Commissioner Cleveland in the queue. So, we'll start down the queue. Mike?

CHAIRMAN BARTHOLOMEW: Quickly.

COMMISSIONER WESSEL: Thank you. And thank you for your testimony. And I appreciate what the NDS has done in terms of refocusing priorities and identifying some of our greatest threats out there.

Help me in terms of, let's call it, a window of vulnerability in the sense of you mentioned China's ASAT test, et cetera, their focus on space and cyberspace as the asymmetric critical domains. It seems that our recognition of their abilities in those fields has been underestimated and they're way ahead of some projections.

You talked about the ability to have a new acquisition model with four separate computers in a missile, et cetera, whatever it may be. I worry about still the supply chain issues and the AI software that may support them.

But where do you think we are in terms of catching up and getting ahead of the Chinese in terms of that window of vulnerability? Are we two, five years? What do you estimate it to be?

DR. ROPER: Well, Commissioner, as the person in charge of making sure we're ready for the worst day, it would be unwise for me to give you an exact answer to your question. But let me try to give you an answer that's in the spirit of the thread that you're pulling.

When I started the Strategic Capabilities Office, working for Secretary Carter and then Secretary Work and then Secretary Mattis, that was the very beginning of the Department talking about dealing with a peer again. Secretary Work used to open up by saying that was step one.

And at that point in time I was learning everything I could learn about fighting a conflict. We hope that one doesn't happen. We hope we're going to be able to deter it. But if we have to, what would it be like, and what technologies would we bring to bear, and what would be different in this century?

And, at that point in time, there was very little, like, recognition of the change that would be in place coming out of the Middle East into China. The thing that has been so valuable with the National Defense Strategy that I was fortunate I got to sit on the steering group that got to write it, is that we now have everyone in the Department talking about competition with China.

The level of vocabulary and thought and strategy that I see just sitting in Air Force meetings is amazing. I can't believe how fast the change has been. And we're now building systems that comport with that strategy. So I'm happy with how quickly we're able to pivot.

China's great strength is their patience. I admire that about them. And I fear that in them. But our great strength is we can change quickly. We can innovate quickly. I'd bet on innovators every day.

COMMISSIONER WESSEL: Thank you.

COMMISSIONER MCDEVITT: Commissioner Jim Talent.

SENATOR TALENT: Thank you. This is a real tonic. I hear you saying -- and if you really disagree with this a lot, say so, but don't unless you really do, because I have another question, and I'm moving quickly -- that, okay, we need to do everything we can to protect our supply chain, our systems, our technology. But, unlike the Cold War, we can't plan on the assumption that we're going to be able to do that. And, therefore, we have to build a strategy around redundancies, around work-arounds, et cetera, which I think is great because it plays to our strength, ingenuity, the ability to move quickly, et cetera.

Question for you. Is there a precedent in the Department's history that you think is similar to this that offers a model for how you're going to do this? The nuclear navy or something like that. I mean, when you talk with the Chief and the Secretary and the others, what's the frame of reference that you're using and working from, or is there one?

DR. ROPER: You know, I was very fortunate early in my career to spend a lot of time with Andy Marshall, who I dearly miss. And he was sharp and strategic and beyond his time, even in his last years. And I would pick his brain about all of the many, many challenges that he

got to see the Pentagon face and overcome. And I would ask him, like, is there a time that's like today?

And there are pieces of it. You could imagine the nuclear navy creating that. There's a new opportunity. There's a new window. There are new threats that we'll face. But there are new opportunities and threads from the beginning of stealth and being able to fly without being seen, but not really something that's perfectly analogous.

And it's crystalized for me being in this job. But there is something different about today. And it's always the -- maybe it's the hubris of the present that we say the present is always different. But I do think there is something different about today, because I can't find a point in history where there has been so much technology available and where its rate of change is so great and the technologies themselves are accelerating that rate of change. I think that is new.

And so that tells me that a Pentagon that is used to having a threat that it predicts in the future turns into a strategy, into a set of requirements, into a set of systems, that that process is now bunk. We don't know what the 2030 threat is going to be.

Space could end up becoming a massively important contributor to national security, especially if satellites continue to proliferate. AI could couple with it. But there are other things that could come along, too, quantum systems, biological systems. There's so much technology you can't keep up with it.

And so that tells me that if you stick with that Cold War acquisition model and pull it into this century, it's not going to work. And we see that it continues to shrink the defense industrial base. So the model we need to switch to is that DuPont model. We need to be faster at taking technology wherever it is and getting it into systems.

It's kind of like playing speed chess. You know, speed chess is less about making the perfect move. It's being able to make good moves faster than your opponent. The clock is your real enemy. I predict in the foreseeable future, the time that I serve, the clock is going to be our enemy. Even though China is sitting across the board, we're playing the clock.

CHAIRMAN BARTHOLOMEW: I wonder if clocks will even become obsolete.

COMMISSIONER MCDEVITT: Some people act like they already are.

(Laughter.)

Commissioner Lee?

COMMISSIONER LEE: Thank you very much.

And thank you, Dr. Roper, for being here today and for your testimony. Very interesting.

I wanted to probe a little bit on the issue of industrial competition in space, and it maybe follows up on some of the points that Commissioner Wessel made about sort of a window of vulnerability. And I'm sort of thinking about timing. Are there ways in which space maybe multiplies some of the questions that we already have on earth around kind of first-mover advantage or the danger of future predatory pricing, the danger of people acting now to gain an irreversible competitive advantage that we're not going to really notice until 5 or 10 or 15 years down the road?

Are there ways in which the U.S. Government intervention today could help us protect against some of that or that might be necessary, even beyond sort of just being open to lots of competition and opening the doors and unleashing the innovation of the American business community? Are there things that we need to be paying attention to now, because if we don't, we're going to miss a crucial moment?

DR. ROPER: There are, and I hope that we're doing them. There's a lot more to do to complete them, but I hope that we've started.

We have to build coalitions in space. We have to strengthen ones that currently exist, but bring new entrants in, because you and I got here today based on information in space. Well, increasingly, the entire world operates on that information as well.

There will be many opportunities for new partnerships where the members will not want conflict to extend into space, even though there are advantages if it does. I think we need to make this a coalition issue, a multinational issue.

But, in the foreseeable future, that security that will come from the coalition will be underwritten by U.S. military capability, similar to what we've seen in other domains, land, air, and sea. There's been a wonderful improvement to the quality of life in the world after World War II that's been underwritten by the security that the U.S. military brings. I think we undersell that. We don't teach people in this country what that has done, what the military has done to improve quality of life.

Well, space is going to be important for a next generation of technology and next generation of industry, and things that were crazy years ago, like mining in space and tourism in space, it's here. It's here. And it's going to make a lot of money and potentially improve life, another step change function.

But we would be naive to assume that, as long as our critical economic veins are exposed in space, that they will not be held at risk or that the appeal of holding them at risk will not pop up in every adversary's mind. So, we have to quickly show that our military might extends into space. It already does, but we're going to put even more focus there because of the threats that we face and make sure that our partners with us in space exploration or industry can count on us being able to keep their satellites safe, just like we've done against orbital debris for decades.

COMMISSIONER MCDEVITT: Commissioner Cleveland?

VICE CHAIRMAN CLEVELAND: Good morning.

I have two questions that are short, but I think complicated. Hoss Cartwright, who preceded you, talked about goals for space programs, including in our cases returning to the lunar surface; whereas, the Chinese seem intent on collecting asteroids for mining purposes. Could you lay out a couple of the key goals that you see as part of our space journey?

And then, the second piece, which is part of that, he also indicated that China's work in quantum communications and other advanced processing constructs set the stage for significant breakout capabilities. And I would like to know if you have some sense of what some indicators might be of what we should be looking for to prevent that breakout capability.

Thank you.

DR. ROPER: Thank you, Commissioner, or Vice Chairwoman in this case.

There are a lot of goals that we have in space. The ones I speak for particularly are for security because that's going to underwrite all the other goals that we hope to meet. We hope to build coalitions in space, so that we can share the burden of security and, also, the benefits, and then continue to expand industries into space. And you're seeing things like broadband and global surveillance, even signature intelligence, start to become commercial fields. I think we're going to see a lot of fields transition into space in the space renaissance that we see.

And then, of course, outside of the Air Force's purview, exploration is back again. There appears to be a lot to learn from continuing to explore space, just like we've benefitted from so many technologies out of the original space conquest.

So, all that has to be done concurrently. But, without security to underwrite it, it will always feel fragile. And so, we have to do our part in the Air Force, in the Department, to make sure that space feels like a secure domain, just like air and sea and land feel like secure domains

today when the U.S. is operating there.

Your second point is an important one. There are new technologies that are important in their own right, but they couple to space. And quantum systems are some of those. Quantum encryption is an important technology if we're going to keep data secure. I guess its antagonist is quantum computing, which threatens to hold encryption at risk. It appears like quantum encryption is winning the race, and that's good for everyone. But we're going to have to think about how we would operate as a military in a world where you can't beat encryption, and maybe there is a way, and we have to think about a way to not beat the physics, but beat the machines that are creating the physics.

So, General Cartwright's statement is an important one to remind ourselves that, when we're talking about space, we're talking about a lot of other technologies that could go there to create a compounded effect.

COMMISSIONER MCDEVITT: I think we have a couple of minutes left, and I have one question for you, Dr. Roper. We've talked a lot about what the U.S. has to do, appropriately, given your job. But I wonder if you could think for a moment on, what are China's key disadvantages in space? And you mentioned patience on there. I'm not sure if that's a disadvantage or an advantage. But, anyway, what do you see, looking at it from your perspective, since we are in a competition, now that they have swept the Pentagon? What are those disadvantages?

DR. ROPER: Commissioner, probably also being the person in charge of building systems to take advantage of disadvantages, I should probably be a bit coy on that as well. I think China is a very interesting case. And I hope that in our thinking we won't default into the Cold War part 2. They're a different competitor, and they're not the same model. We're economically intermingled with them. So, I could see the potential for there being cooperation in a variety of fields with China, having a great cooperation model as opposed to a great competition model.

But human nature is human nature, and we all seek to make sure that our national interests can be achieved. And right now, holding space at risk appears to be something that China sees great efficacy in doing.

And so, I think if we can create a deterrent model in space, where it's clear, not just with the U.S. but across the globe, that warfare in space is a war where everyone loses, and no one wants to go there because of how catastrophic it would be to economies and just things that make daily life happen, that we would be able to generate a new era of discussion with China. But I don't see us earning our way to that era until we can close the door on those advantages, that conflict extending into space, reaching orbital velocity, would bring.

COMMISSIONER MCDEVITT: One quick followup. If China sees that the U.S. is overly dependent on space, and they see that as an inherent Achilles heel, it seems to me that they are rushing like lemmings to replicate our dependence on space, based on their notion of an informationized war, and what have you. So, are they, in fact, moving so quickly toward our dependence on space that your vision of mutual deterrence is potentially actually practical?

DR. ROPER: I think it's very possible, Commissioner. Everyone is getting connected to space. It's an amazing enabler, right? It helps so many fields of research by having centers in space. It helps areas of industry. It's really hard to not go the direction that an enabling technology is going. Those that try to be salmon in the stream of technology don't spawn the future.

So, we've got to go the direction that technology is going. And right now, technology

moving into space is creating wonderful capabilities for industry and military. I think as more and more people become intertangled in that web of space, the more pronounced it will be that a conflict there really isn't going to benefit anyone.

But, right now, as we're beginning the discussion -- and it's wonderful to be able to say publicly we're thinking about conflict extending into space, where we did not have the open door to that in the past. And I think that's something this Administration can take credit for. Now that we can have that discussion, we can think about how we start building a smart interdependency backed by defense, so that space can become that domain that feels more like the final frontier, and not a foreboding frontier.

COMMISSIONER MCDEVITT: I think we have a minute or so before you have to get up and go. So, I'm going to let Commissioner Wessel have his --

COMMISSIONER WESSEL: What I hope is a quick question and, if not, I would welcome followup later on, which is we had a hearing a couple of weeks ago on China and Russia. And Russia has been an important space power, but whether it's assets, economy, et cetera, they appear not to be as aggressive as China has been in looking at that domain. Has China essentially reaped what it can from Russia and is now moving forward and leaving Russia in the dust?

DR. ROPER: I think the way I would characterize the point you're making is that China brings an economic might that Russia does not bring. And so, Russia's strategy is very much based on being able to create maximum pain for least penny. And so, areas where you can have cyber effects or influence effects or gray zone effects or space, these are disproportionate areas. The penny you invest creates a pound of effect. So, I think that is why Russia views these domains the way they do.

China views them that way, but I think in a much more fulsome way. They can bring greater resources to bear. But they view this as a way to be able to hold a much broader set of capabilities at risk inside a much broader national plan.

China has the resource and the technical ability to compete in any domain. And so, that technological exclusivity model from the Cold War simply doesn't apply. And the technologies that are going to change the world are going to be commercial. Everyone will have access to them. And so, we're going to have to be able to get them into our operators' hands first to see that first-mover advantage and to continue to be able to do that time after time.

So that, in that speed chess model, we are always hitting the clock first. And the benefits and advantages that the technologies may give will likely be short-lived compared to the ones that we saw in the Cold War. So, we are changing from that chess model to speed chess, and we're really going to have to get it right at the start, because I think it will be tempting to default back into the Cold War part 2 logic, which simply does not apply to this competition.

COMMISSIONER WESSEL: We may have to go to 3D chess like Dr. Spock.

(Laughter.)

COMMISSIONER MCDEVITT: Thank you very much, Dr. Roper, for your very interesting comments. I think we're going to have a 10-minute break here before we resume.

Thank you very much.

DR. ROPER: In the spirit of your question, I hope that our efforts and your efforts live long and prosper.

(Laughter.)

(Whereupon, the above-entitled matter went off the record at 11:05 a.m. and resumed at 11:15 a.m.)

PANEL I INTRODUCTION BY CHAIRMAN BARTHOLOMEW

CHAIRMAN BARTHOLOMEW: We're going to go ahead and get started.

First, I just want to say I'm really struck by the sheer brainpower that we have appearing before us today, which is not to cast any aspersions on the brainpower of other people who come and testify before us, but we have so much technological expertise and physicists and mathematicians and rocket scientists, and people who deal in realms that some of us really have to struggle a little bit to grasp. So, welcome to all of you.

This first panel will address China's ambitions for global space leadership. We will begin with Todd Harrison, Director of the Aerospace Security Project and Defense Budget Analysis at the Center for Strategic and International Studies, who will testify about China's international space footprint.

Mr. Harrison leads the Center's efforts to provide research and analysis of defense funding, space security, and air power issues. Mr. Harrison joined CSIS from the Center for Strategic and Budgetary Assessments, where he was a Senior Fellow for Defense Budget Studies. He previously worked at Booz Allen Hamilton, where he consulted for the U.S. Air Force on satellite communication systems and supported a variety of other clients, evaluating the performance of acquisition programs. He is a graduate of MIT with both a bachelor of science and master of science in aeronautics and astronautics.

Todd, it's great to have you with us again.

Next, we will hear from Brian Weeden, Director of Program Planning for Secure World Foundation, about China's views regarding international laws and norms in space.

With nearly two decades of professional experience in space operations and policy, Dr. Weeden conducts research on space debris, global space situational awareness, space traffic management, protection of space assets, and space governance. Prior to joining SWF, Dr. Weeden served nine years on active duty as an officer in the U.S. Air Force, working in space and intercontinental ballistic missile operations. As part of U.S. Strategic Command's Joint Space Operations Center, Dr. Weeden directed the Orbital Analyst Training Program and developed tactics, techniques, and procedures for improving space situational awareness.

He has a bachelor's of science in electrical engineering from Clarkson University, an MS in space studies from the University of North Dakota, and a PhD in public policy and public administration from GW University in the field of science and tech policy. He's also a graduate of the International Space University Space Studies Program in Beijing.

Dr. Weeden, thank you for coming today.

Finally, we will hear from Namrata Goswami, an independent analyst and author, about China's space exploration ambitions. Dr. Goswami's work on outer space and great powers is supported by the Minerva Initiative Grant for Social Science Research. She spent nearly a decade at the Institute for Defense Analyses in New Delhi, and she was awarded the Fulbright-Nehru Senior Fellowship, supporting her work on China-India border conflict scenarios. She also served as a Jennings Randolph Senior Fellow at the U.S. Institute of Peace. She received her master's of arts in politics and administration from Pune University and her PhD from the Nehru University School of International Studies.

Dr. Goswami, thank you so much for traveling to be here with us today.

For each of you, please keep your comments to seven minutes.

And, Todd, we'll start with you.

OPENING STATEMENT OF TODD HARRISON, DIRECTOR, AEROSPACE SECURITY PROJECT AND DEFENSE BUDGET ANALYSIS, CENTER FOR STRATEGIC AND INTERNATIONAL STUDIES

MR. HARRISON: Thank you, and I want to thank the rest of the Commissioners for inviting me back here to testify on this important topic.

In the late 1990s, the United States adopted policies designed to thwart China's ability to access space-related technologies. But, over the past two decades, China has developed a human space flight program, launched and operated two rudimentary space stations, and, more recently, landed a lunar rover on the far side of the moon. Last year, China had more orbital space launches than any other country on earth, with 38 successful launches, compared to 34 for the United States and 19 for Russia.

While China was not a significant space power throughout the first four decades of the Space Age, its space capabilities have improved significantly over the past 20 years. As this Commission well knows, China is building a network of partnerships around the world as part of its One Belt, One Road Initiative.

Partnerships in civil space programs could be used as another lever to induce cooperation on earth. More specifically, China could use the prospect of human space flight missions to its new space station, to the moon, and one day to Mars, as an incentive for countries that otherwise could not pursue space ambitions to partner with it in ways that further China's terrestrial ambitions.

China is also advancing its military space capabilities. And to be clear, these military space capabilities are not, in and of themselves, particularly threatening or unusual. One should expect that a country with the second largest GDP in the world would have constellations of satellites for remote sensing, communications, and positioning, navigation, and timing.

Moreover, many of the types of space systems China is developing to support its military are systems the United States has had for decades. While China does not appear to be pulling ahead of the United States in any of these space technologies, it is, nevertheless, making progress.

What is concerning, however, are the advances China is making in its counterspace programs. Counterspace systems are designed to disrupt, degrade, or destroy the space systems we have come to rely upon for national security and economic prosperity.

The appropriate comparison in this dimension of the competition is not whether China has better counterspace systems than our counterspace systems. Instead, what we should be comparing are China's advancements in developing counterspace systems relative to our progress deploying protections against these threats. And in this respect, China appears to be gaining advantage over the United States.

Since China's much derided anti-satellite test in 2007, it has continued to develop, test, and operationally deploy a wide variety of counterspace systems. While it has not conducted a debris-producing test of its direct-ascent ASAT missiles since 2007, it has conducted additional tests, nearly one each year, that have demonstrated its ability to intercept satellites as high as geostationary orbit. With this capability, China can effectively hold all U.S. military satellites at risk.

China's SJ-17 satellite has also attracted attention because of its potential use as a testbed for co-orbital ASAT technologies and operations. This satellite has transited the geostationary belt in space, conducting several close approaches with other Chinese satellites. China has

previously tested other co-orbital systems with robotic arms that can grapple and physically manipulate other satellites.

China has also developed a wide range of non-kinetic counterspace capabilities that can threaten U.S. economic and security interests in space. China reportedly tested a satellite lasing system by illuminating a U.S. imagery satellite as it passed over Chinese territory.

China has demonstrated the ability to jam GPS signals and a variety of satellite communications bands, and it has expressed its intent in the past to use these non-kinetic counterspace capabilities to disrupt U.S. military drone operations in the South China Sea. In April 2018, China followed through on this threat by placing what appears to be truck-mounted jamming systems on Mischief Reef in the Spratly Islands.

These are just a few examples that highlight China's growing counterspace capabilities. China is developing, testing, and operationalizing counterspace weapons at a faster pace than we are making progress protecting our space systems against these threats. This is a competition we cannot afford to lose, and it is a situation that is at least partially of our own making because vulnerability invites aggression. Our slow pace in adapting to the growing threats our space systems face makes the prospect of conflict in space more likely because it incentivizes potential adversaries like China to challenge us militarily in space.

My central recommendation for this Commission, and for Congress, is that we need to rethink our approach to China when it comes to space. We need a multifaceted approach that simultaneously engages and deters. We should engage China proactively in civil space programs when we have shared goals and when our intellectual property and existing space partnerships are adequately protected.

Our policy of excluding China from human space flight and exploration missions to the moon and beyond has not slowed its rise as a space power. Worse, it may create an incentive for China to build an alternative coalition for space exploration that could undermine our traditional leadership role in this arena.

As we engage China more openly in civil space, we should simultaneously make a concerted effort to improve our deterrence posture in national security space. The United States needs to take immediate steps to improve the protection of our space systems against the type of counterspace threats China is developing and deploying. In some cases, this may be as simple as improving encryption and adopting satellite communications waveforms that are more resistant to jamming and spoofing. In other cases, it may require fielding entirely new space architectures that use a larger number of satellites in a variety of orbits rather than small constellations of big, fat, "juicy targets", as general Hyten has referred to them in the past.

To effectively deter conflict from extending into space, we must credibly communicate that we are prepared to fight a conflict that extends into space. Today, we are not adequately prepared for such a conflict, and our lack of preparation undermines deterrence.

China is a rising space power. Our policies must recognize this fact and adapt accordingly to protect our economic and security interests in space. While engagement and deterrence may seem like contradictory approaches at first, it is a strategy that served us well throughout the Cold War. We routinely partnered with the Soviet Union on civil space programs, such as the Apollo-Soyuz test project, while simultaneously deterring the Soviets from attacking our critical space assets. A similar approach can be used with China to create new channels of communication, reduce the risk of miscalculation, and dissuade dangerous developments in space.

Thank you.

PREPARED STATEMENT OF TODD HARRISON, DIRECTOR, AEROSPACE SECURITY PROJECT AND DEFENSE BUDGET ANALYSIS, CENTER FOR STRATEGIC AND INTERNATIONAL STUDIES

Statement before the

U.S.-China Economic and Security Review Commission

"China in Space: A Strategic Competition?"

A Testimony by:

Todd Harrison

Director, Defense Budget Analysis, Director, Aerospace Security Project
and Senior Fellow, International Security Program
Center for Strategic and International Studies (CSIS)

April 25, 2019

419 Dirksen Senate Office Building

While China was not a significant space power throughout the first four decades of the space age, its space capabilities have significantly improved over the past twenty years. In the late 1990s, the United States adopted policies designed to thwart China's ability to access space-related technologies. China responded by accelerating the pace of its space programs. Over the past two decades, China has developed a human spaceflight program, launched and operated two rudimentary space stations, and, more recently, landed a lunar rover on the far side of the moon. Last year, China had more orbital space launches than any other country on Earth, with 38 successful launches compared to 34 for the United States and 19 for Russia.[1] China has quickly become a major player in the space domain and has made significant advances in both civil and national security space programs. While these two streams of effort often overlap with one another, the missions involved are sufficiently different to warrant separate and distinct approaches by the United States.

China's plans for civil space programs include building a new modular space station with an expected lifespan of ten years or longer.[2] It plans to build a space telescope with a field of view 300 times larger than the Hubble Space Telescope and with similar resolution. This telescope will be placed in orbit near the space station to facilitate easier servicing missions throughout the life of the instrument.[3] China is also estimated to spend about $11 billion annually on civil and military space-related programs, a sum that is second only to the United States.[4]

It should be noted, however, that China's recent achievements in human spaceflight, in operating rudimentary space stations, and in landing an un-crewed vehicle on the moon are milestones the United States first achieved in the 1960s and 1970s. While China has made advancements in space technology, it is still behind the United States in many areas. And much of what China has achieved has been in space programs that are not inherently military, although many of the component technologies can be dual-use.

Space diplomacy has been an important component of overall U.S. foreign policy for decades, and China may see similar potential in its burgeoning civil space program. Many nations view space capabilities as a source of national pride. Having a space program brings a certain level of diplomatic clout, and partnerships in space—or the prospect of potential partnerships—can be a significant lure for smaller or less technologically advanced countries that otherwise could not pursue space programs independently.

To emerge as a near-peer competitor to the United States and as a true global power, China is building a network of partnerships around the world, as is evident in its One Belt, One Road

[1] Thomas Roberts, *Spaceports of the World* (Washington D.C.: Center for Strategic and International Studies, March 13, 2019).
[2] Ludovic Ehret, "China Unveils New 'Heavenly Palace' Space Station as ISS Days Numbered," *Phys.org*, November 6, 2018, https://phys.org/news/2018-11-china-unveils-heavenly-palace-space.html.
[3] Joan Johnson-Freese, "China Launched More Rockets into Orbit in 2018 than Any Other Country," *MIT Technology Review*, December 19, 2018, https://www.technologyreview.com/s/612595/china-launched-more-rockets-into-orbit-in-2018-than-any-other-country/.
[4] Bryce Space and Technology, LLC, *Global Space Industry Dynamics* (Alexandria, VA: Bryce Space and Technology, 2017), 3, https://brycetech.com/downloads/Global_Space_Industry_Dynamics_2017.pdf.

initiative.[5] Partnerships in space could be used as another lever to induce cooperation on Earth. More specifically, China could use the prospect of human spaceflight missions to its new space station, to the moon, and one day to Mars as an incentive for other countries to partner with it in ways that further its terrestrial ambitions.

In addition to its civil space programs, China is also advancing its military space capabilities. It is making rapid progress deploying its own *Beidou* constellation of satellites for positioning, navigation, and timing (PNT)—a rival to the U.S. Global Positioning System (GPS) which China claims will one day be more capable and accurate than the U.S. system. The *Beidou* constellation is expected to begin providing continuous global coverage sometime next year, and China has been offering access to *Beidou* as part of its One Belt, One Road initiative.[6] Since 2000, China has launched six new types of remote sensing satellites, with at least 76 operational remote sensing satellites on-orbit as of 2016. In addition, China has some 34 communications satellites on-orbit, at least three of which can be used to relay information from other satellites back to ground stations on Earth.[7]

To be clear, these space capabilities are not, in and of themselves, threatening or unusual. One should expect that a country with the second largest GDP in the world would possess such space systems. Moreover, many of the types of space systems China is developing to support its military are systems the United States has had for decades. While China does not appear to be pulling ahead of the United States in any of these technologies, it is nevertheless making progress.

What is most concerning, however, are the advances China is making in its counterspace programs. Counterspace systems are designed to disrupt, degrade, or destroy the space systems we have come to rely upon. The appropriate comparison in this dimension of the competition is not whether China has better counterspace systems than the United States' counterspace systems. Instead, what we should be comparing are China's advancements in developing counterspace systems relative to the United States' progress in deploying protections against these threats. And in this respect, China appears to be gaining advantage over the United States.

Since China's much derided anti-satellite (ASAT) test in 2007, it has continued to develop, test, and operationally deploy a wide range of counterspace systems. While it has not conducted a debris-producing test of its direct-ascent ASAT missiles since 2007, it has conducted additional tests—nearly one each year—that have demonstrated its ability to intercept satellites as high as geostationary orbit. With this capability, China can effectively hold all U.S. military satellites at risk.[8]

---

[5] China Power Team, "How Will the Belt and Road Initiative Advance China's Interests?," *China Power*, May 8, 2017, updated September 11, 2017, https://chinapower.csis.org/china-belt-and-road-initiative/.
[6] SUN Degang & ZHANG Yuyou, "Building an 'Outer Space Silk Road': China's Beidou Navigation Satellite System in the Arab World," *Journal of Middle Eastern and Islamic Studies (in Asia),* Vol. 10, No. 3, 2016, https://www.tandfonline.com/doi/pdf/10.1080/19370679.2016.12023286.
[7] Kevin Pollpeter, Michael Chase, and Eric Heginbotham, *The Creation of the PLA Strategic Support Force and Its Implications for Chinese Military Space Operations* (Santa Monica, CA: RAND Corporation, 2017), 8.
[8] Todd Harrison, Kaitlyn Johnson, Thomas Roberts, et. al, *Space Threat Assessment 2019* (Washington, D.C.: Center for Strategic and International Studies, April 2019), 11, https://csis-prod.s3.amazonaws.com/s3fs-public/publication/190404_SpaceThreatAssessment_interior.pdf.

China's SJ-17 satellite has also attracted attention because of its potential use as a testbed for co-orbital ASAT technologies and operations. This satellite, launched in November 2016, has transited the geostationary belt in space, conducting several close approaches with other Chinese satellites.[9] China has previously tested other co-orbital systems, such as the Aolong-1, with robotic arms than can grapple and physically manipulate other satellites.[10] Importantly, this co-orbital technology is dual-use: it can be used for peaceful purposes, such as removing harmful orbital debris and repairing other satellites, or it can be used for counterspace activities, such as disabling other satellites. However, it does not appear that China has used its co-orbital capabilities for destructive purposes.

China has also developed a wide range of non-kinetic counterspace capabilities that can threaten U.S. economic and security interests in space. China reportedly tested a satellite lasing system by illuminating U.S. imagery satellites as they passed over Chinese territory in 2006.[11] This technology could be used to cause irreversible damage that would render the attacked satellites useless. China has demonstrated the ability to jam GPS signals and a variety of satellite communications bands, and it has expressed its intent in the past to use these non-kinetic counterspace capabilities to disrupt U.S. military drone operations in the South China Sea.[12] In April 2018, China followed through on this threat by placing what appears to be truck-mounted jamming systems on Mischief Reef in the Spratly Islands.[13]

These are just a few examples that highlight China's growing counterspace capabilities. China is developing, testing, and operationalizing counterspace weapons at a faster pace than we are making progress protecting our space systems against these threats. This is a competition we cannot afford to lose, and it is a situation that is at least partially of our own making because vulnerability invites aggression. Our slow pace in adapting to the growing threats to our space systems makes the prospect of conflict in space more likely because it incentivizes potential adversaries, like China, to challenge us militarily in space.

My central recommendation is that we need to rethink our approach to China when it comes to space. We need a multifaceted approach that simultaneously engages and deters. We should engage China proactively in civil space programs when we have shared goals and when our intellectual property and existing space partnerships are adequately protected. Our policy of excluding China from human spaceflight and exploration missions to the moon and beyond has not slowed its rise as a space power. Worse, it may create an incentive for China to build an alternative coalition for space exploration that could undermine the traditional American leadership role in this arena.

---

[9] Colin Clark, "China Satellite SJ-17, Friendly Wanderer?" *Breaking Defense*, April 19,2018, https://breakingdefense.com/2018/04/china-satellite-sj-17-friendly-wanderer/.

[10] "China's new Orbital Debris Clean-Up Satellite raises Space Militarization Concerns," *Spaceflight 101*, June 29, 2016, http://spaceflight101.com/long-march-7-maiden-launch/aolong-1-asat-concerns/.

[11] Vago Muradian, "China Tried to Blind U.S. Sats with Laser," Defense News, September 25, 2006.

[12] Bill Gertz, "Inside the Ring: China targets Global Hawk drone," *Washington Times*, December 11, 2013, https://www.washingtontimes.com/news/2013/dec/11/inside-the-ring-china-targets-global-hawk-drone/.

[13] Michael R. Gordon and Jeremy Page, "China Installed Military Jamming Equipment on Spratly Islands, U.S. Says," *Wall Street Journal*, April 9, 2018, https://www.wsj.com/articles/china-installed-military-jamming-equipment-on-spratly-islands-u-s-says-1523266320.

As we engage China more openly in civil space, we should simultaneously make a concerted effort to improve our deterrence posture in national security space. Deterrence holds when an adversary believes the diplomatic, economic, and military costs of doing something exceed the likely benefits. The United States needs to take immediate steps to improve the protection of our systems against the types of counterspace threats China is developing and deploying. In some cases, this may be as simple as improving encryption and adopting satellite communications waveforms that are more resistant to jamming and spoofing. In other cases, it may require fielding entirely new space architectures that use a larger number of satellites in a variety of orbits rather than a small constellation of "big, fat, juicy targets."[14] Ultimately, to effectively deter conflict from extending into space we must credibly communicate that we are prepared to fight a conflict that extends into space. Today, we are not adequately prepared for such a conflict, and our lack of preparation undermines deterrence.

China is a rising space power. Our policies must recognize this fact and adapt accordingly to protect our economic and security interests in space. While engagement and deterrence may seem like contradictory approaches at first, it is a strategy that served us well throughout the Cold War. We routinely partnered with the Soviet Union on civil space programs, such as the Apollo-Soyuz Test Project, while simultaneously deterring the Soviets from attacking our critical space assets. A similar approach can be used with China to ease tensions, create new channels of communication, and dissuade dangerous developments in space.

[14] Sandra Erwin, "STRATCOM chief Hyten: 'I will not support buying big satellites that make juicy targets'," *Space News*, November 19, 2017, https://spacenews.com/stratcom-chief-hyten-i-will-not-support-buying-big-satellites-that-make-juicy-targets/.

OPENING STATEMENT OF BRIAN WEEDEN, PH.D., DIRECTOR OF PROGRAM PLANNING, SECURE WORLD FOUNDATION

CHAIRMAN BARTHOLOMEW: Thank you.

Dr. Weeden?

DR. WEEDEN: Thank you for the opportunity to address the Commission this morning.

As the 2018 National Defense Strategy laid out, the United States and China are engaged in a long-term strategic competition across diplomatic, information, military, and economic dimensions. In my opinion, far too much of the U.S. debate is focused on the military aspects of this competition to the expense of looking at the diplomatic aspects. And related to this, my testimony today addresses this diplomatic competition for the future of outer space governance and China's views on the laws and norms of behavior for space.

My oral testimony today reflects the aggregate knowledge insights from across Secure World Foundation's staff. Our perspective on this matter is informed by China's actions and statements in multilateral diplomatic space fora, particularly the United Nations Committee on the Peaceful Uses of Outer Space, COPUOS, and the Conference on Disarmament, and China's activities on orbit; specifically, their testing and development of counterspace technologies over the last 15 years.

To the best of our knowledge, China has complied with the existing legal principles and norms stemming from all four main space treaties, at least to the same extent that the United States and other major powers have. While it is possible that China may choose to break from those legal principles and norms in the future, we do not see strong evidence to support that conclusion, and doing so would contradict the diplomatic positions China has established over the last few decades.

In orbit, China has conducted multiple tests and demonstrations of rendezvous and proximity operations, RPO capabilities, in both low earth orbit and geosynchronous orbit, earth orbit, since 2010. There are no publicly-known cases of Chinese satellites approaching U.S. or other foreign satellites.

While some of these Chinese RPO activities may be precursors to co-orbital anti-satellite capabilities, they are entirely consistent with existing international laws and norms of behavior for space, and similar space activities, testing, and demonstrations are currently being conducted by the United States and Russia.

China has been an active participant within the major multilateral bodies and discussions on space governance. In COPUOS, which focuses mainly on the peaceful uses of outer space, China's statements and positions have generally been constructive to U.S. aims and interests, particularly in comparison to the recent behavior of Russia within COPUOS.

China differs from the United States on the topic of sovereignty in space and utilization of space resources. China has consistently echoed the perspective of developing countries that space is the common heritage of all humankind and any extraction or use of space resources should be done in an equitable manner and consistent with an international framework.

Within the Conference on Disarmament, the main body focused on space arms control and weaponization, China's main efforts have been to push for a new treaty on space weapons. China and Russia were coauthors of the Treaty on the Prevention of the Placement of Weapons in Outer Space, or PPWT, and continue to push for its adoption today.

China has also voiced strong support for the Russian proposal for No First Placement of Weapons in Outer Space pledge and has consistently highlighted the actions of the United States

as detrimental to outer space security.

China's statements and actions in multilateral fora and on-orbit activities lead us to conclude that China is largely complying with international laws and norms in space while also pushing for changes to better suit its national interests. China sees outer space governance as an underdeveloped area in transition where it can play a role to actively shape the outcome, rather than a framework hostile to its interests. Within the existing space governance framework, China is taking full advantage of the freedom of action provided by the gaps in the existing legal and normative framework for space.

To date, we have not witnessed any major gains for China in advancing its own interests over those of the United States in influencing or developing international space law or norms. What small gains China has realized in this area have been more the result of inaction or self-defeating actions by the United States than Chinese successes.

Our main policy proposal is to urge the United States to take a stronger leadership role in space governance discussions and help shape their development in a way that suits U.S. national interests. The United States did so successfully during the dawn of the Space Age and was able to enshrine American national interests at the core of the existing space legal framework, resulting in significant political, economic, and national security benefits to the United States.

Over the last several decades, the United States has ceded this leadership in multilateral space diplomacy to China and Russia, particularly on space security issues. To become an active leader in space diplomacy, the United States needs to be willing to make substantive proposals on current space governance challenges and mobilize support among its allies to push the proposals within international fora.

Congressional support is critical for this to happen, and Congress also plays an important role in ensuring the Department of State is properly resourced, staffed, and empowered to advance the United States interests in space diplomacy.

Retaking this leadership role would create an opportunity for the United States to help shape the future direction of space governance to suit its interests and those of its allies and private sector. The United States should also be willing to engage in dialog with both allies and competitors, including China, to better understand the context of the competition and avoid direct military conflict.

Thank you for your attention, and I welcome any questions you might have.

PREPARED STATEMENT BRIAN WEEDEN, PH.D., DIRECTOR OF PROGRAM PLANNING, SECURE WORLD FOUNDATION

Testimony before the U.S.-China Economic and Security Review Commission

Hearing on China in Space: A Strategic Competition?

April 25, 2019

Submitted by Dr. Brian Weeden

Director of Program Planning, Secure World Foundation

Executive Summary

There is a growing recognition among many countries that the existing space governance framework is not sufficient to deal with current trends and challenges: namely the democratization of space capabilities and technologies, the burgeoning commercial space sector, and the proliferation of military space and counterspace capabilities. Specifically related to the topic of today's hearing, there are active debates underway about how the space governance framework should be updated or modified to deal with national sovereignty, extraction and utilization of space resources, and potential for future conflict in space.

As the 2018 National Defense Strategy laid out, the United States and China are engaged in a long-term strategic competition across diplomatic, information, military, and economic dimensions. Far too much of the domestic U.S. debate has focused on the military aspects of the competition with China and correspondingly there has been far too little consideration of the diplomatic aspects. This part of the competition matters greatly, as it will help determine the future of the space governance framework and whether it continues to support U.S. national interests.

This testimony addresses outer space governance and China's views on space law, norms of behavior, and security-related topics such as the weaponization of space. It focuses on China's own views and interests in the multilateral space diplomacy fora, discusses whether those views conflict with the interests of the United States, and provides policy recommendations for Congress to address these issues.

My oral and written testimony today reflects the aggregate knowledge and insights from across Secure World Foundation's staff. Our perspective on this matter is informed by two main bodies of evidence. The first is China's actions and statements in multilateral diplomatic space fora, primarily the United Nations Committee on the Peaceful Uses of Outer Space (COPOUS) and the Conference on Disarmament (CD). In our role as an NGO, SWF has been an observer and participant at many of these discussions over the last decade, giving us first-hand perspective on how China views issues related to space law and norms. We also have had direct experience partnering with Chinese academic institutions and NGOs to organize workshops and discussions on topics ranging from space debris to commercial space.

The second body of evidence we drew from is China's activities on orbit, and specifically their recent testing and development of counterspace technologies over the last fifteen years. Our experience in this area draws heavily from the research done to support our recently updated annual report on Global Counterspace Capabilities, which is entirely based on open sources.

To the best of our knowledge, China has complied with the existing legal principles and norms stemming from all four main space treaties, at least to the same extent that the United States and other major powers have. While it is possible that China may choose to break from those legal principles and norms in the future, we do not see strong evidence to support that conclusion and doing so would contradict the diplomatic positions China has established over the last few decades.

In orbit, China has conducted multiple tests and demonstrations of rendezvous and proximity operations (RPO) capabilities in both low Earth orbit (LEO) and geosynchronous Earth orbit (GEO) since 2010. There are no publicly-known cases of Chinese satellites approaching U.S. or other foreign satellites. While some of these Chinese RPO activities may be precursors to co-orbital anti-satellite capabilities, they are entirely consistent with existing international laws and norms of behavior for space and similar space activities and testing and demonstrations being conducted by the United States and Russia.

China has been an active participant within the major multilateral bodies and discussions on space governance. In COPUOS, which focuses mainly on peaceful uses of outer space, China's statements and positions have been generally constructive to U.S. aims and interests, particularly in comparison to the recent behavior of Russia within COPUOS. For example, China was supportive of the effort to develop guidelines for the long-term sustainability of space and played an important role in COPUOS reaching consensus on 21 such guidelines in June of 2018.

On the topic of sovereignty in space and utilization of space resources, China has consistently echoed the perspective of developing countries that space is the common heritage of all humankind and any extraction and use of space resources should be done in an equitable manner and consistent with an international framework. Chinese legal experts have actively participated in multi-stakeholder discussions to develop governance frameworks.

Within the Conference on Disarmament (CD), the main body focused on space arms control, China's main efforts have been to push for a new treaty on space weapons. China and Russia were co-authors of the Treaty on the Prevention of the Placement of Weapons in Outer Space (PPWT), originally submitted in 2008 and updated in 2014, and continue to push for its adoption today. China has also voiced strong support for the Russian proposal for No First Placement of Weapons in Outer Space pledge and has consistently highlighted the actions of the United States as detrimental to outer space security.

China's statements and actions in multilateral space fora and on-orbit activities lead us to conclude that China is largely complying with international norms and law on space while also pushing for changes to better suit its national interests. China sees outer space governance as an underdeveloped area in transition where it can play a role to actively shape the outcomes rather than a framework hostile to its interests. Within the existing space governance framework, China is taking full advantage of the freedom of action provided by the existing legal and normative framework for space.

To date, we have not witnessed any major gains for China in advancing its own interests over those of the United States in influencing or developing international space law or norms. What smalls gains China has realized in this area have been more the result of inaction or self-defeating actions by the United States more than Chinese successes. For example, China, along with Russia, have successfully characterized the Trump Administration's rhetoric on "dominating space" and the Space Force as further evidence that the United States is a major threat to peaceful uses of outer space. This propaganda effort damages the ability of the United States to marshal its diplomatic allies and advance its own interests in space governance discussions.

Our main policy proposal is to urge the United States to take a stronger leadership role in space governance discussions and help shape their development in a way that suits U.S. national interests. The United States did so successfully during the dawn of the Space Age and was able to enshrine American national interests at the core of the existing space legal framework, resulting in significant political, economic, and national security benefits to the United States. For the last several decades, however, the United States has either "led from behind" or worked to actively block further progress, particularly on space security-related issues, despite growing international clamor for progress. This lack of U.S. leadership has given China and Russia the opportunity to advance their own agendas and interests.

To become an active leader in space diplomacy, the United States needs to be willing to make substantive proposals on current space governance challenges and mobilize support among its allies to push the proposals within international fora. Congressional support is critical for this to happen; ten years ago, Congressional resistance hamstrung the Obama Administration's efforts to support the voluntary, non-binding International Code of Conduct for Space that would have provided some minimal progress on these issues. Congress also plays an important role in ensuring the Department of State is properly resourced, staffed, and empowered to advance the United States' interests in space diplomacy.

Retaking this leadership role would create an opportunity for the United States to help shape the future direction of space governance to suit its interests and those of its allies and private sector. The United States should also be willing to engage in dialogue with both allies and competitors - including China - to better understand the context for the competition and avoid direct military conflict.

China's Participation and Activities in Multilateral Space Fora

China has been an active participant in the major multilateral fora for discussion on space governance issues for several decades. The two major fora are the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), where the original space treaties were negotiated and discussions on peaceful and civil space continue today, and the Conference on Disarmament (CD), where several arms control treaties have been negotiated and the weaponization and security-related aspects of space are actively discussed today. There are also independent Groups of Governmental Experts (GGEs) that are occasionally formed by the UN to create ideas or proposals on specific issues over a short period of time.

Although there are four main treaties establishing core principles of international space law and several decades of space activities, the outer space governance regime itself is still largely undeveloped compared to international law in the terrestrial, air, and maritime domains. There are still significant debates about the interpretation of key space law principles and no international court cases or decisions to draw upon for insight. Key issues under active debate include the authorization and oversight of private sector space activities, sovereignty and utilization of space resources, and the weaponization of space and potential for conflict in space. The diplomatic environment for these debates is influenced by national policies and legislation as well as diplomatic statements and positions in the key international fora.

This testimony addresses each of these three areas and China's position and proposals on major issues related to space law and norms and proposals in each in the following sections.

United Nations Fourth Committee and COPUOS

The major treaties forming the foundation of international space law were drafted and negotiated at the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) during the 1960s to the 1970s. Established as an *ad hoc* committee in 1958 and as a permanent UN committee in 1959,[1] COPUOS is a committee under the United Nations General Assembly, and is currently one of the largest UN Committees. COPUOS is currently the main multilateral forum for discussing issues related to the peaceful uses of outer space. COPUOS currently has 92 member countries and 41 non-governmental organizations as observers, including Secure World Foundation.[2]

COPUOS has two subcommittees, the Scientific and Technical Subcommittee, and the Legal Subcommittee. Both Subcommittees meet for two weeks each spring in Vienna, Austria, and their reports are considered and adopted by the full COPUOS Committee (or "plenary") each summer, also in Vienna. Those reports are then sent on to the Fourth Committee of the United Nations General Assembly on Special Political and Decolonization Issues.

China was granted admittance to COPUOS in 1980 under UN General Assembly Resolution 35/16.[3] Additionally, China often makes statements concerning these basic principles of space law within this

[1] G.A. Res. 1472 (XIV) (Dec. 12, 1959), *available at* http://www.unoosa.org/pdf/gares/ARES_14_1472E.pdf.
[2] *Members of the Committee on the Peaceful Uses of Outer Space*, United Nations Off. of Outer Space Aff., http://www.unoosa.org/oosa/en/members/index.html (last visited Apr. 15, 2019).
[3] G.A. Res. 35/16 (Nov. 3, 1980), *available at* https://www.un.org/documents/ga/res/35/a35r16e.pdf.

Committee and has been an active participant in several of the COPUOS Working Groups on specific topics.

China's Adherence to Existing International Space Treaties

Along with numerous other nations, the Republic of China (Taiwan) signed the Outer Space Treaty on January 27, 1967, the first day it was opened for signature.[4] Subsequently, the People's Republic of China (PRC) became a successor State Party to the Outer Space Treaty. The Outer Space Treaty is the foundational international treaty regulating the activities of states in the access, exploration, and use of outer space, including the Moon and other celestial bodies, and establishes for states basic international legal rights and obligations pertaining to space activities. Many provisions of this treaty were subsequently expanded upon by later UN treaties on outer space, including the 1968 Astronaut Rescue and Return Agreement,[5] the 1972 Liability Convention,[6] and the 1975 Registration Convention,[7] all of which both the US and China are parties to. However, neither the United States nor China are parties to the 1979 Moon Agreement.[8]

In brief, states parties to the Outer Space Treaty enjoy the right to access, use, and explore outer space, including both 'void' space and celestial bodies.[9] The treaty establishes that these rights to access, explore, and use are not contingent upon permission of other states parties to the treaty, nor of the international community as a whole. Freedoms of access and use are therefore foundational norms of law applicable to outer space. Next, the treaty balances these broad freedoms with various obligations regulating state behavior (and the behavior of those they are responsible for). A main obligation is the prohibition on the placement of nuclear weapons or other weapons of mass destruction into orbit, or the placement of them on celestial bodies. Additionally, states are restricted from asserting territorial sovereignty over space, including over celestial bodies.

A number of obligations requiring states to take particular actions are also contained in the Outer Space Treaty. States bear international responsibility for national activities in outer space, whether such activities are carried on by governmental agencies or by non-governmental entities. They are additionally required that all these national activities are carried out in conformity with the Outer Space Treaty and with international law in general. States are also required to provide "authorization and continuing supervision" for space activities conducted by their non-governmental entities. This means that states are ultimately responsible for what their private entities (such as commercial entities) do in outer space and must ensure that these private entities observe international law. This is noteworthy because it is unique in

[4] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205 [hereinafter Outer Space Treaty], *available at* https://www.state.gov/t/isn/5181.htm//signatory..
[5] Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, Apr. 22, 1968, 19 U.S.T. 7570, 672 U.N.T.S. 119 [hereinafter Rescue and Return Agreement].
[6] Convention on International Liability for Damage Caused by Space Objects, Mar. 29, 1972, 24 U.S.T. 2389, 961 U.N.T.S. 187 [hereinafter Liability Convention].
[7] Convention on Registration of Objects Launched into Outer Space, Jan. 14, 1975, 28 U.S.T. 695, 1023 U.N.T.S. 15 [hereinafter Registration Convention]..
[8] Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, Dec. 5, 1979, 1363 U.N.T.S. 3) [hereinafter Moon Treaty].
[9] Outer Space Treaty, Art. I.

international law that the activities of commercial companies could implicate the international responsibility and potential liability of their authorizing government.

While China, like many other countries, lacks a comprehensive and uniform national space legislation, China has enacted two administrative regulations addressing the issues of launching and registration of space objects: the 2001 *Measures for the Administration of Registration of Objects Launched into Outer Space* (Registration Measures) and the 2002 *Interim Measures on the Administration of Licensing the Project of Launching Civil Space* (Licensing Measures).[10] Additionally, China has also enacted the *Interim Instrument of Space Debris Mitigation and Management* (Space Debris Interim Instrument). The Registration and Licensing Measures have been enacted in the form of departmental regulations, which constitute one of the lowest level of laws in China.

Over the past twelve years, China has issued a series of policy documents, the "white papers" on space activities, to complement the existing regulatory framework. The white papers are issued every five years by the Information Office of the State Council, and while they are not legally binding, they are significant because they reflect the growing size of Chinese space activities and the more active role played by China at the international level. The importance of the white papers is threefold: 1) they promote transparency over the nature of the Chinese space program and facilitate acceptance of China as a reliable partner for international projects; 2) they reinforce China's position of promoting the peaceful uses of outer space and respecting international obligations; and 3) they demonstrate that Chinese authorities are aware of the importance of giving a formal and consistent framework to the Chinese space program. Relatedly, Chinese authorities appear to be aware of the need for a structured national as; as stated by the Secretary-General of the CNSA in 2014, national space law has been listed in the national legislation plan, and the CNSA is directly engaged in the process of working towards enacting the legislation.

In cases where physical damage results from space activities, states bear potential international liability for any physical damage which is caused by space objects of which they are the launching state. These provisions found in Article VII of the Outer Space Treaty were expanded upon in the 1972 Liability Convention, of which both the United States and China are Parties to.[11] However, to date, there has never been a liability case brought to court under these treaties and there remain significant ambiguity as to what constitutes negligence in determining liability for damage to other space objects.

The Outer Space Treaty also requires that states treat astronauts from other states with considerable care, as 'envoys of mankind,' and that any personal or space objects from other states which land in a state's territory, or which they discover, shall receive assistance and returned to the original launching state.[12] These provisions where expanded upon by the 1968 Astronaut Rescue and Return Agreement, of which both the United States and China are parties to.

[10] Fabio Tronchetti, Space Law and China, Oxford Res. Encyclopedia of Planetary Sci. (2016), available at http://oxfordre.com/planetaryscience/view/10.1093/acrefore/9780190647926.001.0001/acrefore-9780190647926-e-66
[11] Liability Convention, *supra* note 6.
[12] Outer Space Treaty, Art. V.

The international registration of space objects, first called for in a UNGA Resolution in 1961,[13] was also subsequently expanded by the 1975 Registration Convention.[14] The United Nations Office for Outer Space Affairs (UNOOSA) keeps and regularly updates an online index of launched space objects, which contain basic orbital parameters and other identifying information. This information is supplied by states on a regular and voluntary basis. UNOOSA does not verify this data and posts it online for the purposes of having a publicly-accessible basic and centralized registry of space objects. The China National Space Administration (CNSA) maintains the Chinese registry, which was established in 2001.[15] China notifies UNOOSA of its space launches on a rolling basis. The UNOOSA online registry lists 23 such submission letters from China to UNOOSA since 1990.[16] As of April 1, 2019, the UNOOSA online registry lists 307 space objects as China's.[17] It is common practice for all States, including the United States, to register payloads and large rocket bodies but not small pieces of orbital debris.

China's Role in Developing Guidelines on the Long-Term Sustainability of Outer Space Activities

In 2010, the COPUOS Scientific and Technical Subcommittee created a Working Group on the Long-term Sustainability of Space Activities.[18] The goal of this effort was to expand upon the success of the international space debris mitigation guidelines to focus more broadly on effort to promote and enhance the long-term sustainability of space. The long-term sustainability guidelines ("LTS guidelines") generated from this Working Group were to be a compilation of existing best practices and focused on four main topics: sustainable space utilization supporting sustainable development on Earth; space debris, space operations and tools to support collaborative space situational awareness; space weather; and regulatory regimes and guidance for actors in the space arena.[19] For the purpose of transparency, SWF's current Executive Director, Dr. Peter Martinez, was the chair of this Working Group prior to coming to SWF.

China and the United States were both active participants in the LTS effort, with experts serving in each of the Expert Groups that began the process and then the subsequent political discussions. In general, China was a constructive participant in the discussions, particularly in contrast to Russia. From 2014 until the end of the LTS effort, Russia sought to undermine, delay, and obstruct the LTS discussions in response to the U.S. and European sanctions following Russia's aggression in Crimea and Ukraine. Notably, China (along with Brazil) broke from Russia during a key moment in the LTS discussions when Russia tried to halt the entire effort. China reaffirmed its support for the LTS discussions and in doing so assured their continuation despite Russian objections.

---

[13] G.A. Res. 1721 B (Dec. 20, 1961).
[14] Registration Convention, *supra* note 7.
[15] United Nations Committee on the Peaceful Uses of Outer Space, Information furnished in conformity with the Convention on Registration of Objects Launched into Outer Space, Note verbale dated 8 June 2005 from the Permanent Mission of China to the United Nations (Vienna) addressed to the Secretary General, UN Doc. ST/SG/SER.E/INF.17, available at http://www.unoosa.org/pdf/reports/regdocs/SER_INF_017E.pdf.
[16] United Nations Office of Outer Space Affairs, Notifications from States & Organizations: China, http://www.unoosa.org/oosa/en/spaceobjectregister/submissions/china.html.
[17] United Nations Office of Outer Space Affairs, Online Index of Objects Launched Into Outer Space, http://www.unoosa.org/oosa/en/spaceobjectregister/submissions/list/china.html.
[18] Committee on the Peaceful Uses of Outer Space, Report of the Committee on the Peaceful Uses of Outer Space, Fifty-third session, 150-168, U.N. Doc. A/65/20 (2010), *available at*: http://www.unoosa.org/pdf/gadocs/A_65_20E.pdf.
[19] Josh Wolny, *The UN COPUOS Guidelines on the Long-term Sustainability of Outer Space Activities – A Secure World Foundation Factsheet*, Aug. 2018, https://swfound.org/media/206227/swf_un_copuos_lts_guidelines_fact_sheet_august_2018.pdf.

The LTS Working Group was largely successful. In 2016, the first set of 12 guidelines were agreed to by a consensus of all the members of COPUOS and the mandate of the LTS Working Group was extended through 2018.[20] In 2018, the LTS Working Group reached consensus on nine more guidelines and the preamble text, bringing the total to 21, as well as agreeing to review their implementation and potentially update them.[21] However, last minute blocking actions by Russia prevented COPUOS from agreeing on a final report that could be submitted to the United Nations General Assembly. Despite this lack of a final report, many countries, including the United States and China, continue to regard the LTS effort as a success and discussed their national implementation of the LTS guidelines during the most recent STSC meeting in February 2019.[22]

China's Views on Space Mineral Resources and Sovereignty

Over the last few years, the topic of sovereignty in space and utilization of space resources, such as water or minerals, has become an increasingly salient topic in COPUOS. Concerns over the unequitable exploitation of space resources led to the negotiation and drafting of the Moon Treaty, which was opened for signature in 1979. However, the Moon Treaty failed to gain traction among most countries, with very few signatories compared to the other four main space treaties. The topic of space resources has been rekindled in recent years due to the rise of private sector entities planning to harvest asteroids or explore the Moon.

Governance of space resources remains an undecided issue. A few countries have taken steps to update their national regulations regimes to support such activities, notably the United States[23] and Luxembourg,[24] but most remain uncertain about the path forward. A minority of countries at COPUOS consider space resource utilization incompatible with the Outer Space Treaty's prohibition on national appropriation, or at least illegal without the sort of international governing framework outlined in the Moon Treaty. However, a majority of countries believe that it is possible to extract and use resources such as water, minerals, or regolith without running afoul of appropriation, but are not sure what the framework should be for doing so or what the constraints should be.

Chinese statements in COPUOS on sovereignty and utilization of space resources have generally been in line with the G77 voting bloc of developing countries. Specific statements were made by the G77 since 2017 emphasize equitable access and space as the province of all humankind and reinforce the need for an international coordinated framework for governance of space resource utilization to avoid gaps or

[20] United Nations, "Guidelines for the long-term sustainability of outer space activities," 10 October 2017, http://www.unoosa.org/res/oosadoc/data/documents/2017/aac_105c_1l/aac_105c_1l_362rev_1_0_html/AC105_C1_L362Rev01E.pdf
[21] United Nations, "Working Group on the Long-term Sustainability of Outer Space Activities: Preambular Text and Nine Guidelines," 8 February 2018, http://www.unoosa.org/res/oosadoc/data/documents/2018/aac_105c_12018crp/aac_105c_12018crp_18rev_1_0_html/AC105_C1_2018_CRP18Rev01E.pdf
[22] Secure World Foundation, "SWF Highlights Implementation of Sustainability Guidelines and Commercial Satellite Servicing Standards at UN," 18 February 2019, https://swfound.org/news/all-news/2019/02/swf-highlights-implementation-of-sustainability-guidelines-and-commercial-satellite-servicing-standards-at-un
[23] Jeff Foust, "House Passes Commercial Space Bill," *SpaceNews*, 16 November 2015, https://spacenews.com/house-passes-commercial-space-bill/.
[24] Andrew Zaleski, "Luxembourg leads the trillion-dollar race to become the Silicon Valley of asteroid mining," *CNBC*, 16 April 2018, https://www.cnbc.com/2018/04/16/luxembourg-vies-to-become-the-silicon-valley-of-asteroid-mining.html.

contradictions from domestic regimes.[25,26,27] Thus, China has positioned itself firmly in the camp of most developing countries who are concerned about "rich" States being able to access space resources to the exclusion of less advanced states..

At the same time, China is also open to governance frameworks for space resource utilization other than the Moon Treaty and has experts actively participating in such discussions. Since 2014, the main forum for these discussions has been the Hague International Space Resources Governance Working Group ("the Hague Group"), a multi-stakeholder group of companies, universities, governments, and non-government organizations.[28] The main purpose of the Hague Group is to identify and develop building blocks for the governance of space resource activities, which might form the basis of a common legal framework to enable space resources development in a manner consistent with the established treaty regime governing space activities at the international level. SWF was one of the founding partners in the Hague Group. The Chinese Ministry of Foreign Affairs is an observer organization to the Hague Group and an academic scholar from the Beijing Institute of Technology has been an active participant in the discussions.

United Nations First Committee and the CD

The United Nations General Assembly's First Committee focuses on disarmament and international security issues. It is the primary multilateral body where space security issues, including the militarization and weaponization of space, are discussed. The Conference on Disarmament (CD) is not an official body of the United Nations but is a major forum where security and arms control issues are discussed. Created in 1980 as a forum directly purposed on international disarmament negotiations, the CD meets in Geneva, Switzerland.[29] The CD and its predecessors were instrumental in drafting numerous arms control agreements, including the Treaty on the Non-Proliferation of Nuclear Weapons (1968), the Biological Weapons Convention (1972), the Chemical Weapons Convention (1993) and the Comprehensive Nuclear-Test-Ban Treaty (1996).

In 1985, the CD established an ad hoc committee to identify and examine issues related to the Prevention of an Arms Race in Outer Space (PAROS) due to strong concerns from many States about the weaponization of space.[30] The United States opposed giving the committee a negotiating mandate. The committee convened each year through 1994, with no further meetings occurring as a result of the objections made by the United States. Since 1994, the CD has co-mingled PAROS with the elimination of

[25] Statement of the G-77 and China during the Fifty-sixth session of the Legal Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space, 27 March - 7 April 2017, delivered by H.E. Ambassador Pilar Saborío de Rocafort, Permanent Representative of Costa Rica, https://www.g77.org/vienna/OOSAAPR17.htm.
[26] G-77 and China statement during the Fifty-seventh session of the Legal Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space, from 9-20 April 2018, delivered by H.E. Ambassador H.E. Ms. Vivian N.R. OKEKE, Permanent Representative of Nigeria, https://www.g77.org/vienna/OOSAAPR18.htm.
[27] G-77 and China Statement during the Fifty-eighth session of the Legal Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space, from 1-12 April 2019, delivered by H.E. Mr. Omar Amer Youssef, Ambassador, Permanent Representative of Egypt, https://www.g77.org/vienna/OOSAAPR19.htm.
[28] International Institute of Air and Space Law, The Hague International Space Resources Governance Working Group https://www.universiteitleiden.nl/en/law/institute-of-public-law/institute-for-air-space-law/the-hague-space-resources-governance-working-group.
[29] Conference on Disarmament, https://www.unog.ch/cd.
[30] *Proposed Prevention of an Arms Race in Space (PAROS) Treaty*, Nuclear Threat Initiative, https://www.nti.org/learn/treaties-and-regimes/proposed-prevention-arms-race-space-paros-treaty/ (last updated Sept. 29, 2017) [hereinafter NTI].

nuclear weapons, fissile material controls, and negative security guarantees and struggled to reach consensus on an agenda of work due to objections from one or more countries on at least one of those topics.

The Russia–China Draft PPWT

In 2008, China and Russia presented a draft Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects (PPWT) to the CD.[31] The PPWT sought to define "space weapons' and to prohibit their deployment into outer space, but was silent on the development, testing, and deployment of ground-based anti-satellite weapons.[32] In addition, the PPWT sought to establish a dispute resolution mechanism and an "Executive Organization" that oversees and enforces the PPWT.[33] The United States dismissed this proposal and characterized it as "a diplomatic ploy by the two nations to gain a military advantage."[34]

In 2014, Russia introduced to the CD an updated draft PPWT it had worked on with China.[35] There were many changes, including but not limited to changes to the definitions of many core terms, language regarding states' right of self-defense, the role of the Executive Organization of the PPWT, the dispute resolution mechanism of the PPWT, and the requirement needed to amend the PPWT.[36]

Also in 2014, Ambassador Robert Wood, the U.S. representative to the Conference in Geneva, said that the United States had completed an in-depth review of the PPWT and that the U.S. analysis concluded the new draft PPWT remained fundamentally flawed.[37] Reasons given include the lack of a definition of space weapon, lack of a verification mechanism, and no restrictions on the development and stockpiling of anti-satellite (ASAT) weapons on the ground. This, Woods said, would allow a nation to develop a readily deployable space-based weapons break-out capability should it decide to withdraw from the PPWT. Further, Ambassador Wood stated that terrestrially-based ASAT systems, not weapons in space, are the most pressing current threat to outer space systems, and the PPWT does not ban any of them.[38]

---

[31] *Id.*
[32] The placement into space of nuclear weapons and other Weapons of Mass Destruction (WMDs) are already outlined in Article IV of the Outer Space Treaty. Likewise, the 1963 Partial Test Ban Treaty prohibits the testing of nuclear weapons in the upper atmosphere, or in outer space. The transit of WMDs through space, such as ICBMs, is not currently impermissible under international law.
[33] NTI, *supra* note 28.
[34] Id.
[35] Permanent Reps. of the Russian Federation and China to the Conference on Disarmament, Draft Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects, U.N. Doc. CD/1985 (June 12, 2014) [hereinafter PPWT].
[36] *Id.*; Specifically, the changes included: the omission of the definition of "outer space." *Id.* at Art. I; a simplified and broader definition of "outer space object." *Id.*; a more expansive definition of "weapon in outer space," including component parts of the definition and allowing infliction of damage "by using any principles of physics." *Id.*; broadening the definition of "placed in outer space." *Id.*; separating and giving individual definitions for "use of force" and "threat of force." *Id.*; clarifying language with respect to recognizing that the PPWT does not affect States' rights to self-defense. *Id.* at Art. IV; expanding the role of the Executive Organization of the PPWT, which would consider matters related to the operation and implementation of the PPWT. *Id.* at Art. VI; clarifying that the dispute resolution mechanism in the PPWT is not obligatory unless a State decides to request another State clarify alleged failures to fulfill obligations under the PPWT. *Id.* at Art. VII; clarifying that the PPWT's dispute resolution mechanism does not override any issues that are subject to the Liability Convention. *Id.*; raising the requirement needed for an amendment to the PPWT from "majority vote" to "consensus." *Id.* at Art. XI.
[37] Jeff Foust, *U.S. Dismisses Space Weapons Treaty Proposal As "Fundamentally Flawed"*, SpaceNews (Sept. 11, 2014), https://spacenews.com/41842us-dismisses-space-weapons-treaty-proposal-as-fundamentally-flawed/.
[38] Id.

In 2015, Ambassador Fu Cong, Head of the Chinese Delegation at the Geneva Space Security Conference, made statements that the PPWT does in fact prohibit terrestrially-based ASAT weapons.[39] The Chinese ambassador then emphasized that the draft PPWT was open to further improvement and that they looked forward to any specific proposals for its amendment.[40] However, in 2017, Counsel Ji Haojun, at the working group on the "Way Ahead," stated a different interpretation that said the treaty does not prohibit land, sea, or air-based ASAT weapons outright, but that banning the use or threat of force against objects in outer space discourages the development of such weapons systems at exorbitant cost.[41] The counselor also stated that the national measures, consultations, and TCBMs in the PPWT were an effective means of ensuring compliance and verification.[42]

Over the last decade, China's statements and contributions in space security discussions have been remarkably consistent in promoting the PPWT and linking it to the broad concerns of the international community over the weaponization of space. In a panel discussion during an Outer Space Conference in Geneva in April 2017, Second Secretary of the Chinese Ministry of Foreign Affairs Mr. Li Zhang emphasized the role of the PPWT in fulfilling the peaceful purposes principle of the Outer Space Treaty and remarked how the notion had "broad international support."[43] During the 2018 iteration of this event, China's Ambassador to the UN in Geneva, Mr. Fu Cong, described China's approach to space security as driven by concerns over space debris and the risk of space becoming a battlefield.[44] These are just two of dozens of such examples of the consistent messaging by China on this issue.

No First Placement of Weapons in Space Initiative

In 2014, Russia was a lead sponsor of draft UNGA Resolution 69/32 proposing an agreement on "No first placement of weapons in space" (NFP) within the UN First Committee.[45] This resolution was adopted with a vote of 126 in favor, 4 against, and 46 abstentions in the General Assembly, with the US one of four the states voting 'no'.[46] In the explanation of its vote, the United States stressed that the NFP pledge was problematic, ineffective, and irrelevant to real issues in space security, because it was prone to the same flaws of the PPWT – namely, that space weapons are not defined, compliance with the NFP would be unverifiable, and that this pledge is again focused on space-based threats, rather than ground-based

[39] *Statement by Ambassador FU Cong, Head of Chinese Delegation at the Geneva Space Security Conf.*, Permanent Mission of China to the United Nations Off. at Geneva and other Int'l Org. in Switz., http://www.china-un.ch/eng/hom/t1291114.htm (last visited Apr. 12, 2019).
[40] Id.
[41] *Statement by Counselor Ji Haojun on the PPWT at the Working Group on the 'Way Ahead'*, Permanent Mission of China to the United Nations Off. at Geneva and other Int'l Org. in Switz., http://www.china-un.ch/eng/hom/t1472400.htm (last visited Apr. 12, 2019).
[42] Id.
[43] Li Zhang, "Remarks on the PPWT at the Outer Space Conference 2017," United Nations Institute for Disarmament Research, 21 April 2017, http://www.unidir.ch/files/conferences/pdfs/prevention-of-the-placement-of-weapons-in-outer-space-the-threat-or-use-of-force-against-outer-space-objects-ppwt-en-1-1238.pdf
[44] "UNIDIR Space Security Conference 2018: Conference Report," United Nations Institute for Disarmament Research, May 2018, http://www.unidir.ch/files/publications/pdfs/space-security-conference-2018-space-security-the-next-chapter-en-714.pdf
[45] United Nations General Assembly Resolution 69/32, No first placement of weapons in space, UN Doc. A/Res/69/32, Dec. 14, 2014, *available at*: https://undocs.org/A/RES/69/32.
[46] The US was joined by three other States (Georgia, Israel, and Ukraine) in voting against this resolution. UNGA Official Records, A/69/PV.62 pgs. 6-7, *available at*: https://www.un.org/en/ga/search/view_doc.asp?symbol=A/69/PV.62.

ASATs and other pressing threats to space security.[47] They also stressed that the NFPs flaws additionally did not meet the criteria for effective TCBMs on space security.[48] Nevertheless, the No First Placement Resolution was adopted by the UN General Assembly in 2014, and has been subsequently adopted in following years.

Although Russia has taken the lead in proposing and promoting the NFP concept within the First Committee, China has voiced strong support for the issue.

Groups of Governmental Experts on Space Security Topics

Occasionally, the United Nations will create an ad hoc group of experts to study a topic, known as a Group of Governmental Experts (GGE). This is generally done by the Secretary General to undertake a study on issues of concern and report findings at the UN General Assembly and may be directed or recommended by the UNGA resolution. A GGE is formed with a specific mandate to examine a topic for a relatively short period of time, usually one to two years, and attempts to reach consensus among its members before the end of that period. GGEs often include up to two dozen experts representing the socioeconomic and geographic diversity of UN member states. The experts are appointed by member states and expected to serve in an individual capacity, but often have instructions from their home governments about national positions.

Over the last decade, there have been two major GGEs convened to study space security topics. Both of the GGEs were driven by the on-going deadlock in the CD and failure of that body to make any progress on PAROS or space security issues. The GGEs were convened to try and find ways around the deadlock and reach consensus on ideas for enhancing space security that could be acceptable to a broad array of States. China and the United States were active contributors to both. One GGE was successful in reaching agreement, but the other was not.

2012-2013 GGE on Transparency and Confidence-building Measures (TCBMs) on Outer Space

UNGA Resolution 65/68 of December 5, 2010, "Transparency and confidence-building measures in outer space activities," (TCBMs) called for UN Secretary General Ban Ki-moon to establish a GGE on transparency and confidence-building measures on outer space activities.[49] TCBMs are means by which governments can share information with an aim of creating mutual understanding and trust, reducing misperceptions and miscalculations and thereby helping both to prevent military confrontation and to foster regional and global stability. The resolution was sponsored by Russia and China and while the United States publicly declared its support for the process, it abstained from voting on the resolution due to its mention of the PPWT. The resolution passed with strong support from the international community.

---

[47] Sixty-Ninth UNGA First Committee Explanation of Vote Before the Vote on: L.14, Agenda Item 94(b): "No First Placement of Weapons in Outer Space" by Ambassador Robert A. Wood Alternate Representative Delegation of the United States of America October 30, 2014, *available at*: http://reachingcriticalwill.org/images/documents/Disarmament-fora/1com/1com14/eov/L14_US.pdf.

[48] Hao Liu & Fabio Tronchetti, United Nations Resolution 69/32 on the 'No first placement of weapons in space': A step forward in the prevention of an arms race in outer space?, 38 Space Policy 64 (2016), available at https://www.sciencedirect.com/science/article/abs/pii/S0265964616300121.

[49] Group of Governmental Experts on Transparency and Confidence-Building Measures in Outer Space Activities, U.N. GAOR, 68th Sess. U.N. Doc A/68/189*, July 29, 2013, *available at:* http://www.un.org/ga/search/view_doc.asp?symbol=A/68/189.

The GGE on TCBMs in Outer Space consisted of 15 international experts nominated by Member States. The permanent members of the UN Security Council (China, France, Russia, the United Kingdom, and the United States) were guaranteed five of these 15 spots. The remaining spots were filled by countries selected by the UN based on State applications and on fair geographic representation. They were (in alphabetical order): Brazil, Chile, Italy, Kazakhstan, Nigeria, Romania, South Africa, South Korea, Sri Lanka, and Ukraine. The Russian expert was chair of the GGE.

The GGE on TCBMs in Outer Space met three times between July 2012 and July 2013 and managed to reach consensus on a set of voluntary TCBMs for enhancing space security. The GGEs recommendations included information exchange on national space policy and goals, and exchange of information on military space expenditures; information exchange on activities in outer space, including orbital parameters, possible conjunctions, natural space hazards, and planned launches; notifications on risk reductions such as scheduled maneuvers, uncontrolled high-risk re-entries, emergency situations, intentional orbital breakups; and voluntary visits to launch sites and command and control centers, and demonstrations of space and rocket technologies.[50]

The GGE on TCBMs in Outer Space was largely considered a success. It remains the only time in the last two decades that the United States, Russia, and China all agreed on a space security-related resolution within the UN. However, implementation of the recommendations from the GGE has been lacking.

2018-2019 GGE on PAROS

More recently, the UNGA convened a second GGE focused on space security-related issues. UNGA Resolution 72/250 of December 24, 2017, "Further practical measures for the prevention of an arms race in outer space", called for the UN to establish a GGE on PAROS, and specifically to consider and make recommendations on substantial elements of an international legally binding instrument on the prevention of an arms race in outer space, including, inter alia, on the prevention of the placement of weapons in outer space.[51] Any recommendations from the GGE were to be sent to the CD for inclusion in their deliberations.

The GGE on PAROS received strong international support, although the United States voted against it.[52] In explaining their vote, the United States expressed concern about China's use of the draft PPWT concepts in the GGE forum and reiterated its long-standing concern to use the PPWT as the basis for a legally-binding agreement. The US also stated "[i]t is also worth noting that this resolution offers an example of China's attempts to impose its national view of multilateralism and world geopolitics on the international system. Our countries cannot agree to this language but look forward to working with China

[50] *See also* Christopher Johnson, *The UN Group of Governmental Experts on Space TCBMs - A Secure World Foundation Fact Sheet*, *available at*: https://swfound.org/media/109311/swf_gge_on_space_tcbms_fact_sheet_april_2014.pdf.
[51] *Further practical measures for the prevention of an arms race in outer space*, UNGA Res. 72/250, Dec. 24, 2017, https://www.un.org/en/ga/search/view_doc.asp?symbol=A/RES/72/250.
[52] United Nations General Assembly, 76th plenary meeting Saturday, 23 December 2017, 11.30 p.m. New York, pg. 12, *available at*: https://www.un.org/en/ga/search/view_doc.asp?symbol=A/RES/72/250; *See also* United States Mission to the United Nations, Explanation of Vote in the First Committee on Resolution L.54: Further Practical Measures for the Prevention of an Arms Race in Outer Space, Oct. 20, 2017, https://usun.state.gov/remarks/8085.

and others in the months and years ahead to sustain and strengthen the international norms on which the global system is based."[53]

Nevertheless, the GGE on PAROS was established. The governmental Experts were from Algeria, Argentina, Australia, Belarus, Brazil, Canada, Chile, China, Egypt, France, Germany, Iran, Italy, Japan, Kazakhstan, Malaysia, Nigeria, Pakistan, Republic of Korea, Romania, Russian Federation, South Africa, United Arab Emirates, United Kingdom, and the United States. The GGE on PAROS was chaired by Ambassador Guilherme de Aguiar Patriota, Special Representative of Brazil to the Conference on Disarmament.

In addition to the official meetings of the GGE on PAROS, there were informal discussions both prior and during its work. Prior to its first official meeting in Geneva, a preparatory meeting was held in Beijing, convened by the United Nations Office for Disarmament Affairs (UNODA), together with the Ministry of Foreign Affairs of China, and the Ministry of Foreign Affairs of the Russian Federation. SWF Space Law Advisor Christopher Johnson was invited to serve as expert speaker at this meeting, and his presentation discussed the underpinnings of international obligations fostering collective security measures, gaps and insufficiency in existing international legal regime for outer space.[54] The Draft PPWT was mentioned numerous times by the Chinese and Russian experts present at this meeting, but it appeared that other GGE experts were not convinced that borrowing directly from the PPWT text was the desirable path forward. During the GGE on PAROS process, informative consultative meetings were held with non-governmental organizations who were also invited to provide written inputs. SWF was one of several organizations that submitted written suggestions for the GGE and PAROS in general.[55]

However, at the final GGE on PAROS meeting in March 2019, consensus on the final report was not reached. As the UNGA Resolution recommending the GGE mandated that its final report be adopted by consensus, and no consensus was reached, no final report will be released, and the GGE meeting ended without any deliverable.

Manuals on International Law and Military Activities in Space

Apart from the formal discussions on weaponization and space security in the First Committee and CD, there are also two informal efforts, led by universities, underway to try and define how international law applies to military activities in space. The Manual on International Law Applicable to Military Activities in Space (MILAMOS) Project[56] is led by McGill University in Canada, and the Woomera Manual is led by the University of Adelaide and the University of New South Wales-Canberra in Australia, the

[53] United states Mission to the United Nations, Explanation of Vote in the First Committee on Resolution L.54: Further Practical Measures for the Prevention of an Arms Race in Outer Space, Oct. 20, 2017, https://usun.state.gov/remarks/8085.
[54] Christopher Johnson, The Status of Norms Applicable to International Security and the Prevention of an Arms Race in Outer Space, International Workshop for the Prevention of an Arms Race in Outer Space, https://swfound.org/media/206199/cjohnson_gge_beijing_jul2018.pdf.
[55] Group of Governmental Experts on Further Practical Measures for the Prevention of an Arms Race in Outer Space, Working paper submitted by the Secure World Foundation, UN Doc. GE-PAROS/2019/WP.5, March 18, 2019, *available at*: https://undocs.org/pdf?symbol=en/GE-PAROS/2019/WP.5.
[56] McGill University, Manual on International Law Applicable to Military Activities in Outer Space (MILAMOS), https://www.mcgill.ca/milamos/.

University of Exeter in the United Kingdom, and the University of Nebraska at Lincoln in the United States.[57] SWF staff participate as experts in both projects.

Both projects bring together legal scholars and practitioners from militaries, universities, and non-governmental organizations to discuss how international law applies to military activities in space, both in peacetime and armed conflict. The Beijing Institute of Technology (BIT) is a partner institution in MILAMOS and a Chinese legal scholar participates in an individual capacity in the Woomera project.

Implications of China's Diplomatic Activities for Space Governance

China's activities outlined above show an overall support for, and compliance with, the existing international legal and normative framework for space. China is a party to the four main treaties establishing international law and principles for outer space and is complying with them, at least to the same extent as other spacefaring nations, including the United States. Like the United States, China is more than willing to exploit the lack of specificity or gaps in the existing legal framework to suit its national security interests.

While working within the existing space governance framework, China's activities in the international diplomatic environment also indicate that China wants to shape the future space governance framework to suit its national interests. Part of China's focus in this regard is to be seen as a major space power and playing a positive role in shaping space governance. This can be seen in China's constructive participation in the COPUOS LTS Working Group and China's role in pushing the LTS effort towards a mostly successful conclusion. On this topic, and most of the topics addressed in COPUOS, China's interests are either aligned with those of the United States or at least not in direct opposition.

The situation is different in the diplomatic fora addressing space security, such as the First Committee and the CD, where China is actively pushing proposals that are contradictory to U.S. interests. China, along with Russia, is an active proponent of the PPWT and NFP, which are largely constructed to position Russia and China as active defenders of peace and security in space. While the PPWT and NFP have not gained significant traction with the vast majority of countries, they are dominating the discussions because of the lack of any alternative proposals. There is a strong desire from many countries to address weaponization and space security topics, and the PPWT and NFP are designed to capture that interest.

China, along with Russia, has also been able to effectively frame the actions and policies of the United States as undermining space security while masking its own military space activities. This is due in large part to consistent and effective messaging and public diplomacy that leverages the United States' own domestic political rhetoric on space domination and warfighting.[58] However, it is also enabled by the lack of alternative proposals from the United States that address space security issues, the reluctance of the United States to discuss Russian and Chinese development of counterspace capabilities, and internal U.S. bureaucratic resistance to a stronger public diplomacy campaign of its own on space governance.

---

[57] "The Woomera Manual," *University of Adelaide*, retrieved from https://law.adelaide.edu.au/woomera/home.
[58] For example, see "Beijing: U.S. should stop weaponizing outer space, work with China, Russia," *China Global Television Network*, 10 April 2019, https://news.cgtn.com/news/3d3d414e3351544f33457a6333566d54/index.html

Chinese Rendezvous and Proximity Operations on Orbit

Another key source of information on what China believes about norms of behavior and space law is their actual activities on orbit. Actions and activities by a state in a domain can serve as evidence of state practice, which in turn can help create norms of behavior or even customary international law.

Recently, there has been a lot of concern about activities of Chinese satellites getting close to or interacting with other space objects. The formal term for these activities is rendezvous and proximity operations (RPO) and they generally involve on space object altering its trajectory to come close to another space object. RPO are not new to space; they have been around since the Gemini 8 mission in 1966 and used extensively for human spaceflight since then. Over the last 15 years, the technology for doing RPO between robotic spacecraft has improved significantly and is now being explored and demonstrated on orbit by commercial firms, civil government organizations, and militaries for a wide variety of applications. Chief among these are the emerging field of on-orbit satellite servicing (OOS), which includes the capability to approach, grasp, manipulate, modify, repair, refuel, integrate, and build completely new platforms and spacecraft on orbit. Some of these RPO capabilities and technologies could also be used to support national security space activities such as surveillance, intelligence collection, and even co-orbital anti-satellite weapons.

As a result of this dual-use nature, China's recent RPO activities have prompted significant speculation about the intent of these activities, whether they are co-orbital anti-satellite tests, and the degree of threat they pose to U.S. national security space capabilities. However, the actual details and nature of these activities are often far removed from their description in the media and by pundits. The following paragraphs provide summaries and relevant details about some of the recent Chinese RPO activities. Further details can be found in the recent SWF report on global counterspace capabilities.[59]

Chinese RPO Activities in LEO

The first known Chinese robotic RPO occurred in LEO in the summer of 2010 and involved the Chinese satellites Shi Jian-12 (SJ-12, 2010-027A, 36596), and the SJ-06F (2008-053B, 33409). The SJ-06F was launched on October 25, 2008, and the SJ-12 was launched on June 15, 2010. Both satellites were reportedly built by the Shanghai Academy of Spaceflight Technology (SAST) under contract to the China Aerospace Science and Technology Corporation (CASC).

In the summer of 2010, the SJ-12 initiated a series of deliberate changes in its orbital trajectory to approach and rendezvous with the SJ-06F satellite.[60] The maneuvers occurred over several weeks between June 12, 2010, and August 16, 2010, and indicated a very slow and methodical approach. On August 19, the two satellites had their closest approach, which was estimated to be less than 300 meters. A change in the orbital trajectory for the SJ-06F around that same time indicates that the two satellites may have bumped into each other, although at a very slow relative speed of a few meters per second. There were no external indications of damage to either satellite, nor any debris created by the incident.

[59] Brian Weeden and Victoria Samson, "Global Counterspace Capabilities: An Open Source Assessment," *Secure World Foundation*, April 2018, https://swfound.org/counterspace

[60] A more detailed technical analysis of this event can be found in Brian Weeden, "Dancing in the Dark; The Orbital Rendezvous of SJ-12 and SJ06F," *The Space Review*, August 30, 2010, http://www.thespacereview.com/article/1689/1.

The incident appears to have been similar to the bumping that occurred during the autonomous rendezvous attempt between NASA's Demonstration for Autonomous Rendezvous Technology (DART) satellite and the U.S. Navy's Multiple Path Beyond Line of Site Communication (MUBLCOM) satellite in April 2005.[61]

Another rendezvous between two Chinese satellites in LEO occurred in 2013. On July 19, 2013, China placed three payloads into roughly similar orbits around 670 kilometers altitude and 98 degrees inclination from the same launch: Shiyan 7 (SY-7, 2013-037A, 39208), Chuangxin 3 (CX-3, 2013-037B, 39209), and Shijian 15 (SJ-15, 2013-037C, 39210). The mission was publicly described by the Chinese government as "conducting scientific experiments on space maintenance technologies."[62] Public information at the time indicated the SY-7 was built by the DFH Satellite Corporation on behalf of the Chinese Academy of Space Technology (CAST), and likely carried a robotic arm being developed to support China's space station program, perhaps similar to the Canadian robotic arm used on the International Space Station. SJ-15 was built by the SAST and was reportedly an optical space tracking satellite similar to, but likely much less capable than, the U.S. Air Force's Space-Based Surveillance System (SBSS) satellite. CX-3 was built by the Chinese Academy of Sciences and was likely a small store-and-forward communications satellite that was the most recent in a series of such satellites.

More than a year later, in October 2014, an internet code repository was discovered that supported earlier claims that the three satellites were engaged in capture and surveillance activities. What was known publicly as SY-4 had an internal codename of Tansuo-4 and was designed with a teleoperated robotic arm that interacted with the separating subsatellite. CX-3 was known internally as Tansuo-3 and was designed to provide optical surveillance of space objects in geostationary and low Earth orbits. The SJ-15 was known internally as Tansuo-5 and was designed to maneuver and conduct proximity operations with other space objects.

In August 2013, the SJ-15 initiated a series of maneuvers to alter its orbit and bring it close to two other satellites. On August 9, the SJ-15 altered its altitude by a few tens of kilometers, which meant it passed above the CX-3 at a distance of a few kilometers before returning largely to its original orbit. On August 16, the SJ-15 altered its altitude by more than 100 km and its inclination by 0.3 degrees, which eventually led to a close approach of Shi Jian 7 (SJ-7), a Chinese satellite launched in 2005 (2005-024A, 28737), to within a few kilometers. Anonymous U.S. officials claimed that the rendezvous was part of a "covert anti-satellite weapons development program," and that one of the satellites "grabbed" another,[63] although the satellite with the arm, SY-7, was not involved in this particular RPO.

On October 18, 2013, the SY-7 initiated a small maneuver to raise its orbit by several hundred meters, and shortly thereafter released another object, which the U.S. military labeled Payload A Debris (2013-037J, 39357). The SY-7 and Payload A debris orbited in relatively close proximity to each other for several days, ranging between a few kilometers and several hundred meters, with some reports claiming

[61] Overview of the DART Mishap Investigation Results," NASA, accessed April 7, 2019. http://www.nasa.gov/pdf/148072main_DART_mishap_overview.pdf.
[62] Jonathan McDowell, posting on the NASAspaceflight.com forums, July 20, 2013, http://forum.nasaspaceflight.com/index.php?topic=30486.msg1076481#msg1076481.
[63] Bill Gertz, "China Testing New Space Weapons," *The Washington Free Beacon*, October 2, 2013, http://freebeacon.com/national-security/china-testing-new-space-weapons/.

the two objects may have physically joined with each other. However, the publicly available tracking is not accurate enough to confirm those claims. Both objects occasionally conducted small maneuvers throughout 2014 and 2015, although the separation distance between them never exceeded more than a few kilometers. This appears to be similar to the 2007 DARPA Orbital Express experiment, which involved two satellites, one with a robotic arm, separating and conducting a series of RPO with each other.[64]

In 2016, another Chinese satellite was launched that again created concerns about on-orbit grappling. The Aolong-1 (AL-1, 2016-042F, 41629), also known as the Advanced Debris Removal Vehicle (ADRV) or "Roaming Dragon," was a small satellite developed by Harbin Institute of Technology under contract to CALT to reportedly demonstrate using a robotic arm to capture a small piece of space debris for removal from orbit. Aolong-1 was placed into orbit on the first launch of China's new Long March 7 (LM-7) rocket on June 25, 2016, along with a scaled-down test version of China's next human spacecraft, a ballast mass, and a few small rideshare cubesats.

Although only a small part of the overall mission, the debris removal experiment generated significant press outside of China due to concerns over dual-use technology. Stories included an inflammatory report that quoted a researcher from the National Astronomical Observatories in Beijing talking about the potential for Aolong-1 to be used as a weapon system.[65] However, it is unclear whether the researcher was truly convinced that was indeed the motive for Aolong-1, or whether he was hypothesizing about military applications for debris removal technology in general, much as American scientists and officials often do.[66] The reality is that, according to U.S. military tracking data, the Aolong-1 did indeed separate into a 380 km by 200 km orbit but did not rendezvous with any other objects. The debris capture experiment appears to have been simulated, and the Aolong-1 does not appear to have altered its orbit during its short two months on orbit.

Chinese RPO Activities in GEO

China has also conducted RPO experiments in the GEO region. On November 3, 2016, China lofted the SJ-17 satellite (2016-065A, 41838) to GEO on the maiden launch of its new Long March 5 (LM-5) space launch vehicle. The SJ-17 was reportedly designed to test advanced technologies such as environmentally friendly chemical propellant, ion propulsion, quad-junction gallium arsenide solar panels, and an on-board optical surveillance sensor.[67]

---

[64] Lt Col Fred Kennedy, "Orbital Express Space Operations Architecture," DARPA Tactical Technology Office, accessed April 7, 2019, http://archive.darpa.mil/orbitalexpress/index.html.
[65] "Is China militarising space? Experts say new junk collector could be used as anti-satellite weapon," *South China Morning Post*, updated June 12, 2017, http://www.scmp.com/news/china/diplomacy-defence/article/1982526/china-militarising-space-experts-say-new-junk-collector.
[66] During a 2011 workshop organized by the National Research Council as part of a study of NASA's space debris program, participants stated that a Department of Defense plan to remove space debris did not go forward in part due to concerns that "most of the proposals had a weapons-like character about them". See National Research Council, *Limiting Future Collision Risk to Spacecraft: An Assessment of NASA's Meteoroid and Orbital Debris Programs*, Washington, DC: National Academies Press, 2011, https://doi.org/10.17226/13244, pg. 143.
[67] "China's Shijian-17 Satellite settles in Geostationary Orbit for Experimental Mission," *Spaceflight101*, November 24, 2016, http://spaceflight101.com/shijian-17-settles-in-geostationary-orbit/.

Several days after reaching GEO, the SJ-17 began maneuvering to place itself into the active GEO belt close to another Chinese satellite. It began with a maneuver on November 10 to lower its orbit and reduce its westward drift, and then a pair of maneuvers on November 11 to fully stabilize within the active GEO belt at a longitude of 162.9 E. This placed the SJ-17 relatively close to another Chinese satellite, Chinasat 5A (1998-033A, 25354). Chinasat 5A was originally built by Lockheed Martin under contract to the Chinese Communications Ministry and launched in 1998 under the name Zongwei 1 to provide commercial satellite communications services for southeast Asia. The SJ-17 made several small maneuvers to circumnavigate Chinasat 5A at a distance of between 100 and 50 km for several days, slowly closing in to within a few km on November 30, and then returning to a 100 to 50 km standoff distance.[68] The two satellite remained close until December 29, when commercial tracking networks reported that Chinasat 5A had begun drifting away.[69]

Since April 2017, the SJ-17 has been relatively active in the GEO region and demonstrated significant maneuvering capability. Between April and June it drifted to 215E and remained there until late when it drifted to 118 E. In January 2018, the SJ-17 began a rapid eastward drift at two degrees per day, followed by a rapid drift westward at four degrees per day starting on February 9. On March 20, the SJ-17 lowered its orbit to reverse its drift, indicating that it is doing fast survey of the GEO region. In January the SJ-17 also raised its inclination from 0.43 to roughly four degrees, before reversing back to zero in July.[70] This was unusual as most operational satellites in GEO are used to provide communication services and are station-kept to remain close to zero degrees inclination for optimal service. Additionally, the relatively sudden change in inclination suggests significant delta-vee capability as plane change maneuvers are among the most energy intensive.

On December 23, 2018, China launched another mission to GEO that has also exhibited unusual behavior. Like its predecessors, the Tongxin Jishu Shiyan (TJS)-3 satellite was launched from Xichang Space Launch Center into an elliptical geosynchronous transfer orbit (GTO). Few details are known publicly about the TJS series, the first of which was launched in early 2017. Chinese official media has described them as communications technology test satellites but observers believe they may also be testing missile warning sensors, deployable antennas, or other technology.[71] TJS-3 appeared to be similar in nature, and the U.S. military ended up cataloging two objects from the launch in GEO: the TJS-3 satellite (43874, 2018-110A) and a second object (43917, 2018-110C) that was assumed to be an apogee kick motor(AKM), a detachable rocket engine often used to circularize a satellite in GEO, as it was slowly drifting westward.

While the modern practice is to separate and dispose of AKMs above GEO for space debris mitigation, it is not uncommon for them to be in GEO. However, shortly after the separation, object 43874 did a series

[68] "In-Space Eavesdropping? – China's Shijian-17 completes High-Altitude Link-Up," *Spaceflight101* December 9, 2016, http://spaceflight101.com/cz-5-maiden-flight/shijian-17-rendezvous-with-chinasat-5a/.
[69] Analytical Graphics (@AGItweets), "ComSpOC has detected that #Chinasat 5A has departed SJ-17 & is drifting 0.9 deg/day westward. SJ-17 remains @ 163 deg," Tweet, December 29, 2016, https://twitter.com/AGItweets/status/814513003798364161.
[70] Jonathan McDowell, "Jonathan's Space Report," No. 754, October 8, 2018, http://planet4589.org/space/jsr/back/news.754.txt; Verified by data compiled from the public U.S. military satellite catalog at https://space-track.org.
[71] "China opens 2017 with obscure communications satellite launch," *Spaceflight101*, January 5, 2017, http://spaceflight101.com/long-march-3b-tjs-2-launch/.

of maneuvers to place it into a GEO slot at 59.07E, near TJS-3.[72] Object 43874 slowly drifted toward TJS-3 and according to Analytic Graphics exhibited photometry consistent with a stabilized object and not one that was tumbling. Thus object 43917 appears to be a subsatellite and not an AKM and maintaining a relatively close distance (100 to 200 km) from TJS-3.

Implications of China's RPO Activities for Space Governance

The activities of the SJ-12, SJ-15, SJ-17, and TJS-3 AKM are consistent with the demonstration of RPO technologies for the purpose of satellite servicing, space situational awareness, and inspection. Notably, it appears the U.S. intelligence community agrees with this assessment. A counterspace assessment released by the Defense Intelligence Agency (DIA) in February 2019 stated that China is developing capabilities for inspection, repair, and space debris removal that may also be used as a weapon but did not specifically state that any Chinese RPO activities was a weapons test.[73]

Based on the public evidence to date, China's RPO activities in LEO and GEO appear to be in line with similar activities conducted by multiple countries, including the United States. This includes the U.S. Air Force's XSS-10 satellite, which was used to do inspections of satellites in LEO in 2005 and 2006[74]; the Swedish Mango (2010-028B, 36599) and Tango (2010-028F, 36827) cubesats that were part of the Prototype Research Instruments and Space Mission technology Advancement (PRISMA) mission, which demonstrated cooperative rendezvous and proximity operations and formation flying in 2010[75]; and the U.S. Air Force's Micro-satellite Technology Experiment (MiTEx) satellites and Geosynchronous Space Situational Awareness (GSSAP) satellites, which have been conducting close-up inspections of U.S. and foreign satellites in the GEO region since 2016;[76] in addition to the other U.S. missions mentioned earlier.

It is also worth noting that no country has called out China's RPO activities, or similar RPO activities done by other States, as illegal or violating any norm of behavior. In fact, China's RPO activities in nearly every case have been preceded by similar or the same activities being conducted by the United States or other countries years, sometimes decades, earlier.

---

[72] See discussion of this in the following thread on the NASASpaceflight.com forums: https://forum.nasaspaceflight.com/index.php?topic=46903.0;all.
[73] Defense Intelligence Agency, "Challenges to Security in Space," February, 2019, http://www.dia.mil/Portals/27/Documents/News/Military%20Power%20Publications/Space_Threat_V14_020119_sm.pdf.
[74] Thomas M. Davis and David Melanson, "Xss-10 Micro-Satellite Flight Demonstration," Smartech.GATech.edu, https://smartech.gatech.edu/bitstream/handle/1853/8036/SSEC_SD3_doc.pdf;jsessionid=906BB52FE69F848048883B704DB20F07.smart2.
[75] "Prisma," OHB Sweden, accessed April 7, 2018, http://www.ohb-sweden.se/space-missions/prisma/.
[76] Brian Weeden and Victoria Samson, Global Counterspace Capabilities: An Open Source Assessment, *Secure World Foundation*, April 2019, section 3-1, https://swfound.org/counterspace.

Appendix

Table 1 - Recent Chinese Rendezvous and Proximity Operations

Date(s)	System(s)	Orbital Parameters	Notes
June – Aug. 2010	SJ-O6F, SJ-12	570-600 km; 97.6°	SJ-12 maneuvered to rendezvous with SJ-06F. Satellites may have bumped into each other.
July 2013 – May 2016	SY-7, CX-3, SJ-15	Approx. 670 km; 98°	SY-7 released an additional object that it performed maneuvers with and may have had a telerobotic arm. CX-3 performed optical surveillance of other in-space objects. SJ-15 Demonstrated altitude and inclination changes to approach other satellites.
Nov. 2016 – Feb. 2018	SJ-17, YZ-2 upper stage	35,600 km; 0°	YZ-2 upper stage failed to burn to the graveyard orbit and stayed near GEO. SJ-17 demonstrated maneuverability around the GEO belt and circumnavigated Chinasat 5A.
Jan. 2019	TJS-3, TJS-3 AGM	35,600 km; 0°	TJS-3 AKM separated from the TJS-3 in the GEO belt and both performed small maneuvers to maintain relatively close orbital slots.

OPENING STATEMENT OF NAMRATA GOSWAMI, PH.D., SENIOR INDEPENDENT ANALYST

CHAIRMAN BARTHOLOMEW: Thank you.

Dr. Goswami?

DR. GOSWAMI: I would like to thank the Commission for this opportunity to appear before it. The Commission posed certain broad questions to me, and I'll answer based on those questions.

The first was the current status of China's space program. I would argue that China's capability to launch, establish presence, and conduct deep space exploration and resource utilization has undergone significant shifts in the last few decades. Just last year, China achieved the world's largest number of space launches, has the second largest number of operating satellites, and also landed Chang'e-4 on the far side of the moon. Most interestingly, this year China established the first state-funded space-based solar power plant in Chongqing. The plant is funded up to $13 billion.

The Chinese state-funded space program is currently estimated to be about $8 billion, but Euroconsult estimated that the size of the Chinese space value chain is about $16 billion in 2017. In 2018 alone, the Chinese commercial space industry received about $2 billion in investment, and China has about 11 Chinese private space startups since 2019.

The second question was based on China's future space goals. So, No. 1, China intends to be the No. 1 space power by 2045. At the highest levels of PRC policy, China has set itself a goal to exceed all other nations by 2049, in time for its 100-year celebration of the establishment of the PRC.

By 2040, China has a grand design of its space infrastructure and activities that will make it a comprehensive space power, which includes full conversion to reusable launch vehicles by 2025; operation of nuclear power shuttles for the purposes of asteroid mining, settlement, and exploration by 2040; an operational solar power satellite in geostationary orbit by 2050; a permanent industrial facility on the moon, and to be industrializing the moon with a purpose of building solar power satellites.

China's Lunar Exploration Space Program, which is a very important part of the China White Paper and supported at the highest level, has announced ambitions from 2019 to 2036. In 2019, they are sending a rover to the near side to collect lunar rocks for purposes of scientific exploration, and by 2036, they want to establish a research base on the moon.

China is also investing in this interesting future concept of space mining, which was spoken about this morning. And so, the idea is to actually capture an asteroid by 2029 and bring it back to earth by 2035 to extract resources from it.

China established, as I mentioned, the first state-funded SBSP base plant in Chongqing. Now the interesting point that I would like to make is that China's space strategy is an incremental development plan to work on these space goals over a very long period. They view their lunar base as enabling their Space Based Solar Power Project as well as space mining and plans for a permanent settlement.

The potential for economic return from space-based resources and energy, as laid out in China's space ambitions, are so vast, and the military potential of it is significant, that the U.S. risks two very important losses. One, that space and its vast potential for commerce will not be part of a U.S.-led world order; and two, that there will not be a U.S.-led world order because the nation that leads in space will be economically and militarily dominant.

The critical question is, can the Commission take these future Chinese space goals seriously? I have offered my entire statement to you in which I lay out the case; for instance, their success in meeting the goal of Chang'e-4, their goal of the Tianzhou-1 engineered spacecraft. And so, when I looked at that, they've actually met almost all the timelines set in the last 30 years within that stated timeline, and that's very interesting to me.

Now the Commission posed me a question about civil-military integration. I would argue that President Xi has offered a clear policy guideline of civil-military integration and has urged China's space civilian agencies and the private sector to work within that civil-military integration.

In 2017, the Politburo of the Communist Party of China established the first civil-military integration body. And it's interesting that they look at space within that particular concept.

The State Administration on Science, Technology and Industry for National Defense is one of the coordinating bodies, and you will find it in my testimony in terms of what they are looking at. And so, the important point is looking at space as a part of their national defense and to turn China into a comprehensive space power by 2049.

Interestingly, China's space officials wear dual hats. So, you have purely generals that are in charge of China's manned mission, China's Space Based-Solar Power Mission, and my testimony records that.

Now, in terms of China and multilateral engagement, as of 2016, China signed 121 cooperation agreements with 37 countries and four international organizations. From the perspective of geostrategy and space leadership, China leads the Asia-Pacific Space Cooperation Organization and views such cooperation within the Belt and Road Initiative. China is investing $9 billion in its BeiDou Navigation System, and the return from that is predicted to be about $57 billion.

The concern I have in terms of China's long-term ambition is that, when I have assessed China's behavior on earth-based territory -- for instance, Tibet, Bhutan, the South China Sea, Antarctica -- I see that China uses first-presence rights, especially in areas which are resource-rich, and then, goes on to establish claims for such territory. I have documented the entire Antarctica case in an article with Lee Foster from the New Zealand Air Force in The Diplomat.

Finally, I'll end, based on that, with policy recommendations. So, the first recommendation I would have is that there is this tendency to kind of downplay China's ambitions or, as was mentioned today in the morning, there is a denial that China is actually catching up. I would argue that the U.S. needs to take the Chinese space goals and timeline seriously.

The second point I would make is that China's space program is a military-directed and -led program in which the Communist Party of China has staked its legitimacy. As a response to the goals set by China, the U.S. should craft a long-term space resource policy guideline that offers guidelines not just in terms of military space, but actually commercial space; for instance, concepts like resource utilization and extraction.

The most important point I make is that there is a serious competition ongoing with China for leadership of space, and China has actually articulated and given speeches and has engaged in diplomacy that wants to show this China as the more attractive option in terms of space leadership.

And finally, I would argue that the most useful lens through which to understand the Chinese space program are its terrestrial efforts to secure resources.

I have several other recommendations, including for a unified space service within the

United States. Please consult my submitted statement.

And I really thank you for your time. Thank you so much.

PREPARED STATEMENT OF NAMRATA GOSWAMI, PH.D., SENIOR INDEPENDENT ANALYST

Statement of Dr. Namrata Goswami
Independent Senior Analyst and Author
2016-2017 Minerva Grantee
Before the U.S.-China Economic and Security Review Commission
Hearing on "China in Space: A Strategic Competition?"
April 25, 2019

This statement is submitted to the U.S.-China Economic and Security Review Commission (Commission), based on my decades old research on China as a major power in international politics and specifically of studying China's space program. My focus today is on China's space program and its long-term ambitions and goals. I would like to thank the Commission for this opportunity to appear before it. The Commission posed a few broad questions to me. I aim to answer them in the following order: a) What are the current status and future goals of China's space exploration programs, including asteroid mining, a lunar base, and on-site resource exploitation? How capable is China of achieving these goals? b) To what degree are China's civilian space programs guided by dual-use aims rather than purely civilian scientific research purposes? Related to that: how does China's international sharing of the outcomes of its space scientific research reflect the primary aims of these programs? c) What access agreement terms China is offering prospective partners for its planned space station, and how successful has China been in attracting partners? d) policy recommendations.

Current Status of China's Space Program. China's capability to launch, establish presence and conduct deep space exploration and resource utilization has undergone significant shifts in the last few decades.[1] In 2018, China achieved the world's largest number of space launches (39), compared to the U.S. (31) and Russia (20).[2] As of November 30, 2018, China has the second largest number of operating satellites (284), compared to the U.S. (849).[3] In early 2019, China landed a lander and rover on the far side of the Moon (*Chang'e 4*), registering a first for humanity.[4] On March 10, 2019, China achieved another milestone with its *Long March 3B* rocket when it successfully launched for the 300th time. The *Long March* carrier rockets are developed by the China Aerospace Science and Technology Corporation (CASC).[5] This July, China will attempt to launch the *Long March 5 Y3*,[6] its heavy lift rocket (25 metric tons to Low Earth Orbit). Its payload capacity is more than double of any other Chinese rocket.[7] The *Long*

[1] The author conducted interviews with Chinese space and security experts in Beijing and Shanghai, China, November 2016.
[2] Ivan Couronne, "In Space, the US Sees a Rival in China", Phys.org, January 6, 2019 at https://phys.org/news/2019-01-space-rival-china.html (Accessed on April 13, 2019).
[3] Union of Concerned Scientists, "UCS Satellite Database", November 30, 2018 at https://www.ucsusa.org/nuclear-weapons/space-weapons/satellite-database (Accessed on April 19, 2019).
[4] "China Moon Mission Lands Chang'e 4 Spacecraft on Far Side", BBC, January 3, 2019 at https://www.bbc.com/news/science-environment-46724727 (Accessed on April 17, 2019).
[5] "China Long March Rocket Completes 300 Launches", China Aerospace Science and Technology Corporation," March 13, 2019 at http://english.spacechina.com/n16421/n17212/c2516621/content.html (Accessed on April 13, 2019).
[6] Andrew Jones, "China will attempt 30-plus Launches in 2019, including crucial Long March 5 Missions", SpaceNews, January 29, 2019 at https://spacenews.com/china-will-attempt-30-plus-launches-in-2019-including-crucial-long-march-5-missions/ (Accessed on April 13, 2019).
[7] Zhao Lei, "Scientists Find Solutions to Keep Rockets Working", *China Daily*, April 17, 2018 http://www.chinadaily.com.cn/a/201804/17/WS5ad52fb0a3105cdcf65189c1.html (Accessed on April 19, 2019).

March 5 Y2 heavy lift rocket suffered a failure during launch in 2017.[8] The *Long March 5 Y3* launch was announced by CASC Vice President, Yang Baohua in a press conference in Beijing on January 29.[9] This launch will test the *Dong Fang Hong* 5 (DFH-5) satellite platform, constructed to support satellites from 6,500kgs to 9,000kgs.[10] The success of the *Long March 5 Y3* is critical as China's *Chang'e 5* lunar sample return mission depends on its success for launch later this year, on the *Long March 5 Y4*.[11] That mission aims to collect two kilograms of lunar rocks and regolith, from an area near the Mons Rümker in Oceanus Procellarum on the lunar near side. Other missions planned for 2019 include the launch of its *Long March 11*, which will attempt the first sea-based launch from the Yellow Sea. According to Jin Xin, Deputy Commander-in-Chief of CASC's Department of Astronautics, "picking the country's Yellow Sea waters for the first sea launch attempt is to reduce launch technical difficulties and the launch service will expand to cover potential users from countries along the routes of the Belt and Road initiative as the technology matures".[12] In connection to the Belt and Road Initiative (BRI), China launched two *Beidou* (BDS)-3 satellites in November 2018, and started providing basic GPS services to countries along BRI.[13] In 2018, China sent up 18 satellites connected to the BDS-3. Wang Jingang, the chief deputy designer of the BDS-3 satellites specifies, "It's a rare chance to devote my intelligence to a symbolic national project…people still mainly depend on navigation by GPS, supplemented by BDS. I hope that in a few years, people can be navigated mainly by BDS".[14] In January 2019, China established its first state funded Space-Based Solar Power (SBSP) plant in Chongqing, a concept supported by Li Ming, the Vice President of the China Academy of Space Technology (CAST).[15] The Chinese state funded space program is currently estimated to be about $8 billion.[16] Euroconsult estimated the size of the Chinese space value chain to be $16 billion in 2017.[17] In 2018 alone, the Chinese commercial space industry received new investment totaling

[8] Jeff Foust, "China's Powerful Long March 5 Rocket Fails on Second Launch", *Space.com*, July 03, 2017 at https://www.space.com/37376-china-long-march-5-rocket-failure.html (Accessed on April 17, 2019).
[9] "China to Send over 50 Spacecraft into Space via over 30 Launches in 2019", *Xinhuanet*, January 30, 2019 at http://eng.chinamil.com.cn/view/2019-01/30/content_9417217.htm (Accessed on April 13, 2019).
[10] Andrew Jones, "China will attempt 30-plus Launches in 2019, including crucial Long March 5 Missions", n.13.
[11] Deng Xiaoci, "China's Long March 5 Rocket to Resume Flight in July", *Global Times*, January 29, 2019 at http://www.globaltimes.cn/content/1137449.shtml (Accessed on April 18, 2019).
[12] Ibid.
[13] "China Focus: China's BeiDou Navigation System Starts Global Service", *Xinhua*, December 27, 2018 at http://www.xinhuanet.com/english/2018-12/27/c_137702707.htm (Accessed on April 18, 2019).
[14] "From Compass to BeiDou: Chinese Wisdom Help Navigate Belt & Road", *China Daily*,
[15] "China Starts to Build World's First Space-Based Solar Power Plant", CGTN, February 18, 2019 at http://www.ecns.cn/news/economy/2019-02-18/detail-ifzeratr8870758.shtml (Accessed on April 18, 2019).
[16] "China Dream :The First Solar Power Station in Space, *The Hindu Business Line*, February 18, 2019 at https://www.thehindubusinessline.com/news/science/chinas-dream-the-first-solar-power-station-in-space/article26304887.ece (Accessed on April 19, 2019).
[17] Euroconsult, "China Space Industry 2018", at http://euroconsult-ec.com/research/China-space-industry-2018-brochure.pdf (Accessed on April 19, 2019).

$2 billion.[18] In 2019, there are no less than 11 Chinese private startups focused on space launch.[19]

China's Future Space Goals.

In light of that, what does the Commission need to know about the Chinese Space Program's future goals?

1. China intends to be the #1 space power by 2045. At the highest levels of PRC policy, China has set itself a goal to exceed all others by 2045 in time for its 100-year celebration of the establishment of the People's Republic of China (PRC). This goal is comprehensive in scope: Industrial, Logistic, Diplomatic, Economic.[20] The goals, articulated by the China Academy of Launch Vehicle Technology (CALVT) was published in the front pages of the *People's Daily* in November 2017. [21] Li Hong, Director of CALVT specified that by 2045, China will possess advanced space transportation in the world. The way to achieve this is to develop nuclear-propelled spacecrafts by 2040. Wang Changhui, Associate Professor of aerospace propulsion at the School of Astronautics at Beihang University in Beijing specified, "The nuclear vessels are built to colonise the solar system and beyond,".[22] The idea is to build a transport hub, that orbits Earth; the nuclear shuttles will be docked permanently there, and reusable spacecrafts would be utilized to transport humans and cargo to and from the nuclear shuttles.[23] These space goals have been repeated and supported by China's top space policy-making body, the CNSA and CAST.[24] To call this a space exploration program is misleading; this is a program for industrial and economic dominance of the Cis-Lunar System.

2. China's 2040 Grand Design. By 2040, China has a grand design of its space infrastructure and activities that will make it a comprehensive space power, which includes:

---

[18] Micheal Sheetz, "China Increases Investment in Emerging Private Space Industry", CNBC, October 10, 2018 at https://www.cnbc.com/2018/10/10/china-increases-investment-in-emerging-private-space-industry.html (Accessed on April 19, 2019).
[19] Jean Deville, , "The Technical Choices of China's New Space Launcher Companies in 2019", *The China Aerospace Blog*, April 14, 2019 at https://china-aerospace.blog/2019/04/14/the-technical-choices-of-chinas-newspace-launcher-companies-in-2019/ (Accessed on April 19, 2019).
[20] See Stacey Solomone, *China's Strategy in Space* (Springer, 2013). Also see Brian Harvey, *China's Space Program-From Conception to Manned Spaceflight* (Springer Praxis Books, 2004). Also see Michael Pillsbury, *The Hundred-Year Marathon China's Secret Strategy to Replace America as the Global Superpower* (New York: St Martin's Griffin, 2016).
[21] Stephen Chen, "China's Nuclear Spaceships will be 'Mining Asteroids and Flying Tourists' as it aims to overtake the US in a Space Race," *South China Morning Post*, November 17, 2017 at https://www.scmp.com/news/china/policies-politics/article/2120425/chinas-nuclear-spaceships-will-be-mining-asteroids (Accessed on April 13, 2019).
[22] Ibid.
[23] Ibid.
[24] "China Outlines Roadmap for Deep Space Exploration", *Space Daily*, April 26, 2018 at http://www.spacedaily.com/reports/China_outlines_roadmap_for_deep_space_exploration_999.html (Accessed on April 17, 2019).

a. Full conversion to re-usable launch vehicles.[25]According to Bao Weimin, Director of the Science and Technology Commission at CASC and an academician at the China Academy of Sciences (CAS), "China's reusable carrier vehicle will use technologies different from those of U.S. commercial space firm SpaceX".[26] This was reiterated by Long Lehao, the Chief Designer of carrier rockets at the CALVT, who stated, "As the current Long March 2, 3, 4 series rockets are fueled by toxic propellants, they cannot be recycled. But we are developing technologies to precisely control the fall of the rocket remains to ensure safety".[27]
b. Operation of nuclear power shuttles for the purposes of asteroid mining, settlement and exploration.[28]
c. An operational Solar Power Satellite in Geo Stationary Orbit (GEO), weighing 300 MT collecting 24 Megawatt (MW) and beaming one MW back to Earth.[29]
d. A permanent industrial facility on the Moon[30] and to be industrializing the moon with the purpose of building solar power satellites.[31]

3. With regard to Space Based Solar Power,[32] as mentioned earlier, China became the first country in the world to establish a state funded SBSP base plant in Chongqing's Bishan district, early this year.[33] The base plant is being constructed under the guidance of the Chongqing Collaborative Innovation Research Institute for Civil-Military Integration (CCIRICMI) in Southwestern China in partnerships with researchers from Chongqing University, CAST's Xi'an Branch in Shaanxi province, and Xidian University. The initial investment for the SBSP plant of $15 million has been made by the Bishan district government. Technologies being tested include the construction of SBSP satellites in GEO using automated assembly and the wireless transmission of power.[34] Li Ming, senior vice president of CAST, asserted that China will lead the world in this critical renewable energy source.[35] The key challenges that the plant will be testing are:

---

[25] "China Developing Reusable Space Rocket", *Xinhua*, April 30, 2018 at http://www.xinhuanet.com/english/2018-04/30/c_137147249.htm (Accessed on April 17, 2019). Also see Tim Fernholz, *Rocket Billionaires: Elon Musk, Jeff Bezos, and the New Space Race* (Houghton Mifflin Harcourt, 2018).
[26] "China Developing Reusable Space Rocket", ibid. Also see Tai Ming Cheung, ed., *Forging China's Military Might: A New Framework for Assessing Innovation* (Washington D.C: John Hopkins University Press, 2014).
[27] Ibid.
[28] "China to Achieve "major breakthrough" in Nuclear-Powered Space Shuttle Around 2040: Report", Xinhuanet, November 16, 2017 at http://www.xinhuanet.com/english/2017-11/16/c_136757737.htm (Accessed on April 17, 2019).
[29] Xinbin Hou and Li Wang, "Recent SPS Activities in China", Qian Xuesen Laboratory of Space Technology, China Academy of Space Technology, 2nd Space Solar Power Satellite (SSPS) Workshop, February 13, 2019, Seoul, Korea.
[30] Hannah Devlin, "Battlefield Moon: How China Plans to Win the Lunar Space Race", *The Guardian*, January 21, 2019 at https://www.theguardian.com/science/2019/jan/21/china-steps-up-bid-to-win-the-lunar-space-race (Accessed on April 17, 2019). Morris Jones, *The New Moon Race* (Rosenberg Publishing, 2009).
[31] "Exploiting Earth-Moon Space: Chinese Ambitions after Space Station", Xinhua, March 08, 2016 at http://m.chinadaily.com.cn/en//2016-03/08/content_23775949.htm (Accessed on April 17, 2019).
[32] On SBSP, see John Mankins, *The Case for Space Solar Power* (Houston: Virginia Edition Publications, 2014).
[33] Zhao Lei, "Scientists Envision Solar Power Station in Space", *China Daily*, February 27, 2019 at http://www.chinadaily.com.cn/a/201902/27/WS5c75c8b3a3106c65c34eb8e3.html (Accessed on April 13, 2019). For more on SBSP, see Brain O'Leary, Construction of Satellite Solar Power Stations from Non-Terrestrial Material", *Journal of Energy*, 1/3, 1977, pp. 155-158.
[34] Pan Zhaoyi, "China Starts to Build World's First Space Based Solar Power Plant", CGTN, February 18, 2019 at https://news.cgtn.com/news/3d3d514f34597a4e32457a6333566d54/index.html (Accessed on April 17, 2019).
[35] Ibid.

a. Microwave transmission of electricity,
b. In-space manufacturing of SBSP satellites.

Xie Gengxin, who is the Deputy Head of CCIRICMI stated that:

> We plan to launch four to six tethered balloons from the testing base and connect them with each other to set up a network at an altitude of around 1,000 meters… these balloons will collect sunlight and convert solar energy to microwave before beaming it back to Earth. Receiving stations on the ground will convert such microwaves to electricity and distribute it to a grid… if everything goes well, a Chinese solar power station will be put into orbit about 36,000 kilometers above Earth and start generating power before 2040.[36]

Pang Zhihou, from CAST, laid out the rationale for why SBSP is a critical investment focus for China's space program. First, it is available 24 hours; it is not susceptible to weather variations like ground solar; it can be utilized to power China's lunar base as well as spacecrafts; and increase efficiency "by freeing spacecraft from huge solar cell wings and greatly increasing power levels and control accuracy. It can also be used as a candidate for deep space exploration energy systems, and it can also be used for space fuel production and space processing manufacturing in the future to realize space industry development."[37] The push for SBSP in China in not new. In 2010, the CAST published a roadmap in which it detailed the following: -

> Establish Research &Design (2010); 2019: Establish prototype of SPS plant; 2020: Finish industrial level testing of in-orbit construction and wireless transmissions; 2025: complete the first 100kW SPS demonstration at LEO; 2030: 1 mW in GEO 2035: the 100mW SPS will have electric generating capacity; and by 2050, the first commercial level SPS system will be in operation in GEO.[38]

One of the biggest advocates within China of SBSP is Wang Xiji, the chief designer of China's first rocket, the *Long March 1*. Wang believes that "The world will panic when the fossil fuels can no longer sustain human development. We must acquire space solar power technology before then…Whoever obtains the technology first could occupy the future energy market. So it's of great strategic significance."[39] Xiji further specified that "Once completed, the solar station, with a capacity of 100MW, would span at least one square kilometre, dwarfing the International Space Station and becoming the biggest man-made object in space".[40] Xiji believed that if China did not act quickly on an SBSP program, countries like the U.S. and Japan will take the lead and occupy strategically important locations in space.[41] According to Duan Baoyan,

---

[36] Ibid.
[37] "China is Expected to take the Lead in Building a Space Solar Power Station", *Science and Technology Daily.com*, February 14, 2019 at http://www.stdaily.com/index/kejixinwen/2019-02/14/content_750019.shtml (Accessed on April 7, 2019).
[38] Gao Ji, et.al., "Solar Power Satellite Research in China", *Online Journal of Space Communications*, Winter 2010 at https://spacejournal.ohio.edu/issue16/ji.html (Accessed on April 17, 2019). Don M. Flourney, *Solar Power Satellites* (New York: Springer, 2012).
[39] Chinese Scientists Mull Power Station in Space", *Space Daily*, March 31, 2015 at http://www.spacedaily.com/reports/Chinese_scientists_mull_power_station_in_space_999.html (Accessed on April 17, 2019).
[40] Ibid.
[41] Ibid.

from the Chinese Academy of Engineering (CAE), "If we have space solar power technology, hopefull [sic] we could solve the energy crisis on Earth."[42] Baoyan was earlier a leading member of the satellite payload expert group within the PLA, and member of the advanced manufacturing technique group of China Electronics Group Corporation (CETC). According to Gao Ji, Hou Xinbin and Wang Li, of CAST:

> Since SPS development will be a huge project, it will be considered the equivalent of an Apollo program for energy. In the last century, America's leading position in science and technology worldwide was inextricably linked with technological advances associated with implementation of the Apollo program. Likewise, as China's current achievements in aerospace technology are built upon with its successive generations of satellite projects in space, China will use its capabilities in space science to assure sustainable development of energy from space.[43]

4. China's Lunar Exploration Program (CLEP) has offered a roadmap from 2019 to 2036 specifying its aims and future missions. Right after the successful landing of the *Chang'e 4* on the far side of the moon on January 3 (10.26 Beijing time), Wu Yanhua, Deputy head of CNSA announced on January 14 that by 2019 year-end, China will launch *Chang'e-5*, to bring lunar samples back to Earth; this will be followed by *Chang'e-6*, aimed at bringing samples from the South Pole; *Chang'e-7* will survey the South Pole for evaluating its composition. The *Chang'e-8* will test key technologies like 3D printing to lay groundwork for the construction of a scientific base on the moon.[44] Critically, scientists at the Technology and Engineering Center for Space Utilization of the Chinese Academy of Sciences (CAS) tested 3D printing technology in micro-gravity by successfully completing a ceramic testing technology in 2018.[45] According to Wang Gong, Director of the CAS Key Laboratory of Space Manufacturing Technology, this evaluated Chinese capability to build bases on the moon and Mars, as well as in-situ resource utilization and space manufacturing with space based resources.[46] Using ceramics is instructive as it is similar in composition to lunar silicate particles. As Wang put it, "Elon Musk and SpaceX are developing technologies to take people to other planets, and we are developing technologies to help them survive.".[47]According to Paul D. Spudis, in his book, *The Value of the Moon*, the moon's "greatest value is its capacity to create new spacefaring capabilities through the exploitation of its material and resources."[48] Spudis recommended the use of small robotic rovers to traverse the lunar poles to measure for ice and other contents. In September 2018, Li Guoping, director of the Department of System Engineering at CNSA, stated that China will be sending

---

[42] As quoted in Namrata Goswami, "China's Get-Rich Space Program", *The Diplomat*, February 28, 2019 at https://thediplomat.com/2019/02/chinas-get-rich-space-program/ (Accessed on April 18, 2019).
[43] Gao Ji, et.al., "Solar Power Satellite Research in China", n. 38.
[44] "China unveils Follow-Up Lunar Exploration Missions", *Xinhua*, January 14, 2019 at http://www.xinhuanet.com/english/2019-01/14/c_137743015.htm (Accessed on April 18, 2019).
[45] "China Focus: China Pioneers Ceramic 3D Printing in Micro-Gravity", Xinhua, June 19, 2018 at http://www.xinhuanet.com/english/2018-06/19/c_137265536.htm (Accessed on April 17, 2019). Richard P. Appelbaum, et.al., *Innovation in China: Challenging the Global Science and Technology System* (Polity, 2018). George S. Yip and Bruce McKern, *China's Next Strategic Advantage:* From Imitation to Innovation (MIT Press, 2017).
[46] "China Focus: China pioneers Ceramic 3D Printing in Microgravity", n. 45.
[47] Ibid.
[48] Paul Spudis, *The Value of the Moon: How to Explore, Live, and Prosper in Space Using the Moon's Resources* (Washington, D.C: Smithsonian Books, 2016).

robotic probes to the lunar poles by 2030.[49] These probes will explore the South Pole to analyze the lunar soil's age, and the composition of the solar wind's isotopes of hydrogen, carbon, helium, and oxygen. The rover that will explore the North Pole will examine whether ice exists in the permanent shadow area. The lunar poles probe will be the final step before establishing China's scientific research base.

China's CLEP is not only aimed at lunar scientific missions, but is also a long-term space presence development strategy to incrementally build capacity for lunar and asteroid mining. The Moon offers the best chance of a planetary body, not difficult to reach from Earth, to build space-faring capacities. This aspect is recognized by Wu Weiren, the chief scientist of CLEP. He states and I quote, "our short-term goal is to orbit the Moon, and land on the Moon, and take samples back from the Moon…our long term goal is explore, land and settle. We want our manned lunar landing to stay for longer periods and establish a research base".[50] Weiren believes that the critical step forward is to establish a lunar palace especially on the South Pole by 2030, given the presence of sunlight and water-ice there. Beihang University in China has experimented with a simulated lunar module in 2018, in which eight students lived in a Moon lab for 370 days, to study how a regenerative life support system might work.[51] Significantly, the *Chang'e 4* carried a 3 kg, (0.8 liters) aluminum alloy cylinder, containing seeds of cotton, potatoes and Arabidopsis, a plant related to cabbage as well as eggs of silk worms.[52] The idea was to experiment if potatoes (food for Moon settlers), and silk worms can flourish on the Moon in a simulated mini biosphere. This was exciting, by itself, as it is the first time that such an experiment was carried out 380,000 kms from Earth, many times further than similar experiments carried out on the International Space Station (ISS) and *Tiangong 2*, in Low Earth Orbit (LEO), just 400 kms above earth.[53] According to the mission chief, Liu Hanlong, the idea was to study the process of developing food for space travelers on the lunar surface. Liu specified, "Our experiment might help accumulate knowledge for building a lunar base and long-term residence on the Moon."[54] What makes this experiment unique is that it is the first step in analyzing whether humans can create Earth-like conditions on the Moon to survive on the long term and is directly connected to China's stated ambition of establishing permanent presence on the Moon. The mini biosphere experiment on *Chang'e 4* is a collaborative effort of 28 Chinese universities led by Chongqing University. Its chief designer, Xie Gengxin, who is also leading

[49] "China Aims to Explore Polar Regions of Moon by 2030", *China Daily*, September 25, 2018 at http://www.chinadaily.com.cn/a/201809/25/WS5ba9f615a310c4cc775e801f.html (Accessed on April 17, 2019). Also see Dennis Wingo, *Moon Rush: Improving Life on Earth* with the Moon's Resources (Lancaster: Apogee Books, 2004).
[50] "What does China want to do in Space", BBC, April 20, 2016 at https://www.bbc.com/news/av/36089689/what-does-china-want-to-do-in-space (Accessed on April 17, 2019). Marina Koren, "China's Growing Ambitions in Space", *The Atlantic*, January 23, 2017 at https://www.theatlantic.com/science/archive/2017/01/china-space/497846/ (Accessed on April 18, 2019).
[51] Guo Meiping, "China's 'Lunar Palace' Breaks Record after 365+5 days", CGTN, May 15, 2018 at https://news.cgtn.com/news/3d3d514e7a67444e77457a6333566d54/share_p.html (Accessed on April 8, 2019).
[52] Rafi Letzter, "There are Plants and Animals on the Moon Now (because of China)", LiveScience, January 3, 2019 at https://www.livescience.com/64413-china-space-moon-plants-animals.html (Accessed on April 17, 2019).
[53] "China Focus: Flowers on the Moon? China's Chang'e 4 to Launch Lunar Spring", *Xinhuanet*, April 12, 2018 at http://www.xinhuanet.com/english/2018-04/12/c_137106440.htm (Accessed on April 17, 2019).
[54] Ibid.

efforts on China's SBSP efforts, and is the Deputy Head of the Chongqing Collaborative Innovation Research Institute for Civil-Military Integration (CCIRICMI) specified:

> We have to keep the temperature in the 'mini biosphere' within a range from 1 degree to 30 degrees, and properly control the humidity and nutrition. We will use a tube to direct the natural light on the surface of Moon into the tin to make the plants grow…We want to study the respiration of the seeds and the photosynthesis on the Moon.[55]

Only the cotton seed sprouted, before the CNSA declared the experiment closed as *Chang'e 4* entered a dormant mode during its first lunar night on January 15. Xie explained why, "Life in the canister would not survive the lunar night…We had no such experience before. And we could not simulate the lunar environment, such as microgravity and cosmic radiation, on Earth".[56] This experiment was aimed at understanding how seeds can be sprouted to acquire further knowledge on ensuring their survival into the lunar night. In a video released by the CNSA on April 24, 2018, anniversary of China's first satellite launch (1970),[57] China offered its vision of a lunar outpost to be manned by SBSP. CNSA reflected on the video that "We believe that the Chinese nation's dream of residing in a 'lunar palace' will soon become a reality."[58] Ye Peijian, head of CLEP, stated that:

> [t]he universe is an ocean, the moon is the Diaoyu Islands, Mars is Huangyan Island. If we don't go there now even though we're capable of doing so, then we will be blamed by our descendants. If others go there, then they will take over, and you won't be able to go even if you want to. This is reason enough.[59]

China's *Chang'e 4* that broke new ground, by landing humanity's first probe on the far side was both technologically and symbolically unique. In May 2018, the *Queqiao* relay satellite, or Magpie Bridge, was placed in the L2 Halo orbit to serve as a communication relay satellite from the Chang'e 4.[60] *Queqiao* can peer into the Lunar polar craters, enabling future landing zones for China's probes in the shadowed regions. Significantly, for purposes of space resources, *Chang'e 4* rover has a radar that can penetrate the lunar surface to look for lunar resources like iron ore. This is to achieve another stated ambition, coming out of Chinese state funded space institutions

---

[55] Ibid.
[56] "China Focus: Moon Sees First Cotton-Seed Sprout", Xinhua, January 15, 2019 at http://www.xinhuanet.com/english/2019-01/15/c_137745505.htm (Accessed on April 17, 2019).
[57] Echo Huang, "China Lays out its Ambitions to Colonize the Moon and Build a "Lunar Palace"", Quartz, April 26, 2018 at https://qz.com/1262581/china-lays-out-its-ambitions-to-colonize-the-moon-and-build-a-lunar-palace/ (Accessed on April 17, 2019).
[58] Neil Connor, "China Plans to Build Manned 'Lunar Palace' Powered by the Sun", *The Telegraph*, April 25, 2018 at https://www.telegraph.co.uk/news/2018/04/25/china-plans-build-manned-lunar-palace-powered-sun/ (Accessed on April 17, 2019). Kerry Brown, *China's Dream The Culture of Chinese Communism and the Secret Sources of its Power* (Cambridge: Polity Press, 2018).
[59] Brendon Hong, "China's Looming Land Grab in Outer Space", *Daily Beast*, June 22, 2018 at https://www.thedailybeast.com/chinas-looming-land-grab-in-outer-space (Accessed on April 17, 2019).
[60] Luyuan Xu, " How China's Lunar Relay Satellite Arrived in its Final Orbit", Planetary Society, June 15, 2018 at http://www.planetary.org/blogs/guest-blogs/2018/20180615-queqiao-orbit-explainer.html (Accessed on April 17, 2019).

like CAS, CAST, and CNSA;[61] that in order to develop space-faring capabilities and move on to the asteroid belt, capture an asteroid and extract resources from it, the Moon serves as a significant basing function. This perspective is supported at the highest level of space policy as articulated by Ouyang Ziyuan, Chief Scientist of China's Lunar Exploration Program (CLEP). Quyang specified more than a decade ago (2002) that "the moon could serve as a new and tremendous supplier of energy and resources for human beings… This is crucial to [the] sustainable development of human beings on Earth... Whoever first conquers the Moon will benefit first".[62] A year later, in 2003, Luan Enjie, the Director of the Chinese National Aerospace Bureau, reiterated that, "We will focus on deep space exploration. The first target selected is the Moon".[63] Similarly, Lieutenant General Zhang Yulin, former Deputy Commander of China's Manned Space Program and former Deputy Chief of the Armament Development Department of the Central Military Commission (CMC), now with the Strategic Support Force (SSF) specified the significance of the Moon in 2016 when he stated, "the earth-moon space will be strategically important for the great rejuvenation of the Chinese nation".[64] Yulin indicated in that same interview that China will be investing in building capacity to generate solar power in space. He was clear on what China's space program focus should be in the long term, "The future of China's manned space program, is not a moon landing, which is quite simple, or even the manned Mars program which remains difficult, but continual exploration of the earth-moon space with ever developing technology".[65] It was Yulin, who was the first Chinese high ranking military space official to publicly acknowledge in 2016 China's ambitions to send astronauts to the Moon by 2036,[66] today an integral part of the CLEP,[67] and included in their 2016 White paper on space activities, as a priority.[68]

5. **Space Mining (Industrialization):** Chinese space scientists are working on plans to capture a Near Earth Asteroid (NEA) and bring it to Earth to inspect and extract its resources. Researcher, Li Mingtao, with the National Space Science Center under CAS along with his team details that plan.[69] The idea is for a spacecraft to bag an asteroid and push it over Earth, followed by a heat

---

[61] "Chinese Lunar Exploration to Enter New Phase with Missions to Moon's Poles and Far Side", Chinese Academy of Sciences, March 02, 2017 at http://english.cas.cn/newsroom/news/201703/t20170302_174524.shtml (Accessed on April 17, 2019).
[62] David Whitehouse, "China denies Manned Moon Mission Plans", BBC, May 21, 2002 at http://news.bbc.co.uk/2/hi/science/nature/2000506.stm (Accessed on April 17, 2019).
[63] David Whitehouse, "China Sets its Sights on the Moon", BBC, December 3, 2003 at http://news.bbc.co.uk/2/hi/science/nature/3288043.stm (Accessed on April 17, 2019).
[64] "Exploiting Earth-Moon Space: Chinese Ambitions after Space Station", Xinhua, March 08, 2016 at http://m.chinadaily.com.cn/en//2016-03/08/content_23775949.htm (Accessed on April 17, 2019).
[65] Ibid.
[66] Zhao Lei, "Senior Officer Expects Moon Visit by 2036', *People's Daily*, April 29, 2016 at http://en.people.cn/n3/2016/0429/c90000-9051633.html (Accessed On April 17, 2019).
[67] "China's Lunar Exploration Program", People's Daily, at http://en.people.cn/90002/91752/index.html (Accessed on April 17, 2019).
[68] "Full text of White Paper on China's Space Activities in 2016", The State Council, The People's Republic of China, December 28, 2016 at http://english.gov.cn/archive/white_paper/2016/12/28/content_281475527159496.htm (Accessed on April 17, 2019).
[69] "Capture an Asteroid, Bring it Back to Earth?", Chinese Academy of Sciences, June 24, 2018 at http://english.cas.cn/newsroom/news/201807/t20180724_195396.shtml (Accessed on April 17, 2019). For more on asteroid mining, please see John Lewis, *Mining the Sky Untold Riches from the Asteroids, Comets, and Planets*

shield that unfolds reducing the velocity of the asteroid as it enters Earth's atmosphere. The landing must be minutely controlled so that it lands in an area far from human habitation. Li is working in collaboration with scientists from the Qian Xuesen Laboratory of Space Technology, under the China Aerospace Science and Technology Corporation (CASTC) to place satellites in the heliocentric Venus orbit, in order to search and analyze NEAs, with a diameter of 10 meters. The challenge after capture would be to drop the speed of the asteroid from 12.5 km per second to 140 meters per second before it touches down on its Earth landing spot. The timeline for such a launch to capture an asteroid is 2029 and the aim is to bring it back to Earth around 2034. A NEA like *3554 Amun*, approximately two kilometers in diameters, contains nickel and iron worth $8 trillion, cobalt ($6 trillion), other precious metals and gold worth $6 trillion, which together totals $20 trillion.[70] Based on such estimates, Li asserts that:

> Space mining might become a new engine for the global economy… Unlike missions to bring samples back, we aim to bring back a whole asteroid weighing several hundred tonnes, which could turn asteroids with a potential threat to Earth into usable resources…Our analysis shows that maneuvering a small asteroid is feasible in principle, and could bring enormous economic and social benefits.[71]

Li's perspective is supported by Huang Wei, who is Chief Engineer within CAST. Wei believes that ideas such as Li's would result in the promotion and development of futuristic space technologies.[72] Space mining is perceived to be to China's future advantage given the rising demands for energy within China. Towards achieving the goals of harvesting space-based resources, a China Aerospace Science and Technology Corporation (CASTC) report outlined in 2017 that China will be developing nuclear powered space shuttles by 2040. Such a long-term strategy is geared towards reusability and developing a space outpost, that augments the development of space transportation capabilities. By 2025, reusable sub-orbital carriers should come to fruition enabling the path towards a long-term vision.[73] China is developing the *Long March 9*, its super heavy lifter. The *Long March 9* is designed to carry a payload of 140 metric tons to LEO, a 50-ton spacecraft to a lunar transfer orbit and a 44-ton payload to Mars transfer orbit.[74] Importantly, in its justifications for the *Long March 9*, China listed the following four goals: 1) launch a Mars robotic exploration mission which is requires 41 tonne payloads, 2) manned Mars missions, 3) deep space missions, and 4) "Constructing orbital solar power plant with 10,000 MW capacity, massing some 50,000 tonnes, requiring 620+ launches)."[75]

(New York: Helix Books, 1997). Robert Zubrin, *Entering Space: Creating a Spacefaring Civilization* (New York: TarcherPerigee, 2007).

[70] Andrew M. Thorpe, *The Commercial Space Age: Conquering Space Through Commerce* (Bloomington: AuthorHouse, 2003), p. 149.

[71] "China Focus: Capture an Asteroid, bring it back to Earth?", Xinhuanet, July 23, 2018 at http://www.xinhuanet.com/english/2018-07/23/c_137342866.htm (Accessed on April 17, 2019).

[72] Ibid.

[73] "China to Achieve "major breakthrough" in Nuclear-Powered Space Shuttle Around 2040: Report", Xinhuanet, November 16, 2017 at http://www.xinhuanet.com/english/2017-11/16/c_136757737.htm (Accessed on April 17, 2019).

[74] http://www.chinadaily.com.cn/a/201903/11/WS5c859b62a3106c65c34edcc0.html

[75] As quoted from Journal of Rocket Propulsion, January 2011, in https://www.globalsecurity.org/space/world/china/cz-x.htm

In summary, the articulated Chinese space goals across a cross-section of their state-owned space institutions (CNSA, CAST, CASC, CALVT) as well as their 2016 White paper, highlight the following, from now to 2050:

2019: Chang'e 5 probe to bring back lunar samples to Earth (China White Paper 2016, CNSA).
2020: First Mars probe (China White Paper 2016).
2020: Finish the industrial level testing of in-orbit construction and wireless transmissions of SBSP (CAST).
2022: Asteroids Probe (CNSA, CAST, CALVT).
2022: Permanent space station, *Tianhe-1* (China space policy papers).
2024: Chang'e 6 to bring back samples from the South Pole (CNSA).
2025: Reusable Suborbital Carrier/suborbital tourism (CASC).
2025: Complete the first 100kW SBSP demonstration at LEO (CAST).
2028: Mars sample return (CNSA).
2029: Jupiter probe (CNSA).
2029: Mission to capture a Near Earth Asteroid (NEA) (CAS).
2030: Probe to Lunar South and North Pole (CNSA).
2030: Launch of *Long March 9* super heavy lifter (CASC).
2030: 1 mW of SBSP power demonstration in GEO (CAST).
2034: Return Asteroid to Earth (CAS).
2035: Test key technologies like 3D printing to lay groundwork for the construction of a lunar base (CAS).
2035: 100 mW SBSP will have electric power generating capacity (CAST).
2036: Manned mission to Moon and establishment of lunar research base (CNSA).
2040: Nuclear powered space fleet to be ready (CASC).
2040: SBSP to orbit (36,000 kms) above Earth and start generating power (CAST).
2045: Most advanced Space Nation (President Xi).
2049: 100th year celebration of the establishment of the PRC and the leading space technology power (President Xi).
2050: First Commercial Level SBSP in operation in GEO (CAST).

The potential for economic return from space-based resources and energy as laid out in China's space ambitions are so vast, and the military potential of an industrial space-logistics system is so militarily imperative, that the U.S. risks two very important losses:

1) That space and its vast potential for commerce will not be part of a U.S.-led world order.
2) That there will not be a U.S.-led world order, because the nation that leads in space will be economically and militarily dominant.

China's space strategy is an incremental development plan to work on these space goals over a long period. China plans on consistently achieving success on the long timelines they set for themselves. Their lunar base enables their SBSP, as well as space mining and plan for permanent space presence.

Should the Commission Take Chinese Future Space Timelines Seriously?

The critical question is: can the Commission take these future Chinese space goals seriously? In order to examine that, I studied the pattern of stated Chinese space ambitions in the past, and whether it met the goals within the specific timeline set. China announced its ambitions for space in the 1950s along with its nuclear ambitions under Mao Tse Tung responding to threatened nuclear weapons use by the United States in the Korean War. Mao's decision was aimed at developing China's own nuclear arsenal as a deterrent against future vulnerabilities. At the same time, in order to shore up international prestige for China, Mao aimed to place a satellite in orbit by 1959 under Project 581. When Soviet technical assistance was withdrawn, there was realization that this aim for a satellite was not possible, and consequently, Project 581 was abandoned.[76] This however did not completely eliminate the space program. Work continued for the next two decades to build the foundations for a long-term program, and finally, in 1970, China's first satellite *Dong Fang Hong 1* was launched on April 24 broadcasting the song 'East is Red' from orbit. After Deng Xiaoping took over as Premier of China, the space scientist community received a further boost to lay down specific aims for China's future space program.[77]

In the late 1980s, China declared that it aimed to send a manned spaceflight in the next two decades. China successfully launched its unmanned mission to space in 1999. In 2003, China sent its first manned space mission, the *Shenzhou V* into space. While some argue that China's success in its unmanned and manned missions was as a result of its 1996 agreement with Russia on space technology acquisition, yet reengineering of Russian space technology simply does not mean the same technology but added on technology fitted by Chinese engineers and scientists. In 2004, Wang Yongzhi, the chief designer of China's space program, stated that China plans to have a permanent crewed space station in the next 15 years.[78] That aim has been reiterated in its 2016 White paper on space activities. The plans to establish a space station incrementally have been met, again as per stated schedule. In 1992, China established Project 921-2 whose mission was to launch a manned spaceflight in next ten years (2003 mission goal met), an orbiting station by 2010 (2011 mission goal met), and finally a permanent space station by 2020-22.[79] In 2007, China announced that between 2008 and 2010, the *Shenzhou* unmanned and manned spaceflights will be launched to dock with *Tiangong* 1(again mission goal met).[80] In 2011, China declared its intentions to launch *Tiangong* 2 by 2015, later postponed to 2016, followed by the *Shenzhou* 11 manned spaceflight to dock with it, to be followed by the Chinese space cargo ship in 2017.[81] All these stated goals have been met within timelines set, including the successful launch and docking of the indigenously built Chinese space cargo ship, the *Tianzhou 1*. In 2016, CNSA announced that China will launch a probe to the far side of the Moon in December 2018, a first

[76] "Project 581", http://www.astronautix.com/p/project581.html
[77] Namrata Goswami, "China in Space: Ambitions and Possible Conflict", *Strategic Studies Quarterly*, March 1, 2018 at http://www.airuniversity.af.mil/Portals/10/SSQ/documents/Volume-12_Issue-1/Goswami.pdf (Accessed on April 18, 2019).
[78] "Timeline: China's Spaceflight History", *New Scientist*, 12 October 2005, https://www.newscientist.com/article/dn8144-timeline-chinas-spaceflight-history/
[79] Ibid.
[80] "Project 921-2", Astronautix.com, http://www.astronautix.com/p/project921-2.html
[81] Tania Branigan and Ian Sample, "China Unveils Rival to International Space Station", *The Guardian*, 26 April 2011, https://www.theguardian.com/world/2011/apr/26/china-space-station-tiangong

attempt by humanity of any such feat.[82] On December 8, 2018 (Beijing time:2:23 a.m.), the *Long March* 3B lifted off from *Xichang* Satellite Launch Center, carrying the *Chang'e 4* rover and lander with it, to the lunar surface, again meeting another critical deadline set two years ago. On January 3, 2019, the mission successfully landed on the far side of the moon.[83]

While the West tends to underplay China's space capabilities with a tendency to call it largely propaganda by the CPC, is it really the case? When China initiated the *Tianzhou* spacecraft resupply program in 2010 and gave the contract to CAST to develop it in 2011,[84] declaring it will send the indigenously built cargo spacecraft by 2016-2017, it was written off in the West as mere propaganda and building prestige for the CPC.[85] When in 2017, the *Tianzhou 1* was successfully launched and docked with the *Taingong*-2 within the stated deadline, the world expressed surprise.

China's stated future space goals of developing a SBSP station and beaming that energy wirelessly back to earth, establishing a manned lunar presence, land on the far side of the moon, explore and mine asteroids, utilizing these resources for in-situ manufacturing, and build a permanent space station, are technologically ambitious to achieve in the 20-30 year time span. The sceptics would argue that such goals are not achievable or feasible given the absence of proven technology. Or that China may rhetorically state these ambitions but it remains to be seen if these goals are achievable. The success in, not only building the technology but also successfully meeting stated timelines announced, vindicates enormous credibility to China's future stated goals of a 2029 asteroid capture mission, a 2036 manned mission to the moon, and establishing an SBSP space station by 2050. It is a fact that these stated goals would require enormous indigenous technology innovation and if successful would establish the independent innovation potential of China's space enterprise. Nevertheless, the *Tianzhou 1*, the *Queqiao* relay satellite, and the *Chang'e 4* are great examples of the growing indigenous technological progress of China's space program. Given the PRC's outstanding record of accomplishing its stated space goals, those who dismiss or ignore China's announced roadmaps for space, should consider the fact that achievements in space are directly connected to the CPC's legitimacy and are not taken lightly, given the high levels of political engagement with the space program. China's achievements in the field of science and technology is well documented. These includes, but are not limited to quantum computing and communications,[86] Artificial Intelligence (AI),[87] data science, etc. While the U.S. is quick to dismiss China's achievements as based on theft of

---

[82] "China to Send *Chang'e 4* to South Pole of the Moon's Far Side", China Academy of Sciences, June 15, 2016 at http://english.cas.cn/newsroom/news/201606/t20160615_164411.shtml (Accessed on April 8, 2019).
[83] "Liftoff for Chang'e 4", *Planetary Society*, December 7, 2018 at http://www.planetary.org/blogs/emily-lakdawalla/2018/liftoff-for-change-4.html (Accessed on April 8, 2019).
[84] Tianzhou", China Space Report, https://chinaspacereport.wordpress.com/spacecraft/tianzhou/ (Accessed on April 17, 2019).
[85] Marco Alberti, *When China Goes to the Moon* (New York: Springer International, 2015). Michael Sheehan, "Did you see that, Grandpa Mao? The Prestige and Propaganda Rationales of the Chinese Space Program", ScienceDirect, 29/2, May 2013, pp. 107-112 at https://www.sciencedirect.com/science/article/abs/pii/S0265964613000246 (Accessed on April 17, 2019).
[86] "China's Quantum Satellite Clears Major Hurdle on way to Ultrasecure Communications", Nature, June 15, 2017 at https://www.nature.com/news/china-s-quantum-satellite-clears-major-hurdle-on-way-to-ultrasecure-communications-1.22142 (Accessed on April 17, 2019).
[87] Louis Columbus, "How China is Dominating Artificial Intelligence", Forbes, December 16, 2018 at https://www.forbes.com/sites/louiscolumbus/2018/12/16/how-china-is-dominating-artificial-intelligence/#550950de2b2f (Accessed on April 17, 2019).

intellectual property, this perspective fails to take into account the fact that China has emerged as second only to the U.S. when it comes to investment in Research & Design (R&D) with $475 billion spent in 2018, compared to U.S $ 553 billion.[88] In 2018, the U.S. National Science Foundation (NSF) statistics revealed that China for the first time surpassed the U.S. (409, 000) with the largest number of published scientific articles (426,000).[89] Foremost amongst those steering the field is the CAS which has about 120 other institutions under it, followed by Chinese Science and Technology universities and their privately owned industries.[90] Take the example of *Huawei* Technologies, the largest telecommunications company in the world. The company invested and is forging closer commercial ties with countries in Asia and Europe, to emerge as the leader in 5G. It has signed 25 Memorandums of Understanding (MoUs) that includes Britain's BT, Bell Canada (BCE), France's Orange, Germany's Deutsche Telekom and global player Vodafone.[91] Vodafone is a big player in India. Huawei is investing in AI as well.

There are certain areas of concern that we need to address with this kind of infrastructure development. For instance, the African Union (AU) headquarters in Addis Ababa was built with an aid of $200 million from the China Development Bank. But in January 2018, it was reported that between 2012 (the year the building was built) to January 2018, the computer system of AU was compromised, with data transferred from AU servers to servers in Shanghai, 8000 kms away. While China and AU have condemned these reports as deliberate ploy by the West to discredit that relationship, the main provider of "information and communication technology systems to the AU headquarters was China's best-known telecoms equipment company – Huawei".[92] Nothing has been proved so far, but challenges to Huawei remain. Ren Zhengfei, the founder of Huawei, employs nearly 80,000 of its staff for R&D alone, and has committed $15-20 billion on its R&D program.[93] This is augmented by the rapid increase in engineering, science and tech graduates in China since 1999.[94] To be sure, those with engineering, science degrees are sought after and draw high start salaries. This is further supported by the Chinese government's 'Made in China 2025' policy.[95] A recent investigative report by NPR reveals that issues like technology theft and cyber hacking, originating in China were known for two decades, but U.S.

---

[88] "2018 Global R&D Funding Forecast", R&D, Winter 2018, at http://digital.rdmag.com/researchanddevelopment/2018_global_r_d_funding_forecast?pg=1#pg1 (Accessed on April 8, 2019).
[89] Jeff Tolefson, "China Declared World's Largest Producer of Scientific Articles", *Nature*, January 18, 2018 at https://www.nature.com/articles/d41586-018-00927-4 (Accessed on April 08, 2019).
[90] Ibid.
[91] Eric Auchard and Sijia Jiang, "China's Huawei Set to Lead Global Charge to 5G Networks", *Reuters*, February 23, 2018 at https://www.reuters.com/article/us-telecoms-5g-china/chinas-huawei-set-to-lead-global-charge-to-5g-networks-idUSKCN1G70MV (Accessed on April 08, 2019).
[92] Karisma Vaswani, "Huawei: The Story of a Controversial Company", *BBC*, March 06, 2019 at https://www.bbc.co.uk/news/resources/idt-sh/Huawei (Accessed on April 08, 2019).
[93] Sijia Jiang, "China's Huawei to Raise Annual R&D Budget to at least $15 billion," *Reuters*, June 26, 2018 at https://www.reuters.com/article/us-huawei-r-d/chinas-huawei-to-raise-annual-rd-budget-to-at-least-15-billion-idUSKBN1KG169 (Accessed on April 08, 2019).
[94] Katherine Stapleton, "Inside the World's Largest Higher Education Boom", *The Conversation*, April 10, 2017 at https://theconversation.com/inside-the-worlds-largest-higher-education-boom-74789 (Accessed on April 08, 2019).
[95] U.S. Chamber of Commerce, "Made in China 2025: Global Ambitions Built on Local Protections", 2017 at https://www.uschamber.com/sites/default/files/final_made_in_china_2025_report_full.pdf (Accessed on April 17, 2019). Joachim Jan Thraen, *Mastering Innovation in China:* Insights from History on China's Journey towards Innovation (Wiesbaden, Germany: Gabler Verlag, 2016).

business turned the other way as they had invested too much of their capital in these joint ventures.[96] We can see a similar pattern emerging in Africa where the African Union is turning a blind eye to Chinese hacking allegations as so much Chinese investments are tied up to African countries, to include their Belt and Road Initiative (BRI). There are allegations that a Chinese national was indicted for stealing technical data from Lockheed Martin, including the plans for the Raptor, shortly after which China developed its J-20 fighter plane [a plane similar to Lockheed Martin's F-22 Raptor].[97]

Civil-Military Integration

China's space program is inspired by three long-term future space goals: developing their ability to access Space-Based Solar Power (SBSP); [98] develop technologies for space mining and permanent presence.[99] China is seeking to update and adapt its civil and military earth-based space institutions, to include the private space sector.

Dual Use is Driven by Top CPC Leadership. President Xi Jinping has offered a clear policy guidance of 'Civil-Military Integration". [100] This last point is critical as Xi is clear about what he wants from such an integration policy: China's space activities, what Xi terms as "China's space dream" [now a part of his signature 'China Dream', and enshrined in the Communist Party of China (CPC) constitution][101] is to utilize China's space capabilities to create the economic resources to maintain China's leading position in the world. In short, China wants its space program to contribute to comprehensive national power and rejuvenation of the Chinese nation.[102] In fact, Xi who is the Chairman of the Central Military Commission (CMC) has frequently urged China's space sector to take up a leading role in his 'civil-military integration strategy'.[103] Xi also specifies that all space agencies (civilian and military) to include the People's Liberation Army Strategic Support Force (PLASSF) must owe complete loyalty and allegiance to the CPC. Party loyalty is, over and above, everything else.[104] Under such a long-

---

[96] Laura Sullivan "As China Hacked, U.S. Businesses Turned a Blind Eye", NPR, April 12, 2019 at https://www.npr.org/2019/04/12/711779130/as-china-hacked-u-s-businesses-turned-a-blind-eye (Accessed on April 17, 2019).

[97] Ibid.

[98] Eric Rosenbaum and Donovan Russo, "China Plans a Solar Power Play in Space that NASA Abandoned Long Ago", CNBC, March 17, 2019 at https://www.cnbc.com/2019/03/15/china-plans-a-solar-power-play-in-space-that-nasa-abandoned-long-ago.html (Accessed on April 17, 2019).

[99] Stephen Chen, "China Plans Ambitious Space Mission to Hunt and 'Capture' Asteroids by 2020", May 11, 2017 at https://www.scmp.com/news/china/policies-politics/article/2093811/china-plans-ambitious-space-mission-hunt-and-capture (Accessed on April 17, 2019).

[100] "Xi Calls for Deepened Civil Military Integration", *Xinhua*, March 12, 2018 at http://www.xinhuanet.com/english/2018-03/12/c_137034168.htm (Accessed on April 6, 2019).

[101] "Full Text of Resolution on Amendment to CPC Constitution", *China Daily*, October 24, 2017 at http://www.chinadaily.com.cn/china/19thcpcnationalcongress/2017-10/24/content_33656521.htm (Accessed on April 6, 2019). Also see Liu Mingfu, *The China Dream Great Power Thinking & Strategic Posture in the Post-American Era* (New York: CN Times, 2015).

[102] "Full Text of White Paper on China's Space Activities in 2016", n.20. Also see Col. Qiao Liang and Col. Wang Xiangsui, *Unrestricted Warfare China's Master Plan to Destroy America* (Panama: Pan American Publishing Company, 2002).

[103] "Xi Urges Efforts to Boost Integrated Military and Civilian Development", Xinhua, June 21, 2017 at http://eng.chinamil.com.cn/view/2017-06/21/content_7646680.htm (Accessed on April 17, 2019).

[104] "Strive to Build a Strong, Modern Strategic Support Force: Xi", Xinhua, August 28, 2016 at http://eng.chinamil.com.cn/view/2016-08/29/content_7231309.htm (Accessed on April 17, 2019).

term direction from Xi, Chinese state funded space agencies to include the CNSA and the China Aerospace Science and Technology Corp (CASC) have come up with clear roadmaps[105] within the guidance provided by Xi, as to what China's space program intends to achieve in the next 30 years.[106] China's space program under President Xi is a critical part of his civil-military integration strategy.[107] Since Xi took up leadership of China in 2012, civil-military integration has become a priority for China's national strategy. On April 24, 2016, Xi announced China's national day of spaceflight, commemorating the launch of its first satellite, *Dong Fang Hong I* that reached for the stars that same day in 1970.[108] This is a move clearly aimed at gaining internal and external legitimacy for China's space program. The 2016 White paper reiterated the significance of space, stating, "To explore the vast cosmos, develop the space industry and build China into a space power is a dream we pursue unremittingly."[109] To boost this power projection capacity in outer-space, President Xi has encouraged reform within the PLA anticipating China's independent space enterprise. Xi succinctly articulated China's space activities within his vision of China's Space Dream, while talking to *Shenzhou 10* astronauts onboard the *Tiangong 1* space station in 2013: "The space dream is part of the dream to make China stronger. With the development of space programs, the Chinese people will take bigger strides to explore further into space".[110] He went on to elaborate that, "exploring the vast universe, developing space programs and becoming an aerospace power has always been the dream we've been striving for".[111] Xi believes that 'the spirit of aerospace' is akin to the 'spirit of the Long March', instrumental in establishing the PRC in 1949.[112] Consequently, he has expressed the desire to turn China into the most dominant space power by 2049, the year China celebrates in 100th birthday.[113] Such a historic connection is significant as it deliberately encourages both state and societal commitments to state funded space programs to include ambitions for a lunar presence, asteroid mining, and deep space exploration.

Coordinating Bodies for Civil-Military Integration.

To provide institutional support for such a strategy, the Political Bureau of the CPC Central Committee established the Central Commission for Integrated Military and Civilian

---

[105] Ma Chi, "China Aims to be Leading Space Power by 2045", *China Daily*, November 17, 2017 at http://www.chinadaily.com.cn/china/2017-11/17/content_34653486.htm (Accessed on April 17, 2019).
[106] Stephen Chen, "China's Nuclear Spaceships will be 'Mining Asteroids and Flying Tourists' as it Aims to Overtake US in Space Race", *South China Morning Post*, November 17, 2017 at https://www.scmp.com/news/china/policies-politics/article/2120425/chinas-nuclear-spaceships-will-be-mining-asteroids (Accessed on April 7, 2019).
[107] "Xi Stresses Military-Civilian Integration in a New Era", Ministry of National Defense of the People's Republic of China, March 3, 2018 at http://eng.mod.gov.cn/cmc/2018-03/03/content_4805775.htm (Accessed on April 17, 2019).
[108] "China to Set April 24 as National Day of Spaceflight", Chinese Academy of Sciences, March 23, 2016 at http://english.cas.cn/newsroom/china_research/201603/t20160323_160828.shtml (Accessed on April 17, 2019).
[109] "Full Text of White Paper on China's Space Activities in 2016", The State Council, The People's Republic of China, December 28, 2016 at http://english.gov.cn/archive/white_paper/2016/12/28/content_281475527159496.htm (Accessed on April 7, 2019).
[110] "Backgrounder: Xi Jinping's Vision for China's Space Development", Xinhua, April 24, 2017, n. 17.
[111] Ibid.
[112] Namrata Goswami, "Waking up to China's Space Dream", n.42.
[113] "Full Text of Xi Jinping's Report at 19th CPC National Congress", *China Daily*, October 04, 2017 at http://www.chinadaily.com.cn/china/19thcpcnationalcongress/2017-11/04/content_34115212.htm (Accessed on April 6, 2019).

Development (CCIMCD) in January 2017. This was the first such body dedicated to civil-military integration to be established by the top CPC leadership.[114] In March 2018, Xi presided over a plenary session of the CCIMCD.[115] In this session, Xi urged private companies across sectors (to include space private startups), to locate their work within this civ-mil integration strategy, in order to build integrated national strategic systems and capabilities.

Role of SASTIND and Other Space Agencies in Civ-Mil Integration. China's space program is directed by the State Administration on Science, Technology, and Industry for National Defense (SASTIND) which functions under the direction of the Ministry of Industry and Information Technology (MIIT).[116] SASTIND overseers the vital link between space technology and nuclear power, and communicates this aspect with other countries and international organizations.[117] SASTIND is tasked with managing and coordinating China's space activities.[118] As per its website, SASTIND is responsible for

> nuclear weapon, aerospace technology, aviation, armament, watercraft and electronic industries. It is established to strengthen military forces with additional personnel and more advanced equipment. Ensuring material supplies for the army is its top priority. Furthermore, it intends to contribute to the prosperity of the whole country by stimulating the manufacturing industry, gaining competitive edges through with superior production techniques. As the administrative and regulatory agency of science, technology and industry for national defense, SASTIND serves the needs of national defense, military forces, national economy, and military-related organizations. Meanwhile, it is also responsible for the coordination of communications and cooperation on the use of nuclear power and space activities with countries and international organizations.[119]

Under SASTIND is CNSA established in 1993. The CNSA is responsible for articulating China's space policies, direct its manned space mission, the lunar mission, the *Tiangong* space station, and the *Long March* series of rockets.[120]

Dual Space Hats Worn by Chinese Military Officials. Significantly, there are several overlaps between those posted into the PLA and China's state funded space agencies. For instance, Major General Liu Shangfu, who now heads China's Military Equipment Development Division (EDD), was Deputy Commander and Chief of Staff of the PLASSF and the commander of the Xichang Satellite Launch Center. He was also Deputy Commander of the human spaceflight program, the General Armament Division (GAD) chief of staff, and till 2017, deputy commander of China Lunar Exploration Program (CLEP). General Zhang Yulin, once with GAD in charge of space applications and Deputy Head of China's space program, now with the PLASSF, offers critical leadership to steer China's space program towards long term technologies like SBSP, and

---

[114] Zhao Lei, "Civil-Military Integration will deepen", *China Daily*, March 3, 2018 at http://www.chinadaily.com.cn/a/201803/03/WS5a99d67ca3106e7dcc13f437.html (Accessed on April 14, 2019).
[115] Ibid.
[116] "Ministry of Industry and Information Technology", The State Council, The People's Republic of China, at http://english.gov.cn/state_council/2014/08/23/content_281474983035940.htm (Accessed on April 17, 2019).
[117] "State Administration for Science, Technology, and Industry for National Defense", The State Council, People's Republic of China, , at http://english.gov.cn/state_council/2014/10/06/content_281474992893468.htm (Accessed on April 17, 2019).
[118] Marco Aliberti, *When China Goes to the Moon* (Switzerland: Springer, 2015), 10-11.
[119] "State Administration for Science, Technology, and Industry for National Defense", The State Council, n. 109.
[120] Elizabeth Howell, "China National Space Administration: Facts & Information", Space.com, 25 May 2016, http://www.space.com/22743-china-national-space-administration.html (Accessed on April 19, 2019).

his insistence on CIS-LUNAR focus. Yulin is now assistant Director for CMC EDD, which is headed by a former top space official as well, General Shangfu. Of critical note is the fact that the Deputy Head of the Chongqing Collaborative Innovation Research Institute for Civil-Military Integration (CCIRICMI), Xie Gengxin, is also in charge of the SBSP Chongqing plant and was the chief designer of the three kg bio-lab experiment that was carried on the *Chang'e 4*. These convergences point to the civil-military integration strategy that has been undertaken under President Xi. In a similar vein, Yang Shizhong, Professor at Chongqing University as well as the Chinese Academy of Engineering, wears several other hats, besides his academic affiliations. Shizhong is also Director of the Academic Board of 'Spacecraft TT&C [telemetry, tracking & Command Systems]', and technical consultant of Military Science and Technology Research Commission at the PLA Headquarters of the General Staff. Shizhong has been instrumental in developing China's first transmission-type satellite remote sensing system, which is now being utilized by China's special forces. Shizhong now has the responsibility for research and development of China's Next Generation Internet (CGNI)-5G under the National Development and Reform Commission. Interconnected to his contribution to wireless mobile access terminals for CGNI, is his engagement with research on the microwave power beaming and supply of space-based solar power. He has been tasked to track the progress of the Chongqing SBSP plant, strengthen the demonstration of key technologies like wireless beaming, as well as plan for making breakthroughs in the years ahead.[121]

PLASSF. According to Xi, the PLASSF is an important decision made by the CPC Central Committee and the CMC to realize the Chinese Dream and the Dream of a Strong Military, and a strategic initiative to build a modern military power system with Chinese characteristics.[122] The PLASSF is also involved in Civ-Mil integration. In 2017, the PLASSF signed a 'Cooperation Framework Agreement" with the China University of Science and Technology, Shanghai Jiaotong University, Xi'an Jiaotong University, Beijing Institute of Technology, Nanjing University, Harbin Institute of Technology and other six universities, as well as Aerospace Science and Technology Corporation, Aerospace Science and Industry Corporation, Electronic Technology Group Corporation.[123] These agreement is aimed at civil-military integration to attract talent, innovation, carry out special training based on technical expertise, and allow smooth transition between civilian agencies and the PLASSF.
[124]

[121] Chongqing University, Scholars Page for Yang Shizhong, at http://english.cqu.edu.cn/info/1162/1298.htm (Accessed on April 16, 2019). Xinbin Hou, "Space Solar Power Development in China and MR-SPS", China Academy of Space Technology, Qian Xuesen Laboratory of Space Technology, November 09, 2018 at http://www.sspss.jp/MR-SPS4.pdf (Accessed on April 16, 2019).
[122] "Xi Stresses Military-Civilian Integration in a New Era", n. 142. "Speech Delivered by Xi Jinping at the First Session of the 13th People's Congress", *Xinhua*, March 21, 2018 at https://www.chinadailyhk.com/articles/184/187/127/1521628772832.html (Accessed on April 17, 2019). "Backgrounder: Xi Jinping's Vision for China's Space Development", Xinhua, April 24, 2017 at http://eng.chinamil.com.cn/view/2019-02/18/content_9429066.htm (Accessed on April 6, 2019).
[123] "Strategic Support Force Cooperates with 9 Local Units to Train High End Talents of New Combat Forces", *Xinhua*, July 13, 2017 at http://military.people.com.cn/n1/2017/0713/c1011-29402123.html (Accessed on April 14, 2019).

125The establishment of the PLASSF meet three specific requirements for power projection capabilities for China in outer-space.[126]

First, the PLASSF offer China the capability to establish co-orbital presence (Earth-Moon space), to include support for its plans for permanent space presence, engage in 'area denial of space' to adversaries by jamming of adversary satellites,[127] and most importantly, the projection of military power in space. Such indigenous space military capabilities are backed by China's growing space presence and ambitions. The PLASSF, for the first time, brings together China's growing military space assets, into a single unit, aimed at dominance across the spectrum of air, space and cyber. This, the PLASSF aims to establish, by taking advantage of the U.S. military's overt dependence on space assets and space infrastructure for combat, reconnaissance, navigation, precision targeting, early warning, weather forecasting, intelligence gathering.[128] All China would require doing to expose U.S. vulnerability is threatening such assets by developing 'asymmetric capabilities' to include its 2007 Anti-Satellite Test (ASAT), that demonstrated its ability to down a U.S. satellite if required during combat. Such ASAT technologies have been further refined in 2010, 2013 and 2014, enhancing their capabilities without generating space debris as did its 2007 test. There are open sources reporting that the SSF is training with ASAT missiles aimed at US satellites. These ASAT includes the variant of the HQ-19 surface to air missile,(utilized in tests in 2007, 2010) and the DN-2 (2013) and the DN-3 (2015, 2016, 2017). According to the National Space and Air Intelligence Center (NASIC) report, *Competing in Space*,

> China has military units that have begun training with anti-satellite missiles. Russia is probably also developing an anti-satellite missile. These missiles can destroy U.S. and allied space systems in low Earth orbit, making intelligence, surveillance, reconnaissance, and communications satellites vulnerable.[129]

Second, by establishing the PLASSF, China is innovating its military to develop futuristic doctrines, training and capabilities to back its state funded space ambitions as well as growing private space industry. Critically, Xi urged China's private space industries to integrate their strategy within his Civil-Military Integration Strategy. Since 2014, President Xi has been urging China's private space sector to emerge as the leader in the "implementation of civil-military integration strategy".[130] Xi's policy guidance has been followed up by the PLA, and

---

[126] Namrata Goswami, Waking up to the China Dream", n. 42.
[127] Daniel R. Coats, Director of National Intelligence, "Worldwide Threat Assessment of the US Intelligence Community", February 13, 2018 at https://www.dni.gov/files/documents/Newsroom/Testimonies/2018-ATA---Unclassified-SSCI.pdf (Accessed on April 14, 2019). Zachery Kack, "China will Soon be Able to Destroy Every Satellite in Space", *The National Interest*, June 30, 2018 at https://nationalinterest.org/blog/buzz/china-will-soon-be-able-destroy-every-satellite-space-27182 (Accessed on April 14, 2019).
[128] Omar Lamrani, "What the U.S. Military Fears Most: A Massive Space War", *The National Interest*, May 18, 2016 at https://nationalinterest.org/blog/the-buzz/what-the-us-military-fears-most-massive-space-war-16248 (Accessed on April 17, 2019).
[129] National Air and Space Intelligence Center, "Competing in Space", December 2018 at https://media.defense.gov/2019/Jan/16/2002080386/-1/-1/1/190115-F-NV711-0002.PDF, p.21 (Accessed on April 14, 2019).
[130] "PLA welcomes Launches of Private Rockets", *China Daily*, February 18, 2019 at http://eng.chinamil.com.cn/view/2019-02/18/content_9429066.htm (Accessed on April 17, 2019).

it has opened up its *Jiuquan Satellite Launch Center* [China's primary launch facility] in the northwestern Gobi Desert for private rocket launches. The planning chief of the *Jiuquan Satellite Launch Center,* Jia Lide, stated that "favorable policies and targeted measures have been created for the benefit of private space enterprises".[131]

Third, in case a dispute breaks out over 'resource ownership' in space, the PLASSF is being optimized and structured to respond in a manner that builds upon domain expertise given its focus solely on utilizing space and cyber for optimal ends. President Xi in a speech to the PLASSF in August 2016 stated that "Innovation is what we need most in building the strategic support force. Innovation is the fundamental solution".[132] Xi stressed the significance of building a training regime and augment war-fighting capacities solely focused on domain expertise and focus. To motivate its personnel, the CMC promoted the Commander of the PLASSF, Gao Jin to General in 2017, the highest 'active-duty' rank in China.[133]

Evidence of Dual Use Systems. There have been conferences and meetings on the dual use of technologies like Artificial Intelligence, Space and Robotics, where China is emerging as a leader. The development of a satellite with a robotic arm that simulated the grab of another Chinese satellite in space in 2013, indicated that such a capacity has dual use and could grab an adversary satellite if required. China has enhanced its capacities for space debris removal through the *Aolong-1 debris cleaner,* which was onboard the Long March 7 rocket launched in 2016. The *Aolong-1* can conduct proximity operations, called Rendezvous Proximity Operations (RPO), to identify, and conduct clean-up of defunct satellites for active debris removal.[134] While space debris removal and satellite refueling, maintenance and repair, are benign activities, such Chinese assets are now directed by the SSF. This implies that civilian space capacities can easily switch to military use when required given China's space program is directed and led by the PLA.

China and Multilateral Engagements in Space.

China's up-coming space station, *Tianhe-1* (harmony of the heavens) is scheduled for launch in 2022.[135] Bai Mingsheng, chief designer of China's first cargo spacecraft *Tianzhou-1*, in an interview to China Central Television, stated that "China might be the only country that will run a space station in the foreseeable future. We could invite other nations to carry out experiments on [our] space station, making it an international scientific platform for all humankind."[136] On May 28, 2018, China issued a call for all U.N. nations to participate in its upcoming space station (including the U.S.) for the peaceful use of outer-space in cooperation with the United Nations

[131] Ibid.
[132] "Strive to Build a Strong, Modern, Strategic Support Force: Xi", Xinhua, August 29, 2016 at http://eng.chinamil.com.cn/view/2016-08/29/content_7231309.htm (Accessed on April 17, 2019).
[133] "China Promotes 5 Officers to General", Xinhuanet, July 28, 2017 at http://www.xinhuanet.com/english/2017-07/28/c_136480993.htm (Accessed on April 17, 2019).
[134] Stephen Chen, "Is China Militarising Space? Experts Say New Junk Collector Could be Used as anti-satellite weapon", *South China Morning Post*, June 28, 2016 at https://www.scmp.com/news/china/diplomacy-defence/article/1982526/china-militarising-space-experts-say-new-junk-collector (Accessed on April 17, 2019).
[135] Deyana Goh, "China's Space Station to be Operational by 2022", Spacetech, March 15, 2018 at http://www.spacetechasia.com/chinas-space-station-to-be-operational-by-2022/ (Accessed on April 17, 2019).
[136] "China's Space Station will Serve all Mankind: Expert", *China Daily*, September 18, 2017 at http://en.people.cn/n3/2017/0918/c90000-9270409.html (Accessed on April 17, 2019).

Office for Outer Space Affairs (UNOOSA).[137] Simonetta Di Pippo, Director of UNOOSA stated in an interview to Xinhua that "This is an agreement which will allow the entire world to use, for scientific purposes, the China Space Station when it will be ready...it's the first time it is open to all member states."[138]

China's invitation to all U.N. member states to participate in scientific experiments abroad its space station is clearly a dig at the U.S. In 2011, a spending bill passed by the U.S. Congress included a clause that prohibited any scientific cooperation between China, NASA and the White House Office of Science and Technology Policy (OSTP). The clause states that NASA or OSTP are prohibited "to develop, design, plan, promulgate, implement or execute a bilateral policy, program, order, or contract of any kind to participate, collaborate, or coordinate bilaterally in any way with China or any Chinese-owned company." It prevents NASA facilities from hosting 'official Chinese visitors'.[139] During my visit to China in 2016 to interact with Chinese space policy makers, academia and students, I asked them about the 2011 U.S. Congressional ban. Almost all argued that such a ban actually galvanized space research in China and improved their indigenous capacities. Chinese academics specializing on outer- space specified that soon it will be only China on whom everyone else will depend, to establish presence in outer-space. This development, by default, would force the U.S. to cooperate with China in outer-space. China's Memorandum of Understanding (MoU) with UNOOSA adds credibility to such a claim and affords it powerful agency in the construction of regulatory regimes in outer-space.

China's former Ambassador to the United Nations, Shi Zhongjun, in a May 28, 2018 statement stated, "The China Space Station belongs not only to China, but also to the world,". As mentioned earlier, in cooperation with UNOOSA, China is inviting applications from public and private companies, universities, all U.N. members, and especially developing countries to submit proposals for conducting scientific experiments abroad its upcoming space station.[140] Zhongjun specified,

> A shared vision for the future in space exploration and use is not only consistent with the objectives and purposes established in the Outer Space Treaty -- that the exploration and use of outer space should be for the benefit and in the interest of all countries -- but also in line with current needs to protect the outer space environment and promote sustainability both for outer space activities and socioeconomic development.[141]

---

[137] United Nations/China Space Station Announcment of Opportunity Ceremony", United Nations Office for Outer Space Affairs, May 28, 2018 at http://www.unoosa.org/oosa/en/informationfor/media/2018-unis-ma-222.html (Accessed on April 17, 2019).

[138] "Interview: Opening up of China's Space Station to Reinforce Cooperation for Outer Space's Peaceful Use—UN Official", Xinhuanet, May 29, 2018 at http://www.xinhuanet.com/english/2018-05/29/c_137214412.htm (Accessed on April 17, 2019).

[139] Jeffrey Mervis, "Spending Bill Prohibits U.S-China Collaborations", Science, April 21, 2011 at https://www.sciencemag.org/news/2011/04/spending-bill-prohibits-us-china-collaborations (Accessed on April 17, 2019).

[140] "United Nations and China Invite Applications to Conduct Experiments on-board China's Space Station", UNOOSA, Press Release, May 28, 2018. Also see Loren Grush, "China invites international researchers to do science on its future space station", The Verge, May 29, 2018 at https://www.theverge.com/2018/5/29/17404896/china-space-station-international-cooperation-united-nations (Accessed on April 17, 2019).

[141] "Chinese Envoy Calls for Strengthening of Outer Space Governance. Cooperation", Xinhua, June 21, 2018 at http://www.xinhuanet.com/english/2018-06/21/c_137268993.htm (Accessed on April 16, 2019).

China's White paper of 2016 highlight multilateral engagements with UNOOSA, the United Nations Committee on the Peaceful Uses of Outer Space and its Scientific and Technical Subcommittee and Legal Subcommittee, as well a field office by the UN in Beijing, called the Regional Center for Space Science and Technology Education in Asia and the Pacific (China). China is a key member of the Asia-Pacific Space Cooperation Organization (APSCO), that includes the APSCO Joint Small Multi-Mission Satellite Constellation Program. It also organized the APSCO Development Strategy Forum within the theme of "the Belt and Road Initiative for Facilitating Regional Capacity Building of the Asia-Pacific Countries."

This kind of 'grandstanding' offers China, influence and power, especially the ability to influence others to do what you want them to do. China views its space initiatives as part of its BRI and is especially keen to see countries the initiative enjoy the benefits of China's space capabilities. While announcing April 24, 2016 as the first National Space Flight day (China's first satellite, the *Dong Fang Hang* 1 launched into space on April 24, 1970), Xu Dazhe, Vice Minister of China's Ministry of Industry and Information Technology (MIIT), administrator of SASTIND and the CNSA specified that China views its international space activities as part of the OBOR, and aims to build an Asia-Pacific focused space cooperation.[142] With such high-end outer-space cooperation comes the power to craft alternate regime structures and norms. China is building a $9 billion Beidou Navigation System (BDS) to be globally operational by 2020. The profits to be earned from this system is estimated to be $ 57 billion in 2020 itself, as predicted by the China Satellite Navigation Office. Companies like NavInfo Co, funded by TENCENTS, aims to make semiconductors for navigation systems based on Beidou. Already, smartphones from Samsung support Beidou. China is already mandating all car companies that sell in China to make them Beidou compatible by 2020. Car makers like Volkswagen are already meeting those requirements.[143] As per its white paper on the Beidou navigation system, China has developed Beidou as per its national security and economic needs. At the sometime, it wants to offer this system to the world. As per the white paper, the third level development of Beidou is to, "provide basic services to the countries along the Belt and Road and in neighboring regions by 2018, and to complete the constellation deployment with the launching of 35 satellites by 2020 to provide services to global users".[144] The first BRI 2017 summit drew the Heads of 28 states, to include Russian President Vladimir Putin, Philippine President Rodrigo Duterte, Turkish President Recep Tayyip Erdogan, Malaysian Prime Minister Najib Razak, Indonesian President Joko Widodo, Vietnamese President Tran Dai Quang and Myanmar's leader Aung San Suu Kyi, besides others. It was also attended by Heads of States from Switzerland, Italy, Hungary, Czech Republic, Kenya, Nigeria. The 2019 summit is scheduled for May. Space is an important component of the BRI.

---

[142] "SCIO Briefing on China's 1st National Day of Space Flight", China.org.cn, April 23, 2016 at http://www.china.org.cn/china/2016-04/23/content_38309726.htm (Accessed on April 17, 2019).
[143] "China Building $9 Billion Beidou Rival to U.S-Run GPS, looks to go global", *The Japan Times*, November 26, 2018 at https://www.japantimes.co.jp/news/2018/11/26/asia-pacific/china-building-9-billion-beidou-rival-u-s-run-gps-looks-go-global/#.XLeZ2OhKiUk (Accessed on April 17, 2019).
[144] State Council, PRC, "Full Text of White Paper: China's Beidou Navigation Satellite System", June 2016 at http://www.scio.gov.cn/zfbps/ndhf/34120/Document/1480623/1480623.htm (Accessed on April 17, 2019).

Bilateral Agreements.

China has signed 121 cooperation agreements with 37 countries and four international organization, as per CNSA spokesperson, Li Gouping.[145] These include a 30 year relationship with Brazil on earth resource satellites, an ocean observation satellite with France, the construction of a BRICS (Brazil, Russia, India, China, South Africa) remote sensing satellite constellation, satellites launches for Sri Lanka, Bangladesh, Algeria, and satellite data sharing with Pakistan, Iran, Turkey, Peru, Chile, Thailand, Laos, Cambodia, Burma.[146] Significantly, China has signed bilateral agreements with Russia, the European Space Agency (ESA), Brazil, Chile, France, the U.K., Germany, the Netherlands, Algeria, Argentina, Belgium, India, Indonesia, and Kazakhstan to strengthen exchanges and cooperation in such areas as space technology, space applications, and space science, education and training. Interestingly, China's White paper on Space 2016 claims that "China and the United States, within the framework of the China-US Strategic and Economic Dialogue, carried out a civil space dialogue, stating that the two countries would strengthen cooperation in space debris, space weather, response to global climate change, and related areas".[147]

Expectations from China's Industrial Space Ambitions based on Territorial Behavior on Earth

While others offer insights that PRC space efforts are mostly aimed at anti-access, or information dominance strategies, in my perspective, what should be of concern to the U.S are the elements that are focused on material and economic strength and securing of space resources. Chinese space activities should be seen through the lens of territorial and resource competitive offensives such as the Belt and Road Initiative and 5G internet.

China's space ambitions indicate that under the leadership of Xi, it is not only establishing capacity to take advantage of the multi-trillion dollar space industry that awaits but also enhancing and streamlining its military capacities for power projection in outer-space. Leading to these are proclaimed ambitions of colonizing the moon, and establish norms and regulations for outer-space led by China. The Commission has good reasons to be skeptical of PRC efforts at norm construction. China supported a joint draft proposal with Russia for the "Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force Against Outer Space Objects" in 2008 and again in 2014.[148] While the move for such a treaty appears noble, an in-depth assessment indicates that it does not include a ban on direct ascent ASAT technologies or terrestrially based space weapons.

The Commission should consider that there are indications China views space territorially and therefore it is relevant to examine how China behaves with respect to territory and resources on

[145] "China Strengthens International Space Cooperation", *China Daily*, April 19, 2018 at http://www.chinadaily.com.cn/a/201804/19/WS5ad899eea3105cdcf65195a1.html (Accessed on April 16, 2019).
[146] Ibid.
[147] "Full text of White Paper on China's Space Activities in 2016", n. 109.
[148] "Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force Against Outer Space Objects (Draft), Ministry of Foreign Affairs of the People's Republic of China, June 16, 2014 at https://www.fmprc.gov.cn/mfa_eng/wjb_663304/zzjg_663340/jks_665232/kjfywj_665252/t1165762.shtml (Accessed on April 17, 2019).

Earth. China's history of signing bilateral agreements with countries it has land disputes with committing to de-escalation and peaceful resolution of disputes, while simultaneously engaging in behavior that is contrary to its signed commitments, do not give us much assurance it will behave any differently in the space domain.[149] This aspect was visible in the 2017 China-Bhutan border dispute. The dispute started when the Royal Bhutan Army (RBA) observed Chinese road-building activities in the Doklam area. The RBA tried to dissuade the People's Liberation Army (PLA) engineers from constructing the road but failed. This led to Indian military intervention on behalf of Bhutan, and de-escalation of the conflict after a 73 days standoff between two nuclear armed nations. Critically, China and Bhutan had signed agreements to resolve this dispute peacefully and have held 24 rounds of negotiations on the same, since 1984. The Bhutanese government's take is that China's roadbuilding activities is against the 1988 and 1998 bilateral China-Bhutan agreements by which all boundary disputes will be resolved by negotiations. Bhutan states that "we have written agreements of 1988 and 1998 stating that the two sides agree to maintain peace and tranquility in their border areas pending a final settlement on the boundary question, and to maintain status quo on the boundary as before March 1959. The agreements also state that the two sides will refrain from taking unilateral action, or use of force, to change the status quo of the boundary".[150] On the other hand, the Chinese perspective is that its road-building activities do not infringe upon Bhutanese territory as Doklam has always been a part of China. Foreign Ministry Spokesperson, Lu Kang, asserted "Doklam has been a part of China since ancient times. That is an indisputable fact supported by historical and jurisprudential evidence, and the ground situation. China's activities in Doklam are acts of sovereignty on its own territory. It is completely justified and lawful".[151]

An analysis of China's past behavior regarding negotiations on disputed territory reveals a clear systematic pattern of engagement which is relevant to its future space ambitons. In its active border and territorial disputes, be it with India over Arunachal Pradesh, or the South China Sea (SCS), or Bhutan, China has favored the signing of 'Guiding principles' or 'Agreements to maintain peace and tranquility" with the state it is in dispute with. Such a framework, by establishing clear guidelines constrains the negotiating power of the fellow signatory state blindsiding it to China's future plans of sudden aggressive broadcasting of territorial claims. For instance, China and India signed a 2005 agreement on "Political Parameters and Guiding Principles for the Settlement of the India-China Boundary Question".[152] As per the agreement's Article IX,

[149] Namrata Goswami, "Can China be Taken Seriously on its 'Word' to Negotiate Disputed Territory?", The Diplomat, August 18, 2017 at https://thediplomat.com/2017/08/can-china-be-taken-seriously-on-its-word-to-negotiate-disputed-territory/ (Accessed on April 17, 2019).
[150] Ministry of Foreign Affairs, Government of Bhutan, "Press Release", June 29, 2017 at http://www.mfa.gov.bt/?p=4799 (Accessed on September 19, 2017).
[151] Ministry of Foreign Affairs of the People's Republic of China, "Foreign Ministry Spokesperson Lu Kang's Regular Press Conference on June 29, 2017 at http://www.fmprc.gov.cn/mfa_eng/xwfw_665399/s2510_665401/t1474166.shtml (Accessed on September 19, 2017).
[152] "Agreement between the Government of the Republic of India and the Government of the People's Republic of China on the Political Parameters and Guiding Principles for the Settlement of the India-China Boundary Question", Ministry of External Affairs, Government of India, April 11, 2005 at https://www.mea.gov.in/bilateral-documents.htm?dtl/6534/Agreement+between+the+Government+of+the+Republic+of+India+and+the+Government

> Pending an ultimate settlement of the boundary question, the two sides should strictly respect and observe the line of actual control and work together to maintain peace and tranquility in the border areas.

Yet, despite this agreement which establishes both China and India's commitment to maintain *status qu*o and peace at the border, in 2006, the Chinese ambassador to India, Sun Yuxi stated categorically that "In our position, the whole of the state of Arunachal Pradesh is Chinese territory. And Tawang is only one of the places in it. We are claiming all of that. That is our position".[153] This was followed by frequent PLA incursions into the Indian side of the LAC on several occasions, as well as an attempt to set up permanent camps and settlements.[154] These intrusions have been augmented by the Chinese Ministry of Foreign Affairs publishing maps in Chinese passports depicting Arunachal Pradesh and other disputed areas like the SCS as Chinese sovereign territory.[155]

A similar pattern of Chinese behavior emerges with regard to the SCS as well which may inform expectations of future Chinese space behavior. China and ASEAN agreed on the framework on a Code of Conduct (CoC) in the SCS in May 2017.[156] The draft CoC commits the parties to resolve crisis peacefully and avoid placing offensive weapons in the SCS islands. In 2002, a 'Declaration on the Conduct of Parties in the South China Sea" was adopted by China and ASEAN.[157] Interestingly, art.5 of the declaration states:

> The Parties undertake to exercise self-restraint in the conduct of activities that would complicate or escalate disputes and affect peace and stability including, among others, refraining from action of inhabiting on the presently uninhabited islands, reefs, shoals, cays, and other features and to handle their differences in a constructive manner.

Yet, China is using early presence and facts on the ground to alter territorial claims despite its adoption of the 2002 declaration and establish exclusion zones and zones of military coercion in the SCS. In January 2014, it was discovered that Chinese vessels were dredging white sand and placing them onto corals at seven points in the disputed Spratlys, namely; Fiery Cross Reef, Mischief Reef, Gaven Reef, Cuarteron Reef, Subi Reef, South Johnson Reef, and Hughes

---

+of+the+Peoples+Republic+of+China+on+the+Political+Parameters+and+Guiding+Principles+for+the+Settlement+of+the+IndiaChina+Boundary+Question (Accessed on April 17, 2019).

[153] "Arunachal Pradesh is our Territory: Chinese Envoy", Rediff, November 14, 2006 at https://www.rediff.com/news/2006/nov/14china.htm (Accessed on April 17, 2019).

[154] Ben Arnoldy, "Growing Number of China Incursions into India Lead to a Strategy Change", *The Christian Science Monitor*, September 29, 2009 at https://www.csmonitor.com/World/Asia-South-Central/2009/0929/p06s06-wosc.html (Accessed on April 17, 2019).

[155] Jonathan Kaiman, "Chinese Passport Map Causes Diplomatic Dispute", The Guardian, November 27, 2012 at https://www.theguardian.com/world/2012/nov/27/chinese-passport-row-diplomatic-dispute (Accessed on April 17, 2019).

[156] "China, ASEAN Agree on Framework for South China Sea Code of Conduct", *Reuters*, May 18, 2017 at https://www.reuters.com/article/us-southchinasea-china-philippines-idUSKCN18E1FS (Accessed on April 17, 2019).

[157] "Declaration on the Conduct of Parties in the South China Sea", Association of Southeast Asian Nations, October 17, 2012 at https://asean.org/?static_post=declaration-on-the-conduct-of-parties-in-the-south-china-sea-2 (Accessed on April 17, 2019).

Reef.[158] Once the artificial islands have been built, China has followed it up with erecting buildings, harbors and airstrips, deploying radar and surveillance, as well as stationing its troops: all activities geared towards establishing ownership and sovereign control over disputed territory.

We see a similar pattern emerge in China's activities in Antarctica as well. As per the Antarctic Treaty System (ATS), in 1961, all territorial claims are to be suspended and the region must remain demilitarized and nuclear-free, and the primary goal is for cooperative scientific exploration. Additional agreements over the continent include the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR, 1982) to protect marine resources, and the Protocol on Environment Protection of the Antarctic Treaty (1991), known as the "Madrid Protocol," which forbids the exploitation of mineral resources. Any alterations to the ATS cannot take effect until 2048 without unanimous approval. CCAMLR tightly prohibits overfishing which can, as a direct flow-on effect, affect the availability of fish in other EEZs.[159] However, Illegal, Unreported and Unregulated (IUU) fishing in the Ross Sea is raising significant concern, particularly the fact that some of the infringing fishers are from ATS signatory states.[160] A Stockholm report from January 2015 tallied 147 cases of suspected IUU activities in Antarctic waters using 72 vessels between 1995 and 2009. These vessels frequently change their names and flag states to conceal the true beneficiaries of their fishing.[161] Anne-Marie Brady suggests that China is flouting the rules of the ATS. In 2014 the Chinese krill catch was 55,000 tons, worth approximately US$10 million. However, in 2015 China announced plans to increase their intake to between one to two million tons.[162] CCAMLR restricts annual krill catch to 680,000 tons.[163] As such, Chinese plans were to definitively and pugnaciously exceed the limits. IUU fishing is not only a security risk to the Antarctic region, it flouts the laws of the global commons and displays ill strategic intent. Furthermore, under the guise of "scientific research" any exploration is deemed accidental, which creates the situation where many real exploratory events are masked under the name of science. This exploration and potential mining are of concern as any conflict arising over minerals would likely involve multiple sovereign claimant states. Scholars suggest that China is the foremost player in the mineral exploitation game, as their four (soon to be five) bases are all in areas it has identified as strategically important and rich in resources.[164] The Polar Research Institute of China (PRIC) estimates there

[158] Derek Watkins, "What China has been Building in the South China Sea", *The New York Times*, February 29, 2016 at https://www.nytimes.com/interactive/2015/07/30/world/asia/what-china-has-been-building-in-the-south-china-sea-2016.html (Accessed on April 17, 2019).
[159] Anne-Marie Brody, "New Zealand's Strategic Interests in Antarctica", *Polar Record*, 47/2, April 2011 at https://www.cambridge.org/core/journals/polar-record/article/new-zealands-strategic-interests-in-antarctica/139EB0FC4E97E6A68D010BB2BFC705B2 (Accessed on April 17, 2019).
[160] L.M. Foster and Namrata Goswami, "What China's Antarctic Behavior Tells us About the Future of Space", *The Diplomat*, January 11, 2019 at https://thediplomat.com/2019/01/what-chinas-antarctic-behavior-tells-us-about-the-future-of-space/ (Accessed on April 19, 2019).
[161] "The Toothfish Bites Back", Stockholm Resilience Center, 2011 at https://www.stockholmresilience.org/research/research-news/2011-06-16-the-toothfish-bites-back.html (Accessed on April 17, 2019).
[162] Stuart Leavenworth, "China Fishing Plan in Antarctica Alarms Scientists", McClatchy, March 19, 2015 at https://www.mcclatchydc.com/news/nation-world/world/article24781990.html (Accessed on April 17, 2019).
[163] CCAMLR, "Krill Fisheries", at https://www.ccamlr.org/en/fisheries/krill-fisheries (Accessed on April 17, 2019).
[164] Anne Marie Brody, "China's Expanding Antarctic Interests: Implications for New Zealand", SSANSE, Policy Brief 2, June 3, 2017 at https://www.canterbury.ac.nz/media/documents/research/China's-expanding-Antarctic-interests.pdf (Accessed on April 17, 2019).

are 500 billion tons of oil and 300-500 billion tons of natural gas on the continent, plus more in the Southern Ocean stating "when all the world's resources have been depleted, Antarctica will be a global treasure house of resources."[165] China's focus is on exploiting resources in and above the ground.

Another issue of growth in the Antarctic is in the development of China's ice-based satellite communications system, the placement of *BeiDou 2* ground stations (China's GPS equivalent) on the ice increasing the accuracy and capability of missile tracking, timing and positioning; and an astronomical program that includes infrared telescopes capable of detecting enemy satellites, drones, and missile launches. The use of this suite of technology means that in any future dispute, the targeting of the Antarctic bases could be a reality even if the conflict is not on the continent. Similarly, China has established its first overseas fully owned 'China Remote Sensing Satellite North Pole Ground Station', at the Kiruna's Esrange Space Centre, 200km north of the Arctic Circle. Professor Liao Mingsheng, a satellite radar expert at Wuhan University's State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing, specified, "A polar station will significantly boost our country's capability for global data surveillance. We should build more ground station overseas – maybe not only in the North Pole, but in the South Pole as well."[166] This project is part of China's Gaofen project – a network of observation satellites orbiting the Earth to provide global surveillance capabilities –due to be completed in 2020. Locating a ground station on the poles implies cutting the time for downloading satellite data from seven hours (from those that fly over China) to about 3.5 hours, for those that fly over the poles. This is due to the fact that satellites used for mapping, forecasting weather and military surveillance, intelligence gathering and reconnaissance are able to orbit the North Pole 12 times per day, compared to five times for those flying over China. This has raised concerns within Sweden with Swedish Defense Research Agency researchers suspecting that China will use these images to compliment military intelligence and surveillance. This scenario is even more plausible given China's space program is run under the direction of the PLA.[167]

What China aims to achieve from its space ambitions is to establish alternative institutions, investment mechanisms and capacities that not only challenges U.S. dominance in outer-space but establishes a China-led space order that it projects as benefiting the world. We can already see this manifesting with its BRI. In 2018, China established the China International Commercial Court,[168] in Xian, Shaanxi province and Shenzhen under its Supreme People's

[165] L.M. Foster and Namrata Goswami, "What China's Antarctic Behavior Tells us About the Future of Space", n. 160.
[166] Stephen Chen, "China Launches its First Fully Owned Overseas Satellite Ground Station near North Pole", *South China Morning Post*, December 16, 2016 at https://www.scmp.com/news/china/policies-politics/article/2055224/china-launches-its-first-fully-owned-overseas-satellite (Accessed on April 16, 2019).
[167] Nilobon Bantoey, "Satellite Station in Sweden can be serving Chinese Military", ScandAsia.com, January 16, 2019 at https://scandasia.com/satellite-station-in-sweden-can-be-serving-chinese-military/ (Accessed on April 16, 2019).
[168] "China International Commercial Court", at http://cicc.court.gov.cn/html/1/219/index.html (Accessed on April 16, 2019).

Court in Beijing, to adjudicate international commercial disputes, especially stemming from Chinese companies' engagement in BRI countries.[169]

Policy Recommendations

General Recommendations

a) The U.S. needs to take the Chinese space goals and timelines seriously. There must be a clear understanding that China's space program is a military directed and led program in which the CPC has staked its credibility.

b) As a response to the goals set by China, the U.S. should craft a long-term space resource policy that offers guidelines on both resource utilization and extraction. These should include long term plans for the Moon, asteroids and Space Based Solar Power.

c) There is a serious competition ongoing with China for leadership of space, and who has the more attractive long-term vision of space resource utilization.

d) The most useful lens through which to understand the Chinese Space program are its terrestrial efforts to secure resources (Tibet, Antarctica, South China Sea). China follows an incremental strategy of capacity development, establishing presence and then crafting institutions that support its presence.

e) Congress should fund a serious study of what a space economy would look like and what would be the implications of such a space-based economy.

China's space program and its future goals indicate a discourse shift from viewing space merely from a 'flags and footprints' model to a long-term presence capacity building model.

Given that, I would recommend further hearings on:

1. The state of Space Based Solar Power within the U.S. and China.
2. The State of Space Mining within the U.S. and China
3. Proposals for a Lunar Industrial Facility.
4. Development of Space Nuclear Propulsion.

Recommendations for Research

1. Intelligence mapping of Chinese space goals, from now to 2050, and a comparative assessment of the U.S. and Chinese space resource programs.
2. Develop scenarios of U.S. or PRC leadership in space resources and recommendations on how to get to a preferred future.
3. Track the progress of the Chinese space exploitation program on an annual basis.

[169] Freshfields Bruckhaus Deringer, "China Establishes International Commercial Courts to handle Belt and Road Initiative Disputes", University of Oxford, Faculty of Law,

Recommendations for Policies to get to a Preferred Future

1. Create capacity to maintain U.S. relative advantage in CIS-LUNAR space.
2. Create a vision for Space Industrialization.
3. Establish near-term goals to drive Space Mining and Space Based Solar Power.
4. Create a dedicated military space service for unity of effort in the space domain, where space is the topmost institutional priority.
5. Ensure the proposed U.S. Space Service has a broad set of missions that allow them to respond to the Chinese strategic offensive, including defense of commerce missions similar to what the U.S. Navy does in the maritime domain.
6. Give significant attention to establish bilateral relationships with non-European democracies such as India, Japan, Indonesia, Brazil, Australia, New Zealand.
7. Empower National Space Council to develop whole of government plans to compete with PRC in space.
8. Task new U.S. SPACE COMMAND as the operational lead for implementing the aforementioned National Space Council Plan.
9. Make U.S. SPACE COMMAND an interagency command. Include other key agencies that deal with space as represented in the National Space Council.

PANEL I QUESTION AND ANSWER

CHAIRMAN BARTHOLOMEW: Thank you very much for interesting testimony from all of you.

We'll start our questions with Commissioner Wessel.

COMMISSIONER WESSEL: Thank you all.

And, Dr. Goswami, your testimony was to the second. So, thank you.

(Laughter.)

But, also, one of your last comments was that many people downplay China's ambitions. I don't think this Commission is necessarily known for downplaying China's ambitions. So, let me pivot off of that point for all three of you.

Mr. Harrison, you talked about cooperation. Dr. Weeden, you indicated -- correct me if I'm wrong -- that China has been essentially, as it relates to space, pursuing international norms.

In the area of space cooperation, as I'm sure you know, former Congressman Wolf was author of certain limitations on cooperation between NASA and China's space authorities because it was viewed as a one-sided relationship that was primarily advantaging the Chinese.

We've looked at other areas, energy cooperation, S&T, et cetera, both in hearings as well as in studies. And most of the evidence is that it's pretty one-sided.

Dr. Weeden, when I look at the Philippines case, when I look at economics, when I look at human rights, and recent actions or activities in Hong Kong and what's happening with the Occupy movement and Chinese pressure, I don't necessarily think that China follows international norms. You're more hopeful than I am.

Talk to me about what you think we can do to advance cooperation and make sure that the U.S. truly benefits. What should we be doing better in terms of international engagement to ensure that there's a backstop, that China doesn't take advantage of this area, and our desire to find the norms and find out, as they advance their capabilities, that we've been naive in sitting back?

And, Dr. Goswami, what can we do better to accelerate our activities?

Mr. Harrison, do you want to start?

MR. HARRISON: Sure, and I'll try to be brief, so everyone has time to get to their answers.

I would say, first of all, the Wolf amendment I believe has largely proven ineffective in what it is was trying to do. It's not slowing China down. It's not preventing China from getting technology, because China is very capable of developing the technology or stealing it on its own.

I think that we ought to look at not only repealing that, but looking at areas where we can engage China in civil space missions. But my criteria would be clear. First of all, no exchange of technology. And you don't need to exchange technology to cooperate. We did not exchange technology with the Soviet Union when we cooperated with them, and we don't exchange technology with Russia today when we continue to cooperate with that country on the International Space Station. You just need to have compatible interfaces. You need to have mission goals that are compatible.

And I think in many places, in terms of space exploration, we do have compatible missions where we want to go to the moon. We want to explore different parts of the moon. There's no reason we could not do that in conjunction with them and prevent some of the worst-case scenarios that have been talked about here of China potentially getting there first and claiming territory or rights or excluding others. If we do it together, they would not have that

option. And so, I think those are goals we should pursue.

The other criteria in cooperation is we need to make sure we do it in a way that does not alienate any of our existing partners in space. So, we have a great alliance on the International Space Station and other countries that NASA cooperates with. And we don't want to risk any of those partnerships when we're engaging China. So, we've got to thread the needle on it, but I think that there are positive, beneficial ways that we can do that.

COMMISSIONER WESSEL: Dr. Weeden?

DR. WEEDEN: So, I would echo Todd's comments about that. I would also say that my organization, we hosted a panel discussion on this exact issue of U.S.-China engagement in space. We called it "engagement," not "cooperation," because it is not necessarily about cooperating with them; it's about how are we going to engage with them across military, civil, and commercial spheres of space activities.

We have a transcript from that that's on our website. I'm happy to share that. But we had participants from NASA, from the Department of Defense, as well as from industry, that were talking about how that engagement should happen.

On the issue of norms, I share your concerns about China's lack of following human rights and other breaking of norms here on the terrestrial sphere. My caution is not to assume that, just because they are doing that in terrestrial space, they will automatically do so in space.

There is a significant difference between the way China looks at, for example, the South China Sea as versus the moon. Historically, they have considered these certain places on earth to be part of China's sphere of influence or part of China's territory; and therefore, see re-acquiring them or annexing or taking control of them as a return to the norm. That is not the case with the moon and parts of outer space. So, I think there is something fundamentally different there that makes it a different analogy.

And as I said, based on everything we've looked at and a decade worth of our participation as observers and NGO in this multilateral discussions, we have not seen China acting contrary to the existing laws and norms in outer space. In fact, they've been upholding them for the most part.

Now the caveat there is that a lot of the existing legal structure for space rests on high-level principles that have not been clearly defined or further fleshed out, right? We've put these treaties in place over the last several decades and that was it. There was not a lot of further -- there's no court cases and a lot of precedents.

So, there is a lot of room for interpretation on those existing treaties and legal principles. And so, that's why I said China is definitely exploiting its freedom of action in space, but that is the same thing that the United States and Russia, and many other countries, are doing, right?

So, I think my concern is more about how those legal principles or norms are shaped in the future and how they are further defined. And the challenge I see is that the United States, over the last 10 years or so, has been either not participating in the discussions about where space governance goes or actively blocking things, because its position was to maximize U.S. freedom of action.

And I think that is great when the U.S. is very far ahead of other countries. But, as other countries catch up, our freedom of action becomes their freedom of action. And so, then, that becomes, I think, a different discussion about where we shape the future of that governance regime.

COMMISSIONER WESSEL: Thank you.

DR. GOSWAMI: Thank you.

So, the question was about how does the U.S. accelerate its space programs. I would urge the Commission to recommend basically integrating your space programs. The problem now is that we have very different actors looking at different maps. So, my recommendation is empower the National Space Council to develop a whole-of-government plan to compete with PRC in space not just for the military perspective.

Because when I'm looking at China's articulation of its space program, especially in my visits to China over the years, talking to their space policymakers and academics, it's that they are looking at space not just as a competition for military dominance, but also in terms of long-term space presence. So, it's very different from the United States concept as a flags-and-footprints model, where you go to a particular area in space, explore, and then, plant the flag. For China, it's a long-term mission of space presence, especially dominance of cislunar, which was mentioned today.

The point I would make in terms of why do I connect the terrestrial to the lunar surface is that, if you look at what the chief of China's Lunar Exploration Program articulates, Wu Weiren, he argues that the moon is an area which is strategically very important. Their challenge is to establish a base in the south pole of the moon. And the most important point that he and, for instance, Wang Xiji, the founder of China's Long March rockets, argue is that, if you do not go there first and if you do not achieve capability to be there first, you would lose out, and we would have to answer to our next generation.

So, if you look at the conceptualization of space and how they view space, within China there are two very distinctive voices. One voice, which is the space scientist voice, who argues that space is a global common; we need to benefit it, to offer our space station to the world. But there is a counterargument, too, which is coming out of the Central Party School, coming of different agencies which are more nationalistic, or the PLA, that space is somewhere that we need to achieve the capability to get there first because always the country or the civilization that goes somewhere first benefits from it from a long-term perspective.

Thank you.

COMMISSIONER WESSEL: Thank you.

CHAIRMAN BARTHOLOMEW: Admiral McDevitt?

COMMISSIONER MCDEVITT: Thank you.

Three excellent presentations and papers. I enjoyed reading them.

An observation to the comment that Dr. Weeden made about the South China Sea. To a degree, I think you're right in terms of China's approach in the South China Sea and the East China Sea; I think to a degree it is sui generis, that it is unique to their outstanding sovereignty claims.

But there one huge caveat to that statement, which is international law is fine as long as it moves their ball forward on what they hope to achieve. If it doesn't, suddenly, domestic law takes priority, and domestic law coming out of the National People's Congress can be cooked up pretty quickly. And so, they decide which law, which approach they want to use in the South China Sea or East China Sea, whichever one moves the ball most effectively.

And so, one would have to worry about -- now this may be a bridge too far but -- a Chinese domestic space law. In fact, one may exist. I have no idea if it does or doesn't. But it would counteract any agreements that are either in place or that could be made.

With that aside -- I just wanted to make that observation; you can react to that or not -- I have a question for Todd Harrison. Both you and General Cartwright I thought made a very compelling case about deterrence, essentially deterrence by denial, that we're just going to make

the target set so hard because there is so much capability up there. Does that mean the U.S. is actually walking away from, if you will, a deterrence by punishment, by ignoring the possibilities of RPO or direct ascent or lasers, and that sort of thing? Or would you recommend that we walk away? -- I guess is a better, a fairer way to pose that.

And for Dr. Weeden, you talked about the United States abandoning our leadership role. I guess I would like some specifics as to what the United States did not do or we did do that offended everybody, or whatever it happened to be that caused this lapse in U.S. space leadership. We just lost interest or we were not in control of the agenda and issues were being permitted that we didn't want to address, et cetera? So, if you could help me think through that, that would be terrific.

And for Dr. Goswami, I loved reading your paper. It had so much good stuff in there. I must admit, though, that one thing I can't get my head around is this idea of an enormous satellite capturing solar energy and how you get it to the United States or to the globe, to earth. I mean, it's not a long extension cord. So, how do you get the electricity, that energy, down to the United States -- or excuse me -- not the United States, to the world, so it can be used?

MR. HARRISON: Sir, to address your question about deterrence, my view of deterrence is we need to work on both sides of the question here. And so, if you think of it as a cost-benefit analysis, what we want to do is we want the Chinese to believe that the cost of them attacking us in space exceeds the benefit. And to help that balance work in our favor, we want to do everything we can to raise the cost and reduce the benefit. So, deterrence by denial is about denying them the benefits.

And so, if we make our space systems more resilient, if we proliferate constellations of satellites, then the benefit of attacking any one of particular satellite is going to be much less because we have many different alternatives. That's one side of the equation.

I don't think we should ignore the other side of the equation, either. We should raise the cost. That can be deterrence by punishment, showing that we can respond to what they do, but it can also just be a matter of making it harder for them to attack our systems. It's hardening of satellites, basically.

What we don't want to do is put ourselves in the position of being an aggressor in space, because our whole goal in this, because we are so dependent on space, because we derive so much economic and national security benefit from space and advantage, our whole goal should be to deter conflict from extending into space, and if deterrence fails, we want to de-escalate it and put it into other domains instead where we have many advantages.

And so, I think that's what our posture has got to be. Raise the cost, reduce the benefits. If they do attack us in space, we want to quickly be able to defend ourselves, first of all, and then, take the conflict into other domains where we're going to have bigger advantages.

DR. WEEDEN: Just a quick comment to follow on to that. When I think of deterrence by punishment in space, it's very difficult for me to come up with a satellite that China values as heavily as we do, SBIRS or AEHF, or something else, right? So, that sort of mad "I'll kill yours if you kill mine" model I don't think applies in space. That's why I very much agree with what Todd said.

So, to your question, China does not have a domestic space law. They have been developing it. It's an effort going on for several years. And that's not unusual. There are only a few countries that have a fully-fledged national legal framework for guiding, overseeing space activities. The U.S. has one, and there are a handful of other countries.

Increasingly over the last few years, more countries have been doing so. New Zealand

now has one. And that is generally driven by growing use of it. So, in the case of New Zealand, they have a company called Rocket Lab that is launching rockets from New Zealand; thus, making New Zealand a spacefaring state and a launching state. So, they put in place a national law to provide oversight of that consistent with their obligations under Article VI of the Outer Space Treaty that says they need to provide authorization and continuing supervision of all national space activities, government and private sector.

So, my impression is the U.S. actually has been encouraging China to put in place a national space law because that is what they're supposed to be doing to implement those activities. Your point about that potentially conflicting with the international framework I think is well-taken, and it's something we need to be aware of.

As I said in my testimony, it is possible that China will try and push space law and norms in a direction that is contrary to where it currently is. We just haven't seen that happen yet.

I do think it's interesting to note that there are many countries who think the U.S. is using its national laws to override international law in space. The example is, 2015, Congress passed a law essentially putting into statute longstanding U.S. policy that a U.S. entity can extract resources from an asteroid or the moon and, then, use them. That has been our policy for decades. We just kind of wrote it down in U.S. statute.

That generated quite a bit of heated discussion in the international community, as there are many countries that felt that was the U.S. basically contradicting part of the Outer Space Treaty that says you cannot appropriate celestial bodies or other resources in our space.

To your last point, your last question about what are we not doing that we did in the past, if I can just briefly summarize it, the Eisenhower Administration was the first to have to deal with space, and it had a huge problem at the time. Its problem was surveillance aircraft getting shot down; couldn't take intelligence, couldn't get intelligence on the Soviet Union. Satellites were the option, the way around that. But it wanted to have a way to do so and sort of protect that capability.

So, the Eisenhower Administration put a lot of effort into creating what became the principle of the Peaceful Uses of Outer Space, as a way to enshrine the norm of freedom of overflight of satellites for peaceful uses, i.e, taking pictures, to fulfill a national security objective.

So, if you look at the core elements of the Outer Space Treaty in 1967, many of those were things that the Eisenhower Administration identified as core national interests of the United States that would help the U.S., and then, had a whole campaign to promulgate them and get them enshrined in international law.

That's what I'm talking about when I say we used to do this and we haven't. Since the fourth major space treaty was -- the Registration Convention was signed, the U.S.'s position has basically been we're good; we don't need anything new. We don't need to talk about anything new. We can just talk about complying with what's already out there. And the U.S. has largely opposed anything new.

That is the gap where Russia and China have recently been trying to fill, in that they are the ones proposing new ideas. They're the ones seizing the diplomatic initiative and controlling the discussion because they're the ones saying yes, or at least proposing idea, and the U.S. has been saying no.

DR. GOSWAMI: So, in terms of questions of how are they going to lift a Space Based Solar Power Satellite which is 10,000 metric tons, actually, the plan is not to lift it from earth. As I mentioned before, the China Academy of Space Technology announced a research plan in

2010, 10 years ago, to establish an entire design of how do you do this.

So, first -- and it's in my written statement on page 5 -- is that you first establish a design as to what do you want to invest in. The idea is that Space Based Solar Power is 24 hours. It doesn't have the variance of weather, and it's going to be the most important renewable energy. That's the No. 1 goal.

The No. 2 is that, in 2010, the China Academy of Space Technology indicated that they would have a prototype plant in Chongqing by 2019. And they have met that goal. So, this year they announced their first prototype plant.

So, the idea is they are actually investing in two technologies, and they're trying to build the capability on that to a 2030 timeline. So, the first capability is micro-based transmission of electricity. What you do is that you actually use microwave to transmit electricity. This has been proven by the Japanese Space Agency already, but not to that extent. They showed it moving within a 6-mile diameter. John Mankins in the United States also has shown it in the Arizona desert. So, China is actually picking up ideas and innovations and actually, then, starting state-funded programs.

The second important thing which is connected to their lunar program -- and that is why I argue that they're not looking at the moon to show off their technology or putting an astronaut. They are looking at it from a long-term point of view, and they're actually articulating that goal very often.

Just yesterday, China had its -- so, 24th April is China's Space Flight Day, as you know. They had several programs yesterday to celebrate the first launch of their satellite, and the head of the China National Space Administration again argued and pointed out that they want to establish a base on the moon, basically to enable these goals that they have set.

So, the idea is that you will use resources on the lunar surface by automated manufacturing to build satellites that are heavy and actually lift it from the moon and put it in GEO or LEO.

So, they actually have an incremental strategy and plan in place to achieve something which looks like science fiction, but actually has been proven. It's only that we have to bring down the cost of it, which is expensive.

Thank you.

CHAIRMAN BARTHOLOMEW: Thanks very much.

Commissioner Lewis?

COMMISSIONER LEWIS: Thank you very much for helping educate us.

I'd like to ask all three of you what your optimistic and pessimistic view of why China is developing a counterspace policy.

MR. HARRISON: In terms of a policy that's unilateral on the Chinese side or are you talking a policy for the U.S. in order --

COMMISSIONER LEWIS: The Chinese side.

MR. HARRISON: On the Chinese side? Well, I mean, optimistic, I think that, well, the most realistic optimistic scenario is that they go no farther than they have right now, which is developing a full array of counterspace weapons and showing that they can operationalize them and use them, if need be.

A more pessimistic case is they actually focus on developing more of the non-kinetic forms of attack, specifically forms of attack where attribution is difficult, where they're not necessarily, the effects are not publicly visible, and then, they begin to use these forms of attack on a day-to-day basis as a form of gray zone aggression against us. And they basically can

condition us to expect that on a day-to-day basis we're going to see widespread jamming; we're going to see lasing, and they make space unreliable for us.

COMMISSIONER LEWIS: Commercially?

MR. HARRISON: Commercially, militarily, you know, across the board. That would be my most pessimistic case because I think that becomes a very difficult proposition to deal with. How do you respond to frequent and pervasive jamming of signals, if they're cutting us off from our space assets? But jamming is largely invisible. Others may not realize the effects that are happening. We may not want to communicate some of these effects because it can, you know, it's advertising a vulnerability. And that makes it very difficult for us to respond.

And if it's non-kinetic and our best response is something kinetic on the ground, questions of proportionality come into the equation and whether or not we would actually be willing to escalate, whether we're going to cross a threshold over something that's non-kinetic and doesn't kill anyone directly. So, that would be my most pessimistic scenario that would keep me awake at night.

COMMISSIONER LEWIS: Thank you very much.

DR. WEEDEN: So, my optimistic scenario is that China's development of counterspace capabilities would serve as a deterrent for either side to engage in direct military conflict in the future, in a similar fashion that nuclear capabilities largely deterred full-out war with the Soviet Union during the Cold War.

I think my most pessimistic scenario is one where those capabilities are used to deter. So, the example would be there is a brewing crisis in the South China Sea or elsewhere between the U.S. and China, and China decides to use its capabilities to destroy or eliminate a U.S. missile warning satellite over the Pacific, as a way to deter the U.S. from actively getting involved in the crisis or a conflict that's going on.

I do not think that would have the effect that China thinks it might have in terms of deterring the U.S. I think it would have quite the opposite effect, and that would actually lead to direct military conflict, which everyone from General Hyten on down has said would be a very bad day for everyone involved, and everyone would end up much worse than they were off beforehand. So, to me, that's the worst-case scenario.

COMMISSIONER LEWIS: Thank you.

DR. GOSWAMI: So, for me, the most optimistic scenario is China's own strategy of building multilateral cooperations, for instance, the Belt and Road Initiative. So, I would argue that, based on a similar kind of strategic restraint shown by the United States after the Second World War, where the United States actually supported a post-war institution-building like the United Nations, you would, then, constrain yourself in terms of how you behave.

My optimistic scenario is that China, because it's investing so much in alternate institutions; for instance, the Belt and Road Initiative -- in 2018, China established the first China International Commercial Court to deal with disputes coming out of the Belt and Road Initiative. So, all the countries that are part of the Initiative, hopefully, will constrain China in terms of its willingness to use military weapons in space or countering U.S. space assets.

My pessimistic scenario is actually where I'm more concerned about, because in my conversations with Chinese thinkers and strategic analysts in Beijing and Shanghai, their biggest worry was that the United States has conventional superiority. So, the only way that China can hold the United States vulnerable is to target the U.S. military's extreme dependence on satellites and, also, on your space capability.

So, for instance, an interesting article that came out of the China Academy of Military

Sciences, I think in 2005, which was also quoted in the MIT review -- I can share that link with you -- where they argued that the only way that China can hope to achieve some kind of parity with the U.S. is to double up asymmetric capability and to hold U.S. dependence on satellites vulnerable.

And this thinking actually came out from their observation of U.S. success in the Gulf War. So, this is a very old and very nuanced and very thought-through point of view that they have come to actually engage in. So, that's my pessimistic scenario for you.

Thank you.

CHAIRMAN BARTHOLOMEW: Thanks.

COMMISSIONER LEWIS: Thank you.

CHAIRMAN BARTHOLOMEW: Senator Talent?

SENATOR TALENT: Thank you.

Dr. Weeden, I agree with a lot of what you recommended, but I have to return to the subject of Commissioner Wessel's question. Are you really telling us that China's activities in the South China Sea is a reason for us to be reassured about what they're going to do if they achieve, as Dr. Goswami, their program of economic and industrial domination of the cislunar system?

DR. WEEDEN: If they end up going down the path of following that model for space, I do not think that is good news. All right. My point was that I'm not ready to assume that is the path they're going to take with respect to outer space and the moon. And we have not seen any evidence that they are laying the groundwork for that path in all of their actions and statements in the areas that talk about these sorts of things, the international foras that talk about this. In fact, all of their statements, all of their proposals, are all either supportive the international regime, and, in fact, going further than the U.S. is in saying it is a global common and it is common heritage of mankind.

So, I think if you were, I guess, extremely cynical, you could argue that is all a front and that is all a cover operation for the real truth which has come out; they're going to go seize control of it. If you play that out, I don't see how that benefits at all because, then, they've just thrown away decades and decades of diplomatic positioning and relationships they've built with other countries trying to bring them to their side in these diplomatic engagements.

I think that is certainly a possibility. I think it is a very low probability of it happening.

SENATOR TALENT: Really? Because it's not just the South China Sea. I mean, Dr. Goswami talked about Antarctica, India. In fact, they made a lot of commitments about what they would do in the world trading system, and we've documented pretty thoroughly that they haven't kept those.

I'm just concerned that they may feel as if, if they get adequate domination, economic and industrial domination of the cislunar system -- I love that phrase, Dr. Goswami; I'm going to use it and try to remember to attribute it to you -- they may figure, you know, it doesn't really matter what the other countries want to do or think about this because, you know, we're putting colonies on the moon. So, I don't know that I'd call it cynical.

Now I agree that view is cynical. I agree with you that we have allowed them to take the diplomatic initiative in shaping the landscape, which was a mistake, I think, and perhaps because the United States always felt like, well, why should we bind ourselves to anything when we have this freedom of action? So, I do agree we ought to fill this diplomatic space. I just don't know that I share your optimism about their intentions.

You can comment if you want to.

DR. WEEDEN: Two very quick things. One, I think my fear is that, if we assume that they're going to go ahead and do that, there are some who will argue, well, the U.S. needs to do it first, right? That means the U.S. is not supporting rule of law in space. We're going to go break that first, so we can be the ones to grab and seize that first. I don't think that helps us. I think that plays right into their hands because now they can say, well, the U.S. did it first; we're going to go ahead and do it, too. And we're the ones that take all of the bad press to be the ones to do it.

I think our position should be to uphold and enforce the existing rule of law and to work to shape it and deal with the gaps that currently exist, and shape them in a way that does reflect our interests. That's what I hope our actions are.

CHAIRMAN BARTHOLOMEW: Mr. Harrison, go ahead.

MR. HARRISON: If I could add one other thing, and I don't mean to throw a wet blanket on all of this. But China may very well intend to try to dominate cislunar space, but right now there's nothing really to dominate, at least not yet. We're here in cislunar space. We're talking about beyond geostationary orbit, so beyond how we currently use space for commercial and military purposes. We're talking all the way out to the moon.

One day there very well may be activity that's economically viable on the moon and in cislunar space, mining for materials, you know, manufacturing propellant for missions that go to other regions of space. That may become economically viable in the future, but it's not today. So, I don't know exactly what they would be dominating.

And so, if we're going to try to be there to dominate first, the same question applies: what exactly are we dominating and why are we doing it? I think a much better approach is we should go to them and say, hey, let's engagement. We both want to go explore. We both want to go see if there is something worthwhile here, and we can do that in a cooperative manner. This does not have to immediately go to conflict.

Now, looking out into the future, one day, sure, there may be economically-viable activities going on on the moon and in cislunar space and in near-earth asteroids. And at that point, we do need to start to think carefully and more strategically about how do we protect these emerging trade routes, because wherever commerce goes, conflict is likely to follow. That is many decades out, and I think that, right now, we should just be focused on how do we explore, so that one day we can actually get to that future.

DR. GOSWAMI: My perspective on this is different from Todd's and in this particular regard: because when I look at their future ambitions, they are very clear; it's about space economy; it's about the fact that China is going to become the most important economic power by 2050. And this is not just coming out of China. PricewaterhouseCoopers did an interesting an analysis in which China is the No. 1 economy by 2050.

So, the conversation within China is that one day we will have to look -- we may run out of resources. And so, that's why the space economy is very important. And so, that's why in my testimony I have very clearly articulated that their strategy is a long-term incremental strategy of ensuring that they are able to dominate that access to the resources we are talking about.

Dr. Roper today mentioned about a trillion dollar economy waiting, but he was actually talking about a trillion dollars just out of the space assets we have today. He did not touch on the trillions of dollars that await once you extract resources from space. And that's where China's program is pegging itself.

So, in my assessment, strategy is not just looking at behind or today, but looking at the future. If you look at the future, I would argue that it's very important that we keep in mind their

long-term goals, and the articulations coming out from not just President Xi, who actually has pushed his might behind this program. He calls it "the China dream," as you know, and it's instituted within the China dream of a space dream and it's part of the Chinese Communist Party Constitution today. So, there is this legitimacy building, too, and I think we need to keep that in mind.

Thank you.

CHAIRMAN BARTHOLOMEW: All right. Commissioner Cleveland?

VICE CHAIRMAN CLEVELAND: I'm actually interested in this question around manufacturing in space, but I have three quick questions, mostly for you, Dr. Goswami.

You note in your testimony that Xi has driven this dual-hat approach to space exploration. And I'm wondering if you see that as unique to space; therefore, enhancing its importance.

I'm also interested in whether or not any international universities are engaged with the PLA SSF on civil-military integration in space exploration.

And then, the third question is, what is the goal of the mining and manufacturing? Is it to, essentially, tap into resources that would be exported back to the earth or is this to position them for longer-range exploration?

DR. GOSWAMI: So, in terms of your first question which was about manufacturing in space, and also in terms of civil-military integration in that regard, in 2017, the PLA SSF signed a Memorandum of Understanding with about 16 universities within China -- and I have documented that in my testimony -- in which they are looking at three concepts. One is innovation towards developing capacity for in situ manufacturing. And second is to develop capacity for science and technology within their Made in China policy, which is 2025. And the final thing is, how do you, then, develop automated manufacturing in space?

What I find unique and interesting from the Chinese space program perspective is that they have started establishing programs within the China Academy of Sciences, which has about 120 different institutions within it, that looks at these particular three concepts.

One is their Qian Xuesen Institute with the China Academy of Sciences, which looks at space mining and manufacturing. So, one of the technologies that they have already started investing in is 3D printing. And so, they have a separate research cell for that, so to use 3D printing to, then, do in situ manufacturing.

And the name is also very unique because, as you know, Qian Xuesen was the founder of the Jet Propulsion Laboratory in NASA. He was deported, and then, became the father of China's missile program. So, you can see the very interesting connection that they have.

Now, as I said before, again, in terms of dual-hatting, in my perspective, China's space program is directed by SASTIND, which is the State administration for Technology, Industry, and for National Defense. Under SASTIND is the China National Space Administration. So, the China National Space Administration is the main policymaking body, but it does not really craft the policy. It's the organization that actually introduces the policy to different institutes. The main organizations are the State Council, the Politburo, and the CMC. So, if you see the connection, it's very clear as to how their policy gets crafted, and that I think is very unique.

Finally, what I think is unique is that they've already started investing not just conversations, but money on their future space program. For instance, there is a $30 million commitment for their Space Based Solar Power Plan, and it's coming from the Bishan District of Chongqing. So, you can see how they're actually developing the capacity for reaching those goals that they have articulated.

Now whether they will succeed or not, that's why I recommended to the Commission that we need to continue following those programs to see if they succeed in the 20-year timeline that they have set.

VICE CHAIRMAN CLEVELAND: And the mining interest?

DR. GOSWAMI: They have enormous interest in mining. So, again, within the China Academy of Sciences and the China Academy of Space Technology, they have a separate cell that looks at space mining.

So, one of the researchers who has actually published articles on this in China, and also in the English language press, their idea is that they would not just extract resources in space, but would try to capture an asteroid which is a small asteroid and bring it back to earth by 2034.

And again, this particular perspective has been supported by none other than Li Ming, who is the Vice President of the China Academy of Space Technology. So, you can see that the support for the kind of investment that they are having is unique. And so, Li Mingtao, who is the researcher who talks about space mining, argues that, given the fact that space mining will become a very lucrative industry in the next, say, 20-30 years -- and it's interesting because he bases his assessment based on John Lewis' famous book, Asteroid Mining, that comes out of the U.S., and Paul Spudis' book, the Value of the Moon. Why do you want to invest in the moon? To build spacefaring capacity. So, I find it very interesting that they're inspired by ideas that come from here, but they're actually willing to invest money in those programs.

Thank you.

CHAIRMAN BARTHOLOMEW: Dr. Weeden, go ahead.

DR. WEEDEN: I'm thinking of that thing that Namrata mentioned of drawing addition from the U.S. None of these are new ideas. As she mentioned, many of these are things produced by the U.S. and suggested.

I think it's interesting, the asteroid retrieval, you know, that was a mission the Obama Administration proposed for NASA to do, to go grab an asteroid and move it back on the earth. That was, for lack of a word, I think widely ridiculed and did not get much support from Congress. They thought this was a big waste of NASA's money and time.

And I find it interesting that, now that China is proposing something very similar, suddenly it is a huge issue and we need to think about what to do about it, when we had that idea and it never really gained any traction.

To answer your question about what the other resources, mining is a bit of misnomer. In regard to the moon, the issue is water and regolith. If you can extract water from the moon, that becomes rocket fuel that you can use there to refuel and come back to the earth or go elsewhere. And you can use regolith to, hopefully, build things on the moon, structures, instead of bring them from the earth. So, in the context of the moon, you're looking at those two things, water and regolith, mainly to support infrastructure for staying on the moon or going elsewhere.

COMMISSIONER MCDEVITT: What's regolith?

DR. WEEDEN: Regolith is rocks, rocks and dirt, basically.

DR. GOSWAMI: Lunar mare.

(Laughter.)

DR. WEEDEN: In the case of asteroids, there's a lot of hype about this, the mythical trillion dollar platinum asteroid, right? Again, U.S. companies have been exploring this for quite a few years. There were just two U.S. companies recently that have gone under. They were looking at doing this mining and basically could not build a business model around it. The technology was too far out for them to really make it practical.

In that sense, it is more about using those resources for other things in space than it is about bringing them back. That is extremely difficult to do, and it's really hard to see how the economics of that work. But that doesn't mean people aren't still exploring it.

CHAIRMAN BARTHOLOMEW: Mr. Harrison?

MR. HARRISON: I mean, I would just add, to pick up on what Brian said, if we want to compete economically in space in the long-term and looking at all of these potential applications that could arise in cislunar space, I think the thing to do is to fund our civil space programs because, in order to make things like in-space mining and manufacturing possible, there's a lot of science and technology that still needs to be developed. And in particular, we've got to do more exploration. We've got to understand what exactly is in these near-earth-orbit asteroids. What kind of materials can you actually mine and refine on the moon that could be viable, that we might be able to bring back to earth to use? We don't know the answer to a lot of these questions yet.

And so, if we want to compete economically, we need to make the investment in finding out what's out there and how can we use it. In that economic competition with China, that's an area where we can quickly pull ahead and have an enduring advantage, because I fundamentally believe that our free market economic system will be much better suited to exploit those opportunities, if we find them, than the Chinese model of state-run enterprises.

CHAIRMAN BARTHOLOMEW: Dr. Goswami?

DR. GOSWAMI: Yes. So, in terms of estimates of asteroids -- since the conversation is coming up and it's useful to have data -- John Lewis in Asteroid Mining had done that kind of assessment, and so has Nature and National Geography.

So, I'll give you an example which John Lewis provides us. And that is, a near-earth asteroid like 355 million from earth, approximately 2 kilometers in diameter, contains nickel and iron ore worth $8 trillion, cobalt worth $6 trillion, and other precious metals and gold worth $6 trillion again, which together makes it about $20 trillion. And what I find the most insightful is that Li Mingtao quotes that particular figure in terms of explaining why China needs to invest in space mining. The most interesting point from this particular conversation is that, and then, you see President Xi arguing about it in his speech to the National People's Congress.

And the other thing which I find fascinating in terms of just China, if you look at the last few years, the people who have got promoted within China are not just Communist Party loyalists, but also many of their space scientists. And that's also documented in my testimony. So, you can see that they see space as a very important core competency to be developed in the long-term.

Finally, the argument about research, and there is this usual refrain in the U.S. or coming out of U.S. circles, even when I present, that China is way behind; it's always just copying us. You know, they are stealing technology.

But I was just looking at data from the National Science Foundation. It's astounding. In 2018, China actually invested about $485 billion in R&D. It's the second country in the world to do that, just behind the U.S.

And also, in terms of scientific publications, China has about 425,000 publications in

2018, peer-reviewed publications on science and space, and the U.S. has about 419,000. So, it actually surpassed the U.S. So, you can see the investment that China is doing.

And finally, in quantum, China has sent up a quantum satellite already and investing heavily in AI.

So, thank you.

CHAIRMAN BARTHOLOMEW: Thank you.

Gosh, one of the things about coming last in the first round of questioning is there are so many issues that I could bring up.

I guess, first, Doctor, not to beat a dead horse, but I have to join my colleagues in just sort of wondering why you think that China will uphold the global norms in this sphere, when they have consistently not upheld global norms. You've answered that.

But, Mr. Harrison, a corollary to that for me is, when you were talking about cislunar space, it sounded like you were saying, well, let's worry about it when we have to worry about it. But, consistently, over the history of our relationship with China, if we wait until something is happening and we have to worry about it, it's too late. Then, we have a discussion about, well, why didn't we pay attention to this before it happened?

But, in terms of cislunar, General Cartwright spoke about that this morning. And what's interesting to me is we are talking here about all of the economic consequences or the economic value of space exploration, but there's also the strategic consequences. And what he said about cislunar is it's the hill, and if you control the hill, you control the valley. So, I don't want us to lose the security and strategic significance in the discussion about how much money could be made by different companies. If you have a comment to that, that's fine.

I want to also clarify something, which is the United States has the responsibility for tracking space junk, correct? I mean, we have the agency that tracks space junk and informs other people. Is that correct, Dr. Weeden?

DR. WEEDEN: We don't have the responsibility; we do it.

CHAIRMAN BARTHOLOMEW: We do it, right.

DR. WEEDEN: Yes. Other countries do it. The U.S. military has done it the longest and has some of the robust government capabilities, but there are others who are doing it as well.

CHAIRMAN BARTHOLOMEW: And do people, including people in China, generally turn to us for that information?

DR. WEEDEN: I guess walk back to the context here. The U.S. military has done this mission since the 1960s, first, to see if there were things in space that could be nuclear weapons that could be orbited around the earth. And then, it evolved to ways to protect our satellites from space weather and collisions and counterspace weapons.

In 2009, U.S. and Russian satellites collided, the Iridium-Kosmos collision. And after that, the U.S. military made a decision to start providing close-approach warnings to all satellite operators in the world, Russian, Chinese, commercial, French, German, everyone. And that was done as a service, in part, so that they would use the U.S. capabilities and not develop their own capabilities.

So, that is currently being used today, but Russia, China, Europe, other countries are investing in their own SSA capabilities and developing those. They're not quite as advanced as what the U.S. has, but they're significant. And there's also commercial capabilities that are being developed as well.

CHAIRMAN BARTHOLOMEW: Okay. Thank you for the clarification on that.

I'm interested that several of you kept referring to Chinese, well, a civilian space

program, and, also, this idea that there are Chinese private startups, private companies. And this is an issue that we have struggled with over the years here, which is, are there really private Chinese companies?

In circumstances like this when we know that this is sort of one of the core interests of developing a space program for China, and they're willing to invest a lot of money, right, and it's directly and it's indirectly through subsidies and tax breaks and diplomatic initiatives that they do, are there really these private companies that you're referring to?

I mean, Mr. Harrison, you talk about the need for sort of civilian-to-civilian space program cooperation, but I have to be convinced that there's actually a civilian program in China that is not sort of controlled by the military and being used by the military, and by the Party, actually, by the Party, yes.

MR. HARRISON: So, can I start in going back to dominating cislunar space and the military value of being on the moon? My only point is not that we should just wait and see what happens, and once China starts to dominate, then respond, not at all. I think we have to understand what is the thing; what is the "it" that is of value in cislunar space? And I don't think we know yet. I don't think we know yet what is going to be economically-viable, what is going to be strategically-significant in space.

And I would caution that this metaphor of the ultimately high ground, it only goes so far, right? Because you get so far out in space, it stops becoming useful to be there. Just to give you an idea, the moon is about 10 times farther away than geostationary orbit. If you launch a projectile from the moon, it takes about three days to get back to the earth. I mean, at that kind of distance, even communications is very difficult. You have to have very large arrays and transmit at very high power levels just to get a weak signal, a slow data rate through.

So, I think that there are limits to thinking about this as the ultimate high ground. Now there certainly are some strategic chokepoints along the array, the Lagrange points between the earth and the moon and the other side of the moon. The poles of the moon are particularly useful because they can have continuous coverage from the sun. They can have water that exists down in craters. There are some points that are important on the moon, but let's not oversell it.

We don't yet know if this is going to be viable to use or not. We have to explore it first to figure that out. So, that's why I would say, before you send the military out to protect something, let's send the explorers out to figure out if it's worth protecting.

And then, to your other question about civil space programs within China, well, I think the administration of these programs and the organizations that carry them out are certainly intertwined. And I am not enough of a China expert to try to unwind that.

What I look at is the missions. What are the missions they're doing? If you've got a mission that's putting a lunar rover on the far side of the moon, there's nothing military about that. There's no military utility to that. Could there be some dual-use technologies involved? Of course. Guidance navigation and control systems that are used for that could be used for other missions. I take that point. But that is fundamentally exploration mission. That falls into the civil category, regardless of who was doing it.

And I look at our own space programs, and what we're doing on the International Space Station, that is for civilian purposes. I think it's very clear. Other nations should recognize that. That's clearly for civilian purposes. They don't have to believe that NASA is really a civil space agency. Just look at the work that we're doing.

So, I would judge China's space programs in that same respect. Let's look at what they're doing. Is there military value to what they're doing or is this really for science and exploration?

And I think that there's clear evidence that they are doing things that are purely for science and exploration. Many other things that they're doing are for military purposes, and other things are ambiguous.

Like this SJ-17 satellite that's going around the geostationary belt, it is not clear if they are doing this for peaceful purposes, for inspection of the geobelt, to practice remote proximity operations that could be used on civil, you know, human space flight missions. Or are they doing it for nefarious purposes in developing an ASAT capability? That falls into the gray area, quite frankly.

CHAIRMAN BARTHOLOMEW: Dr. Weeden?

DR. WEEDEN: So, I guess one more iteration of the norms discussion, I guess. Let me try it this way: my sense is that a large part of the reasons why China has broke with or pushed back against some of the legal regimes and institutional regimes here on earth is that they do not have a say in the creation of them, and they felt that they were created to suit the U.S. interests, which most of them were. And so, therefore, they don't feel like they have to comply with them because they don't have a say, and doing so would be contrary to China's interests.

My sense in engaging with them in the space diplomatic regimes, it's different, in part, because the framework is not well-developed. All we have are these broad principles, and everything else is sort of left up to interpretation.

And so, therefore, I think my sense is that China sees it more as they could play a role in establishing the governance framework and don't have to disrupt it or break it down because it's not yet formed. Now, if it forms and it ends up in a way contrary to their interests, then there may be a different discussion. But, right now, we are in the process of the formation of it and the creation of it, and they are participating and in a mostly constructive manner, at least outside of the weaponization and security discussions.

And a quick point on the commercial company side of it. Yes, there are -- I haven't done in-depth research on this but -- upwards of a hundred or so private sector companies started in China on everything from launch capabilities to flying satellites, building satellites, developing technologies, suppliers. Yes, the usual questions about how much that is really private sector or not. I would point out that the U.S. is almost alone in terms of this firewall between the government and its private sector among most countries in the world. Even Europe and Japan, and elsewhere, there's usually more engagement there between the private sector and the government.

But China definitely sees what's going on in the U.S. in terms of the private sector space boom and the kinds of innovations coming out of there, and how it's benefitting the U.S., and absolutely wants to try to capitalize on that.

CHAIRMAN BARTHOLOMEW: All right. I think, Dr. Goswami, you have something to add to this?

DR. GOSWAMI: Yes, to your question about the private.

So, we have to end at 12:40.

So, in terms of the private commercial sector, China has actually already launched suborbitally. So, OneSpace has already launched in 2018. This year it tried to launch to the orbital space, but failed.

But if you listen to the interview by the CEO, he argues that SpaceX failed; Falcon 1, Falcon 2 failed. And then, you succeeded with Falcon 9.

So, they're investing in that capability. And actually, some of their activities are within the civil-military integration strategy of President Xi, and there is an interview given by the head

of the PLA for Xichang Satellite Center where he argues that, because of President Xi's guidance, they are going to open up their satellite facilities in the Gobi Desert with subsidized rates for their private companies.

Finally, I'll end with this: that what China is doing in space in terms of its long-term ambition and strategy is nothing nefarious. It wants to become the lead power in space by 2045 and wants to celebrate that status by 2049. And they're actually articulating their ambitions because their idea is to use their space capability diplomatically, economically, and militarily. So, it's part of a comprehensive strategy.

And actually, they're not hiding that ambition. They are talking to, they are publishing in articles around the Asia-Pacific, so that the audience is not just the U.S. The audience is also their geopolitical countries that are around their border.

So, I'll end at that. Thank you.

CHAIRMAN BARTHOLOMEW: Yes, and it's interesting because, of course, in many things they have been quite transparent, their economic plans over the decades. It's just been that we have failed to understand the implications of those plans for the United States and to prepare for that. So, that's some of why we're pushing on what is it that we need to be paying attention to, and let's not make a mistake in space that we have made in other areas in our relationship with China.

I had thought that we would have a second round of questions, but, actually, we've run out of time.

So, thank you very much to all of our witnesses. You've been terrific. We've learned a lot. We might well be in touch with you for additional questions.

We will break for lunch and come back at 1:30.

Thanks.

(Whereupon, the above-entitled matter went off the record at 12:39 p.m. and resumed at 1:31 p.m.)

PANEL II INTRODUCTION BY COMMISSIONER MCDEVITT

COMMISSIONER MCDEVITT: Ladies and gentlemen, let's go ahead and get started with our second panel of our afternoon -- or first panel, which is actually the second panel. The first panel of the afternoon session.

It's going to be focused on the role of military-civil fusion in China's space ambitions. First we're going to hear from Lorand Laskai, a visiting researcher at Georgetown's Center for Security and Emerging Technology, who's going to talk about military-civil fusion's application to China's space sector.

Mr. Laskai recently started at Georgetown. And before that he was a research associate at the Council on Foreign Relations. Previously he was the lead researcher at Danwei, the research division of The Financial Times in Beijing.

Mr. Laskai earned his BA in Political Science from Swarthmore. And he's an incoming JD candidate at Yale Law School.

Lorand, welcome to Washington, and thank you for coming.

And next we're going to hear from Michael Gold, Vice President of Regulatory and Policy at Maxar Technologies. Prior to joining Maxar, then it was called Space Systems Loral in 2016, Mr. Gold spent 13 years working for Bigelow Aerospace.

In 2008, Mr. Gold was appointed to the Commercial Space Transportation Advisory Committee under the FAA. And in 2012, he was appointed Chair of the Committee as a whole.

And in this position he has continued to push for further development of private space sector activities and common sense regulatory reforms. We don't want any non-common sense regulatory reforms. That's for darn sure.

He is a graduate of the University of Pennsylvania Law School. Michael, thank you for your testimony.

And our third expert on the panel will be Kevin Wolf, a partner at Akin Gump Strauss Hauer and Feld.

Mr. Wolf previously served as Assistant Secretary of Commerce for Export Administration with the Bureau of Industry and Security Reform from 2010 to 2017, where he developed and implemented policies pertaining to export administration issues, particularly the license requirements of the export administration regulation.

He has more than 25 years experience providing advice and counseling regarding the laws, regulations, and policies and politics pertaining to expert controls, sanctions, national security reviews, foreign direct investments, and other international trade issues.

Mr. Wolf, we're looking forward to hearing from you about your direct experience in the development of export controls. And which is one of the main themes of this panel.

And so with that, if I can ask Mr. Laskai to start. A reminder, you all have about seven minutes to make your comments. And that will leave room, or time for us to bombard you with questions afterwards, so.

OPENING STATEMENT OF LORAND LASKAI, VISITING RESEARCHER, GEORGETOWN CENTER FOR SECURITY AND EMERGING TECHNOLOGY

MR. LASKAI: Great. Thank you. I'd like to thank the Commission for having me here. It's a true privilege and honor.

And I feel obliged to start my testimony by stating that I am, in fact, not a space expert. But I am a close watcher of Chinese industrial policies. And more specifically an observer of Beijing's attempts to implement military-civil fusion in a range of dual-use sectors.

Over the past few years I've seen few sectors in which Beijing has made more progress implementing military-civil fusion than the space industry. I firmly believe that this will change the nature of U.S.-China competition. And space making China more of a well-resourced, innovative and market-based competitor in space.

But first let me start by defining what I mean by military-civil fusion. Because this is a topic that's frequently discussed, but not often defined.

And military-civil fusion, the context which I'm using it, denotes Beijing's attempts to build pathways between the commercial sector and the defense industrial base, allowing for more resources, talent, and technology to flow between the two.

You can think of this as sort of a spin on/spin off relationship. The defense industrial base where the military spins off various defense related IP that has commercial potential. The commercial sector produces it. Maybe innovates based on it. Builds it at scale. And then spins on various technology back to the defense industry.

That's used to create a virtuous cycle between the commercial sector and the defense industrial base, allowing for both to reinforce each other. This cycle is central to achieving Xi Jinping's ambitions of turning the PLA into a world class fighting force at the technological leading edge.

It is also central to turning China into a high tech advanced economy. Since many high value-added sectors are inherently dual-use.

The fact that we're here today even discussion Chinese ambitions in space within the context of military-civil fusion is testament to how much progress China has made. Until 2014 there wasn't really a commercial space sector to speak of aside from the state-owed defense industrial base.

But over the course of three to four years, we've seen Beijing make enormous strides in opening the space industry to the commercial sector. Which has developed into a vibrant ecosystem of private start ups doing everything from launching vehicles, to building micro-satellites, to offering satellite-based application services.

And critically, what most of these companies share in common, is they all have some connection back to the military, the defense industrial base, or various state-owned R&D institutions. And this is basically military-civil fusion working in practice.

It's important to ask why is Beijing succeeding? Because military-civil fusion has been around for almost two decades. And it frankly has often not succeeded to Beijing's own detriment.

And basically in the space sector two things are at work that's helping this happen. The first is the technological trends. As Assistant Secretary Roper said earlier, you know, in many emerging technologies there is a, you know, the trend is towards greater commercialization, accessibility and affordability.

In the space industry, the trend toward miniature satellites and nanosatellites have really

brought down the cost of building satellites, launching them, and created a viable business model for small start ups.

The second and more fundamental reason is that Beijing has really made this a priority under Xi Jinping. In 2017, he founded a Commission, a high level commission basically looking at military-civil fusion, and pushing it along.

This was an incredible signal that this was a high level priority. And more broadly throughout the defense industrial base, you do see some agreement that in space that the statist model has -- is not working.

That it is not going to be enough for Beijing to succeed. They, you know, Chinese experts look at SpaceX and Blue Origin and other commercial companies and see something that needs to be replicated. And if Beijing does not actually catch up with these companies, they're at risk to get left behind.

Now, I want to focus largely on what the threats of this are. Because this sector is very much in its initial early phase. Like, none of these companies have yet launched an orbital rocket. Even though they've tried, and they probably soon will.

But, it's important to take note in this early stage that, like, if this sector does develop, and if military-civil fusion does work, it's going to pose a number of threats to the United States.

The space competition will become less state based. It will become more commercial. And Beijing can use this to its advantage in a number of ways.

The first threat I think is really to export controls. The space sector has been primarily state based. And that has, you know, allowed the U.S. to really enforce export controls in a meaningful way against Chinese entities.

But if commercial money is pouring into the sector, and that money is melding or fusing with state owned capital, which is happening, then it becomes much easier for state-based entities to evade export controls, potentially capture important technology and exfiltrate it back to China or the military.

We really need to think, be conscious about how we're doing export controls and how we're vetting Chinese companies. Because it's about to get a lot more difficult.

The second point is, and this is more of a long term threat. Is that there really is a risk of undercutting the U.S. space industry.

We've seen this all before when a -- when China goes into a sector and considers it strategically important and pours funds and money to create national champions to compete internationally, what happens is often Beijing pulls out the rug from underneath the global market.

You know, floods the market. Makes it hard for other companies to compete. And over the long term we do need to seriously consider the risk that China might dominate certain sections of this commercial space market.

Especially at the low end, around miniature satellites, and you know, might CubeSats and other sort of small devices which, you know, the real incentive is to launch them cheaply.

And there, I believe there will be a tension between addressing both of these risks. The export controlled risk is going to require us to sort of clamp down. But the second more long term risk is going to require us to really make sure that our companies are competitive internationally.

And I won't go through all my recommendations. I have my written testimony. But I will highlight certain components of them.

I believe in the export control of space, we really need to adopt what Robert Gates called

a small yard, high fence strategy. We can debate what that actually means, but I just wanted to sort of highlight the fence component, because we do need to really make sure that we're scrutinizing companies that are buying U.S. satellite equipment or investing in U.S. companies and seeing where the stakes are.

In the recent Wall Street Journal stories involving Boeing satellites, there is always a state owned capital element to the companies. We should be able to catch that and that should be a tripwire.

And I believe we really need to start thinking seriously about our industrial base. And preempting any moves by Beijing.

We don't want this to be the telecom sector. We don't want this to be the solar panel sector where Beijing basically flooded the market and we were holding hearings later, saying what should we do after the sector is already gone?

I think the commercial drone industry is a great example. In 2014, you know, Chinese competitors basically, you know, wiped out the U.S. competitors in the manufacturing space.

And we can't really do anything when it's too late. And finally, I think, you know, ultimately Beijing is trying to replicate something that we've done really well, which is public/private partnerships.

And we ultimately have a lead in this because we have a rule of law in this country. We have impartial arbitration. We have IP protections.

So, it's really incumbent on us to double down on what we do best. And I think Assistant Secretary Roper put forward many great ideas.

On that I will yield my time, and look forward to questions.

COMMISSIONER MCDEVITT: Thank you. You were only six seconds over. I thought that was commendable.

(Laughter.)

PREPARED STATEMENT OF LORAND LASKAI, VISITING RESEARCHER, GEORGETOWN CENTER FOR SECURITY AND EMERGING TECHNOLOGY

April 25, 2019

Lorand Laskai
Visiting Researcher, Center for Security and Emerging Technology (CSET)

Testimony before the U.S.-China Economic and Security Review Commission
Hearing on China in Space: A Strategic Competition?

Building China's SpaceX: Military-Civil Fusion and the Future of China's Space Industry

Introduction

Days after SpaceX successfully launched the Falcon Heavy last year, several experts from the China Aerospace Academy of Systems Science and Engineering (CAASSE) wrote, "the lack of utilization of social resources has become an important issue that restricts the better and faster development of China's space industry."[1] The *Global Times* put the implications of SpaceX's achievement for China in more blunt terms: "Our country finds itself in a surprising position where it must desperately catch up with a private company."[2]

China has responded to the rise of the U.S. commercial space industry by building its own commercial space industry through military-civil fusion 军民融合.[3] Military-civil fusion or *junminronghe* is the catch-all term for China's two-decade-long push to enlist private enterprises to upgrade China's defense industrial base through developing scale and efficiency in dual-use sectors like information technology, robotics, and aerospace. Under the tenure of General Secretary Xi Jinping, China has doubled down on military-civil fusion as a means to modernize the People's Liberation Army (PLA), particularly in emerging sectors like space. In June 2017, General Secretary Xi called for "a great effort to turn the space domain into the foremost sector in the development of military-civil fusion."[4]

The commercial space industry has been a notable priority and early success of Xi's military-civil fusion drive. Over the past four years, a crop of private launch providers and small satellite makers

---

[1] Xue Huifeng, Zhu Bin, Kangxi Tong, Li Chengfang, Zhang Kui, and Zhang Hao, " How to View the Falcon Heavy Launch from the Perspective of U.S.-China Space Development," Military-Civil Fusion in ICT Magazine, February 13, 2018, https://mp.weixin.qq.com/s/fKIA7xMQQr1bkNMYvaMWmQ.

[2] "Americans complete a major feat in the early morning, showing us how large the gap is between the U.S. and China [美国人凌晨完成一项壮举，告诉我们中美差距还有多么巨大], Global Times, February 7, 2018, http://world.huanqiu.com/article/2018-02/11589880.html.

[3] The correct translation of *junminronghe* is somewhat contested. "China's State Council uses 'civil-military integration' as the official translation. However, Greg Levesque and Mark Stokes convincingly argue that 'military-civil fusion' underscores the ways in which *junminronghe* is qualitatively different from traditional attempts to promote civil-military integration in other countries. For the purpose of this testimony, I use 'military-civil fusion' to denote the ways in which *junminronghe* not only aims to build connections between the military and civilian economy, but 'fuse' them together. For more, see Greg Levesque and Mark Stokes, "Blurred Lines: Military-Civil Fusion and the 'Going Out' of China's Defense Industry," Pointe Bello, December 2016, https://static1.squarespace.com/static/569925bfe0327c837e2e9a94/t/593dad0320099e64e1ca92a5/1497214574912/062017_Pointe+Bello_Military+Civil+Fusion+Report.pdf.

[4] "Strive to establish new era in deep development of military-civil fusion in Shanxi" [努力开创新时代山西军民融合深度发展新局面], Provincial Defense S&T Industry Office, September 28, 2018, http://sxgfgb.gov.cn/gongzuodongtai/4508.html.

have heeded the government's call and entered the previously closed-off sector. The push dovetails with technological advances in miniaturized satellites like cubesat, which are less capital intensive to produce and launch than traditional satellite technology, and therefore, provide a viable commercial model for small startups. This has allowed military-civil fusion to move ahead in the space sector, even as it struggles to gain traction in other sectors.

Military-civil fusion has two central mechanisms:

- On one side, there is the converting defense technology and resources to civilians (spin-off) component *junzhuanmin* 军转民, which calls for the military and defense industrial base to spin-off defense technology with commercial potential.

- On the other side, there is the "opening up" (or spin-on) component *mincanjun* 民参军, which denotes efforts to increase commercial enterprise participation in defense development and production.

In the case of China's nascent commercial space sector, both mechanisms are at work. The military and state-owned defense industrial base are actively supporting China's fledgling space startups through transferring technology and technical know-how. At the same time, China's Central Military Commission (CMC) and The State Administration for Science, Technology and Industry for National Defense (SASTIND) are beginning opportunities for private enterprises to participate in defense research and procurement.

Military-Civil Fusion Becomes a Priority

Close watchers of Chinese industrial policies noticed a subtle but meaningful development in China's commitment to military-civil fusion starting in 2016. In March 2016, the Central Politburo raised military-civil fusion to the status of "national strategy."[5] Less than a year prior, China's State Council unveiled Made in China 2025, which targeted many of the same dual-use industries relevant to military-civil fusion, including space. In January 2017, Xi Jinping established the Central Commission for Integrated Military and Civilian Development, a high-level body to oversee the implementation of military-civil fusion. Several months later, in March 2017, the Equipment Development Department of the CMC released nearly 3,000 patents related to defense technology to the public, marking the first time the PLA has declassified defense patents.[6]

Taken together, these developments have amounted to a significant shift in how China's state-owned defense sector and People's Liberation Army (PLA) interact with the private economy. Nowhere has that shift been more pronounced than in China's fledgling private space industry. In 2014, the State Council announced that it would allow private capital and enterprises to enter the previously closed-

[5] Lorand Laskai, "Civil-Military Fusion: The Missing Link Between China's Technology and Military Rise," *Net Politics*, January 29, 2018, https://www.cfr.org/blog/civil-military-fusion-missing-link-between-chinas-technological-and-military-rise.
[6] Meia Nouwens and Helena Legarda, "China's Declassification of Defence Patents: Novel, but not (yet) a game changer," IISS, January 2018, https://www.iiss.org/-/media/images/comment/military-balance-blog/2018/february/chinas-declassification-of-defence-patents.ashx?la=en&hash=6191B53451810369DC90075E31961C3F5099CC4D.

off sector.[7] A series of guiding opinions and action plans released throughout 2017 referenced the space industry as a key sector in the military-civil fusion drive. The 13th Five Year Plan Sci & Tech Military-Civil Fusion Development Special Plan, for instance, specifically named manned spaceflight as a military-civil fusion "mega project," suggesting that private entities would likely have a role in developing China's Tianhe-1.[8] In a strong signal to the private sector, the PLA Rocket Force recruited 13 private sector consultants to work on key projects in October 2018, marking the first time that the PLA has allowed civilians to participate in sensitive defense projects.[9]

Policies like these are starting to have an impact. For decades, two state-owned defense conglomerates, China Aerospace Science & Industry Corporation (CASIC) 中国航天科工集团 and China Aerospace Science and Technology Corporation (CASC) 中国航天科技集团, have had a near monopoly on launch and space technology. Within the course of several years, regulatory changes have given rise to a crop of private-funded startups like OneSpace 零壹空间 and LandSpace 蓝箭空间科技 that are attempting to develop affordable launch technologies. Around these launch companies, an ecosystem of startups specializing in niche segments like nanosatellites and microsatellites, satellite-based geopositioning and internet services, and specialized components is starting to take shape.

A mature commercial space industry would accord several significant benefits to China's national space program and the PLA.

- On the *spin-off* side, the commercial sector can develop a scale and efficiency that the defense sector is unable to achieve. In the same way that U.S. companies like SpaceX and Blue Origin are poised to drastically lower the launch cost, the hope is that Chinese companies can reduce cost of launching payloads, first with small satellites and then eventually with larger payloads. Some in the commercial space sector believe that as the commercial space industry gradually matures, the military will withdraw from its direct involvement in rocket development and production and instead act as a customer in a competitive market place.[10] This would free up resources within the PLA and state-owned defense industrial base to focus on more ambitious projects like the Long March 9.

- On the *spin-on* side, the blurring between commercial and military ventures in the space industry will make it easier for Chinese entities for evade U.S. export controls and capture important technologies. Over time, a robust commercial space sector built through military-civil fusion will help the PLA absorb and integrate space-related technologies from abroad that it currently lacks. In December 2018, the *Wall Street Journal* reported that a startup

[7] "Guiding Opinion on Encouraging Social Capital in Investment and Financing Mechanism in Key Innovations Areas" [国务院关于创新重点领域投融资机制鼓励社会投资的指导意见], State Council, November 16, 2014, http://www.gov.cn/zhengce/content/2014-11/26/content_9260.htm.
[8] "13th Five Year Plan Sci & Tech Military-Civil Fusion Development Special Plan" ["十三五"科技军民融合发展专项规划]," Ministry of Science and Technology, September 11, 2017, http://news.sciencenet.cn/htmlnews/2017/9/387703.shtm.
[9] Liu Zhen, "China's military recruits private experts to work on defence projects," South China Morning Post, October 12, 2018, https://www.scmp.com/news/china/military/article/2168385/chinas-military-recruits-private-experts-work-defence-technology.
[10] Analyzing China's commercial space market: Launch companies cannot burn money like bike-share companies," [中国商业航天市场解析：火箭企业不如共享单车烧钱], China Economy Weekly, November 27, 2018, http://www.xinhuanet.com/finance/2018-11/27/c_1210003050.htm.

controlled by a Chinese state-backed investment firm had succeeded in placing an order with Boeing for an advanced satellite with restricted technology.[11] Boeing had then obtained an export license from the Commerce Department, despite the clear Chinese money trail. While Boeing canceled the order after the WSJ story, the incident illustrates the challenges U.S. officials will face in distinguishing legitimate commerce in space-related industries from state-linked efforts to extract critical technology as China's space ambitions.

Running with a Familiar Concept

The drive to integrate military and commercial sectors springs, in part, from the PRC's close study of the U.S. experience cultivating commercial-military ties. One study by two Chinese scholars in 2012 attributed China's weakness in key dual-use industries like semiconductors and aerospace to the lack of civilian coordination with the defense industry.[12] State-media often cites data showing that in the United States 85 percent of the military's core technology comes from the private sector and 80 percent of firms that supply the US military also sell commercially.[13]

Many Chinese military planners would prefer a U.S.-style defense industry that promotes the efficient allocation of resources through commercial-sector collaboration and procurement. In January 2018, a study group at the State Council's Development Research Center tasked with researching a potential Military-Civil Fusion Law produced a study outlining the role of legislation like the Federal Technology Transfer Act of 1986 and Federal Acquisition Reform Act in the development of dual-use industries in the US.[14]

In China's space industry, U.S. companies like SpaceX and OneWeb have been held up as examples of the efficiencies and innovation to be had if China's successfully implements military-civil fusion. "SpaceX has achieved huge breakthroughs in a short period of time, which is inseparable from military-civil fusion the U.S. space field," wrote Wan Jing, a professor at the PLA's National University of Defense Technology.[15] In the view of Chinese aerospace experts, SpaceX's close cooperation with NASA and the U.S. Air Force, which yielded the company access to technical support, spin-off technology, and lucrative contracts, was central to its success.[16]

---

[11] Brian Spegele and Kate O'Keeffe, "China Maneuvers to Snag Top-Secret Boeing Satellite Technology," The Wall Street Journal, December 4, 2018, https://www.wsj.com/articles/china-maneuvers-to-snag-top-secret-boeing-satellite-technology-1543943490.

[12] Xie Xuanting and Liu Yun, "Lessons for China from U.S. efforts to push military-civil integration style development" [美国推动军民融合的发展模式及对我国的启示], National Defense Technology Base, October 2012, available at: http://www.cnki.com.cn/Article/CJFDTOTAL-GFJC200704012.htm.

[13] For example, see "Shanghai's Minhang district: Military-civil fusion helps local industries upgrade" [上海闵行区：军民融合助地方产业升级], Reference Times, August 1, 2017, http://finance.chinanews.com/cj/2017/08-01/8292315.shtml.

[14] "Notable characteristics and lessons from military-civil fusion legislation in the United States" [美国军民融合法律体系的特点及启示], Development Research Center of the State Council, October 24, 2017, http://www.drc.gov.cn/n/20171024/1-224-2894553.htm

[15] Wan Jing, "Viewing SpaceX's rise from the perspective of civil-military integration in the U.S. space industry" [从 SpaceX 崛起看美国航天领域军民融合], Defense Technology Review, Vol. 39 No. 3, June 2018, pg. 111.

[16] Also see Danghui Liu and Yunxia Yin, "Opportunities and Challenges in Commercial Space Launches" [商业航天发射的机遇与挑战], Journal of Aerospace Science and Technology, Vol. 6 No. 04, November 2018, https://image.hanspub.org/Html/2-2980101_27743.htm; an Cun Cao, "Analysis of SpaceX's Latest Civil-Military Integration" [SpaceX 公司最新军民融合实践分析], China Academy of Launch Vehicle Technology R&D Center, November 2017, http://www.doc88.com/p-9962814377552.html.

However, military-civil fusion in China extends beyond traditional efforts to promote civil-military integration in other countries through public-private partnerships. Under military-civil fusion, private enterprises are at best an appendage of the state-owned defense industrial base. The state-owned defense ecosystem remains dominant on account of the scale of state-owned defense conglomerates, as well as their privileged access to defense R&D institutes and government financing. In addition, the lack of IP protection for commercial enterprises creates an asymmetrical relationship between private enterprises and defense sector.

The unique relationship between the private sector and defense industrial base under military-civil fusion manifests in the financing ecosystem that has taken shape in dual-use sectors. So-called 'guidance funds' 引导基金 and other state-backed investment vehicles play a central role in supporting nascent dual-sectors related to military-civil fusion.[17] These funds essentially pool together state-owned and private capital, thereby obfuscating the line between the state and private investment and allowing the state to guide investment into enterprises deemed strategically valuable.

Currently, the top seven state funds dedicated to investing in military-civil fusion industries claim to have over RMB 362 billion ($56.85 billion) in capital.[18] A 2017 State Council guiding opinion called for provincial and municipal governments to set up investment funds that target dual-use industries, as well as for the State Administration for Science, Technology and Industry for National Defense (SASTIND) to set up a national military-civil fusion fund, presumably to assist local development.[19]

Surveying the Landscape of China's Commercial Space Sector

China's commercial space industry has rapidly expanded since 2015, growing from a virtually non-existent industry to a crowded field of launch provider and satellite makers. As top-level support for commercial space has become clear, entrepreneurs and investors have flocked to the sector. Private space launch startups include OneSpace, LandSpace, LinkSpace 翎客航天, ExPace 航天科工火箭技术有限公司, and I-Space 星际荣耀. Commercial micro/nano-satellite makers include Spacety 天仪研究院, Commsat 九天微星, and Changguang Satellite Technology 长光卫星技术有限公司.

Chinese launch providers lag significantly behind international leaders like SpaceX and Blue Origin. Despite multiple attempts, no Chinese startup has successfully delivered a payload to orbit**.** Moreover, the industry is largely reliant on solid-fuel rockets, which are less sophisticated and adaptable than the liquid-fuel rockets used by OneSpace and BlueOrigin. Nevertheless, Chinese companies are making rapid technical progress in a short period of time. I-Space and OneSpace have both successfully launched suborbital rockets. The industry is also quickly moving towards more

[17] Guidance funds function as "mother funds" that provide anchor capital to sub-funds. This allows government officials to spread state-owned capital via multiple sub-funds and dilute the government's direct share of individual investments to a minority and allows non-government capital (although often still state-owned) to play a leading role. Some top-level guidance funds like the Ministry of Science and Technology's National S&T Commercialization Guidance Fund 国家科技成果转化引导基金 have nearly twenty sub-funds.
[18] Lorand Laskai, "In Drive for Tech Independence, Xi Doubles Down on Civil-Military Fusion," Jamestown's China Brief, May 9, 2018, https://jamestown.org/program/in-drive-for-tech-independence-xi-doubles-down-on-civil-military-fusion/.
[19] "Local governments lend energy to establishing two types of fund to promote military-civil fusion" [各地借力两类产业基金推进军民融合], Securities Daily, June 19, 2018, http://fund.jrj.com.cn/2018/06/19075724693400.shtml http://www.gov.cn/zhengce/content/2017-12/04/content_5244373.htm.

advanced launch technology. LinkSpace has tested a vertical take-off, vertical landing rocket, similar to SpaceX's reusable rocket system.[20] In January 2019, LandSpace (not to be confused with LinkSpace) began testing a technologically-advanced liquid oxygen-methane rocket engine. If successful, LandSpace will make China the third country after the United States and Russia with a private company capable of developing liquid-oxygen/methane engines.[21]

There is a strong entrepreneurial ethos that runs through China's commercial space sector. With the exception of ExPace which is a subsidiary of CASIC, all entrants into the sector are privately-owned. China's first private launch company LinkSpace, for example, was established in 2014 by Hu Zhenyu 胡振宇, a then 21-year-old rocket enthusiast who received seed capital from internet mogul Nick Yang. Naturally, entrepreneurs in the industry revere Silicon Valley titans Elon Musk and Peter Thiel and view them as examples to be replicated. The perception of Chinese space startups as commercial in nature, rather than extensions of the state-owned defense sector, is important since Chinese launch providers and satellite markers see foreign customers—primarily, in the Middle East, Africa, and Europe—as critical to their success.

Nevertheless, the Chinese state and PLA play a formidable guiding role in the industry's development. The Central Military Commission (CMC) maintains a monopoly over the approval process for commercial rocket launches, meaning private enterprises cannot conduct the business of launching rockets without the military's blessing. For the most part, the military sees a clear advantage in allowing commercial launches to proceed. "If commercial rockets succeed and prosper, then the military can pit commercial rockets against state-owned rockets to extract the best value, which is good for the military," explained LinkSpace founder Hu Zhenyu.[22]

The links between the commercial space sector and the state-owned defense industrial base also runs deep. The technical teams of commercial space startups are filled with former employees of defense conglomerates and state research institutions.[23] OneSpace's Chief Technology Officer Chen Xiaojun, for instance, worked at the China Academy of Launch Vehicle Technology (CALT) before joining the company.[24] I-Space founder Mao Hongtao 毛洪涛 continues to work for an undisclosed aerospace research institute.[25] Founder and CEO of LandSpace is Zhang Changyu 张昌武 returned to China through the Thousand Talents Program 千人计划 after a 15-year stint working at the European Space

[20] "Linkspace successfully launches NewLine Baby (RLV-T5) reusable rocket, China's first sub-orbital rocket landing," Room.eu, April 3, 2019, https://room.eu.com/news/linkspace-successfully-launches-reusable-rocket-prototype.

[21] "LandSpace completed successful test of 80-tonne thrust engine" [蓝箭航天 80 吨发动机燃气发生器点火试车成功], LandSpace Sci & Tech, Jan. 6, 2019, https://mp.weixin.qq.com/s/nZbyyCBlwcL9gKzlWJMH0g; Blaine Curcio and Tianyi Lan, "The rise of China's private space industry," SpaceNews, Mar. 25, 2018, https://spacenews.com/analysis-the-rise-of-chinas-private-space-industry/

[22] "Analyzing China's commercial space market: Launch companies cannot burn money like bike-share companies."

[23] OneSpace states on their website that 70 percent of the startup's technical team are from institutions like CASIC, CASC, AVIC, and the Chinese Academy of Science, among other institutions. http://www.onespacechina.com/electronic/

[24] "Private space companies welcomes spring as OneSpace's launch plans receives approval" [民营航天迎来春天 零壹空间火箭方案已通过评审], Xinhua, October 28, 2016, http://news.ifeng.com/a/20161028/50170329_0.shtml

[25] "The Elon Musks of Yizhuang."

Agency and worked at a state-owned aerospace company for several years before founding LandSpace.[26]

Beyond talent, launch vehicle enterprises require three inputs: capital, technology, and a manufacturing base. China's state-owned defense base has provided China's fledgling commercial space enterprises access to all three. Despite attracting sizable private investment, China's space startups rely heavily on state investors for funding. SASTIND has provided early-stage funding to several startups including iSpace and OneSpace.[27] Municipal and provincial-level guidance funds were early backers in OneSpace and LandSpace.[28] Spacety and Commstat have received several rounds of financing from two Chinese Academy of Science (CAS)-backed venture capital funds.[29] This melding of private and state-owned capital is typical of dual-use sectors where the Chinese government has clear strategic aims.

The breakneck speed at which many startups have launched rockets suggests that at least some companies also rely on the military and defense sector for "spin-off" technology. While most launch startups are working on their developing their own rocket technology, "spin off" technology from the defense sector is clearly crucial. In March 2017, LandSpace had to explain to investors and customers that the company had to scrap its first rocket launch plans after a defense conglomerate pulled out of an agreement to supply the rocket's engine.[30] A year earlier, a LandSpace representative told a *Quartz* reporter that the company was utilizing designs from a flight-proven rocket, possibly the Long-March 11.[31] Analysts have suggested that OneSpace's OS-M rockets may use propulsion technology from retired PLA missiles.[32] One employee at I-Space described the benefits of "spin-off" technology as like "standing on the shoulders of a giant."

Even when commercial space startups develop their own proprietary technology, they need a place to manufacture it. Chongqing Aviation Industry Investment Group co-invested in a manufacturing facility with OneSpace. The Wuhan municipal government and CASIC are building the country's first national-level commercial space manufacturing base for launch and satellite companies; state-

---

[26] "The Elon Musks of Yizhuang."; Tim Fernholz, "The SpaceX of China aims to commercialize a mysterious rocket on the world stage," Quartz, Sept. 27, 2016, https://qz.com/791879/landspace-the-spacex-of-china-plans-to-commercially-launch-a-rocket-based-on-the-long-march-11/.

[27] "The Elon Musks of Yizhuang."

[28] "LandSpace announces Rmb 200 million in b-round fundraising" [蓝箭航天宣布完成 B 轮 2 亿元融资], Xinhua, July 4 2018, http://www.xinhuanet.com/info/2018-07/04/c_137301106.htm.

[29] "Spacety raises Rmb 150 million in B-round financing led by Legend Capital" [天仪研究院完成 1.5 亿元人民币 B 轮融资，君联资本领投], PEDaily.cn, July 20, 2018, https://pe.pedaily.cn/201807/433740.shtml; Commsat finishes RMb 100 million plus a-round financing" [「九天微星」 完成过亿元 A+轮融资，将发射一箭七星], 36KR, November 30, 2018, https://36kr.com/p/5164676.

[30] "Uncovering China's SpaceX: China's rocket startups are on the rise" [揭秘中国版 SpaceX：中国的火箭创业公司正在崛起], Economic Observer, February 11, 2018, http://tech.sina.com.cn/d/2018-02-11/doc-ifyrmfmc1387262.shtml.

[31] Tim Fernholz, "The SpaceX of China aims to commercialize mysterious rocket on the world stage," September 27, 2016, https://qz.com/791879/landspace-the-spacex-of-china-plans-to-commercially-launch-a-rocket-based-on-the-long-march-11/.

[32] Rui C. Barbosa, "Maiden launch of OneSpace OS-M rocket fails," NASA Spaceflight, March 27, 2019, https://www.nasaspaceflight.com/2019/03/maiden-launch-of-onespace-os-m-rocket-fails/; Stephen Clark, "Chinese startup OneSpace fails in first orbital launch attempt," Spaceflight Now, March 27, 2019, https://spaceflightnow.com/2019/03/27/chinese-startup-onespace-fails-in-first-orbital-launch-attempt/.

media claims that 19 enterprises including Commsat have registered and that the base will have an annual production capacity of 50 carrier rockets and 140 commercial satellites by 2020.[33]

Implications for the United States

China is not yet a near competitor to the United States in the commercial space sector. China's share of the global space market is estimated at around 3 percent, and within China, commercial space companies still holds a negligible share of the market in comparison to CASIC and CASC.[34] Nevertheless, military-civil fusion in China's space industry presents a unique set of challenges to the United States and may portend more significant competition in the future.

China's burgeoning commercial space sector, on one hand, will challenge U.S. export controls and inbound investment screening process, creating opportunities for Chinese state-backed entities to capture critical technologies or co-opt promising emerging technologies before they fully develop. The influx of private capital into China's space sector will help disguise state-owned capital, and in some cases, allow state-linked investment vehicles to acquire critical technology under the guise of being private investors.[35] Even where state-owned capital is not involved, increased interlinkage between China's space sector and the international market will create opportunities for informal technology transfer.

The Boeing-Global IP incident was a warning sign. Two other recent examples should give policymakers pause:

- In December 2018, U.S. startup Global Constellation accepted a minority investment from HCH Group, a Hong Kong-based subsidiary of Haier Group, a Chinese appliance and electronics giant with an opaque ownership structure.[36] The startup aims to launch a constellation of low-orbit satellites that will act as a space-based cloud computing center.

- Chinese tech giant Tencent led B-round fundraising for Satellogic, a Buenos Aires-based microsatellite startup with an office in the United States.[37] The startup aims to launch a constellation of remote sensing satellites with hyperspectral capabilities. It recently reached an agreement with a CASC subsidiary to launch 90 smallsats on as many as six long March 6 rockets.[38]

---

[33] "19 enterprises join Wuhan national-level space industry base" [19 家企业入驻武汉国家航天产业基地], China News Service, April 24, 2018, http://www.chinanews.com/cj/2018/04-24/8499221.shtml.

[34] "China's share of global space industry is only 3 percent—room for commercial space development is large [中国航天产业总收入仅占全球 3% 商业航天发展空间巨大], Daily Economics News, December 12, 2018, https://baijiahao.baidu.com/s?id=1620379225475294873&wfr=spider&for=pc.

[35] For examples of state-linked funds acquiring critical technology in the semiconductor space, see Emily Feng, "How China acquired mastery of vital microchip technology," Financial Times, January 29, 2019, https://www.ft.com/content/7cfb2f82-1ecc-11e9-b126-46fc3ad87c65.

[36] "Cloud Constellation Corporation Receives $100M Series B Commitment," PR Newswire, December 20, 2018, https://www.prnewswire.com/news-releases/cloud-constellation-corporation-receives-100m-series-b-commitment-300769736.html; "HCH Group," Crunchbase, https://www.crunchbase.com/organization/hch-group#section-overview.

[37] "Tencent leads $27m series b in satellite data service provider Satellogic," Deal Street Asia, June 27, 2017, https://www.dealstreetasia.com/stories/tencent-series-b-satellogic-76095/.

[38] Jeff Foust, "Satellogic selects China Great Wall to launch satellite constellation," Space News, Jan. 15, 2019, https://spacenews.com/satellogic-selects-china-great-wall-to-launch-satellite-constellation/.

On the other hand, the rise of China's commercial space industry has the potential to cut into the market share of U.S. companies. Revealingly, in an interview last year, OneSpace founder and CEO Shu Chang 舒畅 said his goal was not to be "China's SpaceX," but to be the "Huawei of the space industry."[39] The goal is not so much to push the bounds of commercial space technology as to commercialize existing technology and sell it at a lower cost. Some launch companies have offered small satellite companies free launch services as a way to gain market share.[40] The chairman of CASIC-subsidiary ExPace has said the company will attempt to price satellite payloads on its Kuaizhou rockets at less than half the prevailing commercial price.[41] This cost-cutting approach might not work in the medium and heavy-lift launch market, especially if it involves cutting corners, but it could provide a competitive advantage in the growing market for small satellite launches and services.

Conclusion and Recommendations

China's military-civil fusion drive in the space industry presents clear challenges. As the United States responds, there will be a clear tension between defending U.S. technology and enabling U.S. companies to compete against Chinese newcomers.

With this in mind, Congress should consider the following:

1. **Embrace a "small yard, high fence" approach to export controls and inbound investments.** In the past, over regulation of satellite-technology under International Traffic and Arms Regulations (ITAR) led to a loss of U.S. market share to European competitors with "ITAR-free" technology.[42] In the future, similar overregulation could lead to a loss of U.S. market share to Chinese competitors, facilitating the rise of China's commercial space industry. This prospect means that Congress should adopt what former Secretary of Defense Robert Gates called a "small yard, high fence" approach defending U.S. space technology"—that is, selectively choosing technologies to defend, but aggressively defending them.[43]

   Export control reform under the Obama administration significantly reduced the number of space-related goods and services on the U.S. Munitions List (USML) and moved the USML towards a "positive list" with precisely defined technology. However, the Export Control Reform Act of 2018's mandate to restrict "emerging and foundational technologies" could

[39] "OneSpace CEO Shu Chang: In comparison to SpaceX, we are more interested in becoming the space industry's Huawei" [零壹空间 CEO 舒畅：相比中国 SpaceX 更想做航天业的华为｜前行者], Zhihu Zhuanlan, March 27, 2018, https://zhuanlan.zhihu.com/p/35002700

[40] Echo Huang, "A startup aims to launch China's first privately backed orbital rocket," Quartz, March 23, 2019, https://qz.com/1577395/china-private-rocket-company-onespace-attempts-orbital-launch/

[41] Peter B. de Selding, "New Chinese commercials-launch company advertises high launch rate, low price," SpaceNews, November 29, 2016, https://spacenews.com/new-chinese-commercial-launch-company-advertises-high-launch-rate-low-price/

[42] "U.S. Space Industry 'Deep Dive' Assessment: Impact of U.S. Export Controls on the Space Industrial Base,' Prepared by U.S. Department of Commerce Bureau of Industry and Security Office of Technology Evaluation, February 2014, https://www.bis.doc.gov/index.php/documents/technology-evaluation/898-space-export-control-report/file.

[43] Lorand Laskai and Samm Sacks, "The Right Way to Protect America's Innovation Advantage," Foreign Affairs, October 23, 2018, https://www.foreignaffairs.com/articles/2018-10-23/right-way-protect-americas-innovation-advantage.

mark a return to a broad, subjective list. Congress should ensure that ECRA is not implemented in a way that significantly impedes the development of the U.S. space industry.

2. **Preemptively defend supply chains critical to U.S. competitiveness in the space industry**. Given Beijing's support for advanced manufacturing through Made in China 2025, the rise of China's commercial space sector has the potential to chip away at important manufacturing competencies within the United States, particularly in emerging, low-cost industry segments like micro/nano-satellite technology. Senator Mark Warner and Mark Rubio's proposed legislation to create the Office of Critical Technologies and Security, which would be responsible for coordinating an inter-agency strategy to defend U.S. supply chains and manufacturing capacity, is a welcome step to increase the U.S. government's ability to preemptively defend important technologies and our ability to manufacture them.[44]

3. **Continue to leverage and scale up public-private partnerships to encourage innovation.** It's important to remember that the success of public-private partnerships in the United States is the reason why China is pursuing military-civil fusion in the space industry. The success of companies like SpaceX and Blue Origin have convinced Chinese leaders that the statist model towards space is insufficient. The United States should continue leveraging these types of partnerships and extend them to a new generation of startups. Innovation outfits within the Pentagon like DIU and AFWERX are doing positive work incubating startups developing microsatellite technology. In general, developing, iterating, and commercializing hardware is far more capital intensive than software. Congress, therefore, should fund capital programs specifically for dual-use hardware like the National Security Innovation Capital (NSIC).[45] As long as China cannot guarantee IP protections and impartial arbitration for private enterprises, the United States will have a first mover's advantage in public-private partnerships and should make full use of them.

[44] "Warner, Rubio Introduce Bipartisan Legislation to Combat Technology Threats From China," Office of Senator Mark Warner, January 4, 2019, https://www.warner.senate.gov/public/index.cfm/pressreleases?ID=9D405E99-2E31-4A2D-A79F-9F3FF3B32122.
[45] "Pentagon seeks $75m for dual-use tech venture capital program," Inside Defense, March 19, 2019, https://insidedefense.com/daily-news/pentagon-seeks-75m-dual-use-tech-venture-capital-program.

OPENING STATEMENT OF MICHAEL GOLD, J.D., VICE-PRESIDENT, REGULATORY AND POLICY, MAXAR TECHNOLOGIES

COMMISSIONER MCDEVITT: Mr. Gold, over to you.

MR. GOLD: Shoot to be six seconds under here, so. I appreciate the opportunity to testify before the Committee.

My name is Mike Gold and I serve as the Vice President of Regulatory and Policy for Maxar Technologies. Maxar is comprised of four Heritage companies, Space System Loral, or SSL, Digital Globe, Radiant Solutions, and MDA.

Maxar has roughly six thousand employees located throughout the U.S. and Canada. It is a global leader in satellite manufacturing, space-based robotics, geospatial intelligence, and analytics.

Maxar is the world's most prolific geotelecommunications satellite manufacturer with roughly 270 satellites launched, approximately 80 still in orbit, and an unprecedented 2,200 on orbit years of experience.

If you are using your cell phone today, it was likely a Maxar satellite you were using, unless it was a dropped call, in which case it was a French satellite. And shame on you for going that route.

It's a challenging time in the geocommercial satellite field. No more than a few years back global satellite orders averaged 20 per year. In 2017 and 2018, that figure dropped to eight per year. With only two orders so far in 2019.

While Maxar maintains its world leading market share, the amount of work available has dropped precipitously. These headwinds that geocommercial satellite manufacturers face are now being exacerbated by new Chinese competition.

China has become a leading satellite manufacturer, producing 40 satellites in a two-year period. A rate that rivals the productivity of U.S. and Europe.

China's growth strategy is focused on establishing a Space Silk Road, developing regional customers by leveraging China's economic and political influences.

Specifically, China has had great success in building, launching, and operating satellites for countries such as Venezuela, Nigeria, Pakistan, Sri Lanka, Belarus, and Laos.

Although China has focused on developing nations and political allies, they're already achieving success with traditional commercial satellite operators. For example, in October 2016, China Great Wall Industry Corporation won a breakthrough contract for a high throughput broadband satellite for Thaicom at a value of 208 million dollars.

China followed this victory by winning another contract in May 2017, this time from an Indonesian joint venture, for Palapa N1, another high throughput satellite.

These two wins for China Great Wall, were the first instances of the company taking away satellite manufacturing business that otherwise could have gone to American, European, or Japanese manufacturers.

China Great Wall's success was based no small part on aggressive financing. Specifically when Maxar's Heritage SSL business unit sought to compete for the Palapa N1 in 2016, we discovered that China Great Wall was offering 70 percent financing, which would be immediately available upon contract signing.

Normally, it takes at least six months after contract signing, and often up to a year for satellite financing to be released. China Great Wall won Palapa N1 primarily because it could offer aggressive financing.

And if the U.S. government fails to resuscitate the Export-Import Bank, domestic satellite manufacturers will be unable to compete with the Chinese, or for that matter, rival European and Japanese firms.

Although EXIM was reauthorized by Congress in 2015, the bank is unable to approve any transactions greater than 10 million dollars in value since it currently lacks a quorum of three voting board members.

The Bank has been in this position for nearly five years, and the economic impact on American businesses has been devastating.

At the peak of EXIM's activity in 2012, the Bank financed 35.8 billion in transactions, supporting thousands of small businesses and 255,000 U.S. jobs.

In 2017, EXIM approved just 3.4 billion in transactions. Less than 10 percent of its activities from five years earlier.

Moreover, 43 billion worth of export deals for U.S. businesses are currently being held up due to EXIM inaction, resulting in massive amounts of jobs, innovation, and revenue going overseas to countries that have export credit agencies.

The Trump Administration recently acknowledged the vital importance of the EXIM to both the nation's economy and security. Last month Larry Kudlow, the Director of the U.S. National Economic Council, called the EXIM Bank a financial tool and a national security weapon.

Combined with traditional favorable views of the Bank from Democrats, EXIM should enjoy bipartisan support. Therefore, I implore this Commission in its recommendations to Congress, to strongly support the restoration of the EXIM Bank.

Not only to help America compete with China economically, but as Larry Kudlow described, as a vital means of defending our country.

Additionally, the Commission should recommend that when the Department of Commerce develops new export controls for emerging technology, such as space-based robotics, artificial intelligence, and quantum computing, all of which will be critical to next generation satellites, that these new rules adopt a balanced approach that will not result in unintended consequences that ultimately benefit China.

Specifically, if Commerce adopts new rules constraining China, these regulations should be paired with the elimination of red tape and bureaucracy that would otherwise hinder or prevent U.S. companies from working on emerging tech with NATO and major non-NATO allies.

When the U.S. is forced to withdraw from international collaborations and financing, it leaves a leadership void that is often filled by China. Therefore, a balanced approach should be adopted.

Finally, America has never been more dependent on its orbital assets. They have never been under greater threat.

Per Congressional testimony in 2017 from Dan Coats, the Director of National Intelligence, China as well as Russia, are developing directed energy weapons, conducting missile tests, and are applying their own robotic systems, all with the goal of disabling American satellites.

The U.S. must respond to this threat by bolstering the resilience of its in-space infrastructure. Currently, Maxar is working with NASA on the Restore-L program, which will result in a robotics spacecraft that for the very first time will refuel a satellite while in orbit.

We're also working with NASA on in-space robotic assembly technologies. Specifically,

via the NASA tipping point program, we are developing robotics that can build and repair satellites after they are deployed.

In its recommendations to Congress and the Executive Branch, I urge the Commission to emphasize the importance of the federal government fully supporting the development, and utilization of satellite servicing, and in space assembly systems.

Again, I appreciate this opportunity to testify. And look forward to answering any questions the Commission may have.

PREPARED STATEMENT OF MICHAEL GOLD, J.D., VICE-PRESIDENT, REGULATORY AND POLICY, MAXAR TECHNOLOGIES

Testimony before the U.S.-China Economic and Security Review Commission

Hearing on *China in Space: A Strategic Competition?*

by

Mike Gold, Vice President – Regulatory and Policy, Maxar Technologies

April 25th, 2019

I. Introduction and Background:

I appreciate the opportunity to testify before the Commission. My name is Mike Gold and I am Vice President for Regulatory and Policy at Maxar Technologies ("Maxar"). Maxar combines four heritage businesses, Space Systems Loral ("SSL"), the world's most prolific commercial communications satellite manufacturer and a global leader in space-based propulsion and robotics; DigitalGlobe, the world's leading commercial source of satellite imagery, geospatial information, and location-based intelligence; Radiant Solutions, which provides state-of-the-art geospatial analysis and intelligence leveraging next-generation artificial intelligence ("AI") and machine learning capabilities; and MDA, which develops and delivers advanced surveillance solutions, defense and maritime systems, radar geospatial imagery, and space-based robotics. Maxar has approximately 6,000 employees spread across numerous locations throughout the U.S. and Canada.

Today, I am here to focus on Maxar's communications satellite manufacturing business which is executed by our heritage SSL team primarily out of facilities in California. Maxar traces its commercial satellite pedigree back to Philco and Ford Aerospace, and was one of the first tech companies to develop in Silicon Valley. We were in Silicon Valley when the only Apple presence existed via the numerous orchards that surrounded our facility. Since that time, our company has gone on to lead the world in commercial geosynchronous ("GEO") satellite manufacturing, with more of our GEO satellites in orbit than any other company. Maxar boasts a total of roughly 270 satellites launched, with approximately 80 still in orbit, and an unprecedented 2,200 on-orbit years of experience.

However, due to the dramatic downturn in the GEO commercial satellite market, it is an extraordinarily challenging time, even for a leading company like Maxar. Over the course of the last few years, annual global GEO commsat orders have dipped from an average of 20 orders per year to just 8 orders per year for the last two years, with only two orders so far in 2019.[1] Further exacerbating these difficulties is new and robust competition from China.

[1] *Recently awarded GEO-Sat Contracts*, GUNTER'S SPACE PAGE, https://space.skyrocket.de/doc_sat/sat-contracts.htm (last updated Apr. 18, 2019); Satellite Industry Association, *State of the Satellite Industry* (2018), https://www.sia.org/wp-content/uploads/2018/06/2018-SSIR-2-Pager-.pdf.

II. China's Satellite Manufacturing Strategy and Successes:

China has made great strides in satellite manufacturing in a shockingly short amount of time. A little more than a decade ago, China lost both of its initial GEO communications satellites, Sinosat-2[2] and Nigcomsat-1,[3] to solar array malfunctions in 2006 and 2008 respectively. Today, China has become a global leader in satellite manufacturing, producing 40 satellites in a two-year period, a rate that rivals the productivity of the U.S. and Europe.[4]

China's growth strategy has focused on establishing a 'Space Silk Road' developing regional customers by leveraging China's economic and political influence.[5] Specifically, China has had great success in building, launching, and operating satellites for countries such as Venezuela, Nigeria, Pakistan, Sri Lanka, Belarus, and Laos.[6] Satellite sales to these nations are part of a much broader economic and political plan to support Chinese strategic objectives via the Belt and Road initiative ("BRI") as described in an Observer Research Foundation Special Report on China's Design to Capture Regional SatCom Markets from July of 2018.

> "That China is seeking resources as well as markets for its products through the BRI is known. The electromagnetic spectrum and geostationary orbital positions are also natural resources and heavily contested. The number of government and commercial entities owning a satellite is increasing. The international launch contracts not only give China revenue from the upstream activities (satellite manufacturing and launch) but also downstream business opportunities (space services – images or broadcasting) with some of the customers. China is developing its customers into regional hubs for satellite services.
>
> For example, China is investing into SupremeSat to help it become the South Asian regional hub for space services. Where feasible, the satellites are being controlled by new companies established for this specific purpose. China could then obtain stakes in those companies such as NigComSat in exchange for funding its two new satellites. China will be entering into cost and revenue sharing satellite contracts with Pakistan. SupremeSat is receiving major funds from China. Chinese companies command 55 percent share in the LaoSat-1 joint venture company. When Belintersat-1 was purely interested in satellite services export revenue, NigComSat entered into a partnership for servicing Belarus' African market."[7]

China intends to capture a majority share of the global communications satellite and launch market by developing strong relationships with countries that are adverse to U.S. interests

---

[2] *Sinosat 2, 4 (Xinnuo 2, 4)/ZX 9A (ChinaSat9A)*, GUNTER'S SPACE PAGE, https://space.skyrocket.de/doc_sdat/sinosat-2.htm (last updated Dec. 11, 2017).
[3] *NIGCOMSAT 1, 1R*, GUNTER'S SPACE PAGE, https://space.skyrocket.de/doc_sdat/nigcomsat-1.htm (last updated Dec. 11, 2017).
[4] Caleb Henry, *Back-to-back commercial satellite wins leave China Great Wall hungry for more*, SPACENEWS (Aug. 22, 2017), https://spacenews.com/back-to-back-commercial-satellite-wins-leave-china-great-wall-hungry-for-more/.
[5] Vidya Sagar Reddy, *China's Design to Capture Regional SatCom Markets*, ORF Sepcial Report No. 70, 15 (July 2018), https://www..orfonline.org/wp-content/uploads/2018/07/ORF_SpecialReport_70_China_SatCom.pdf.
[6] *Id.* at 2.
[7] *Id.* at 16.

(e.g.,Venezuela) and using such nations as gateways to pursue regional opportunities.[8] Like other BRI projects, China is financing satellite launch and manufacturing. Politics clearly looms large in much of China's international satellite manufacturing and launch work, and may even have primacy over economic gains.[9] China provides the capital via loans for allied nations to purchase China Great Wall Industry Corporation ("CGWIC") satellites, and it's currently unclear whether China can actually generate profits from these agreements or, alternatively, if China is simply willing to operate at a loss to enjoy nontrivial strategic and technological benefits.[10]

Although China has focused on developing nations and political allies, CGWIC is already achieving success with traditional satellite fleet operators. For example, in October of 2016, CGWIC won a breakthrough contract for a high-throughput Ka-band broadband satellite for Thailand's Thaicom via its subsidiary International Satellite Co. Ltd. for a value of $208 million.[11] China followed this victory by winning another contract in May 2017, this time from Palapa Satelit Nusantara Sejahtera, a joint venture of Indosat Ooredoo and Pasifik Satelit Nusantara (PSN), for Palapa-N1, a high-throughput Ku-band satellite with 10 Gbps of capacity.[12] These two wins for CGWIC were the first instances of China taking away satellite manufacturing business that otherwise could have gone to American, European, or Japanese manufacturers.

CGWIC's success was based in no small part on aggressive financing. Specifically, when Maxar's heritage SSL business unit sought to compete for Palapa-N1 in 2016, we discovered that CGWIC was offering 70% financing to PSN which would be immediately available at contract signing. It normally takes at least 6 months after contract signing and often up to a year for satellite financing to be released. Because SSL couldn't even begin to compete with such aggressive financing terms, we did not pursue Palapa-N1, surrendering the jobs, revenue, and innovation that the satellite manufacturing work provided to China.

III. Policy Recommendations:

A. Revive the Export-Import Bank

Again, China is seeking to capture a majority share of the global satellite manufacturing market.[13] The eventual loss of domestic commercial satellite manufacturing capabilities represents a nontrivial threat to the U.S. industrial base and national security. Therefore, at a moment when GEO telecommunications satellite sales are at an all-time low, Congress must move with alacrity to prevent yet another high-tech manufacturing capability from being lost to overseas competition.

---

[8] *Id.*
[9] *Id.*
[10] *Id.*
[11] Peter B. de Selding, *China wins breakthrough contract for Thaicom telecommunications satellite*, SPACENEWS (Oct. 28, 2016), https://spacenews.com/china-wins-breakthrough-contract-for-thaicom-telecommunications-satellite/.
[12] Henry, *supra* note 4.
[13] Reddy, *supra* note 5 at 16.

SSL's experience with Palapa-N1 is directly relevant to a potential solution. CGWIC won the Palapa-N1 primarily because it could offer aggressive financing and, without the Export-Import Bank ("Ex-Im" or the "Bank"), domestic satellite manufacturers will be unable to compete with Chinese or, for that matter, rival European and Japanese firms. Satellite development is an inherently long-term exercise. Financing is always required since revenue cannot be generated for years while a satellite is being manufactured and later deployed. Without financing, the economics of satellites would collapse, yet U.S. manufacturers have been facing this very scenario due to an incapacitated Ex-Im.

Although the Ex-Im was reauthorized by Congress in 2015, the Bank is unable to approve any transactions greater than $10 million in value since it lacks a quorum of three voting board members.[14] The Bank has been in this position for nearly five years and the economic impact on American businesses has been devastating. At the peak of Ex-Im's activity in 2012, the Bank financed $35.8 billion in transactions, supporting thousands of small businesses and 255,000 U.S. jobs.[15] In 2017, Ex-Im supported just $3.4 billion in transactions, less than 10 percent of its activities from five years earlier.[16] Moreover, $43 billion worth of export deals for U.S. businesses are currently being held up due to Ex-Im inaction, resulting in massive amounts of jobs, innovation, and revenue going overseas to countries with active Export Credit Agencies ("ECAs").[17]

> "Because EXIM is sidelined, El Al is outfitting its new fleet of Boeing planes with Rolls Royce engines made in the UK instead of GE engines from Ohio. A $2 billion Egyptian order of industrial equipment—which translates to at least 10,000 jobs—will be sourced in Canada and Europe, not the U.S., for the same reason. Many U.S. companies are losing contracts or being forced to source from abroad as we step aside while country after country steps up to help their companies win deals we leave on the table. Today, there are nearly 100 ECAs around the world."
>
> - *Fred P. Hochberg, former Chair of the U.S. Export-Import Bank*[18]

Without Ex-Im, competing in what is already a very difficult global satellite manufacturing market could become problematic. Even once the Ex-Im is fully revived, competing with CGWIC in particular will be difficult, since the financing provided by the Ex-Im pales in comparison to aggressive ECA support that China is providing to its manufacturers. China and other nations are exploring how to or already have gone beyond traditional ECA activities, while the U.S. has been unable to even resuscitate Ex-Im, leaving domestic high-tech companies that are vital to the U.S. industrial base and the country's national security at a dramatic disadvantage relative to China and every other industrialized nation which have uniformly embraced ECAs.

---

[14] Thomas Wade, *Four Years On—Reauthorizing the Export-Import Bank: A Policy Evaluation*, AMERICAN ACTION FORUM (Jan. 15, 2019), https://www.americanactionforum.org/insight/four-years-on-reauthorizing-the-export-import-bank-a-policy-evaluation/.
[15] Fred P. Hochberg, *The Senate is making a big mistake as it drags its feet over EXIM Bank confirmations*, CNBC (July 18, 2018, 11:39 AM), https://www.cnbc.com/2018/07/17/ex-im-bank-needs-senate-support-to-save-us-jobs.html.
[16] *Id.*
[17] Wade, *supra* note 14.
[18] Hochberg, *supra* note 15.

American companies just want a chance to compete on an even playing field, or at least one that isn't tipped completely toward foreign competition.

The Trump administration recently acknowledged the vital importance of the Ex-Im to both the nation's economy and security. Last month, Larry Kudlow, the Director of the U.S. National Economic Council, called the Ex-Im Bank a "financial tool and a national security weapon".[19] Combined with traditional favorable views of the Bank from Democrats, Ex-Im should enjoy bipartisan support. However, the Senate has yet to take action and it's unclear when or if this will change. Therefore, I implore this Commission in its recommendations to Congress to strongly support the restoration of the Ex-Im Bank, not only to help America compete with China economically but, as Larry Kudlow described, as a vital means of defending our country.

B. Export Control Reform

While necessary, export controls can, and often have been, implemented in a counterproductive fashion.[20] Due to legitimate concerns over Chinese investments in Silicon Valley and venture capital funds, the FY 2019 National Defense Authorization Act called for the Department of Commerce to establish appropriate controls for "emerging and foundational technologies".[21] These emerging and foundational technologies include a wide variety of critical capabilities such as artificial intelligence, quantum computing, and advanced robotics.[22]

Again, while export controls in these areas are justified, particularly relative to China, the Departments of Commerce, State, and Defense, as well as other Executive Branch agencies, must not implement controls in a counterproductive manner. Many of these emerging and foundational technologies are being developed in a global fashion involving cross-border financing and substantive international collaborations. If U.S. companies are constructively prohibited from entering into these global partnerships and obtaining foreign financing, American efforts and progress will be stymied. Accordingly, when America withdraws from advancing global technological development, it provides an excellent opportunity for China to fill the leadership void.

Therefore, in its recommendations to Congress and the Executive Branch, this Commission should endorse a balanced approach to export controls, wherein higher walls are constructed around smaller areas. Specifically, any new export controls for emerging and foundational

---

[19] Jeffrey Rodack, *Kudlow Dubs Beleaguered Ex-Im Bank a 'National Security Weapon,'* NEWSMAX (Mar. 28, 2019, 1:26 PM), https://www.newsmax.com/newsfront/larry-kudlow-banks-security-exports/2019/03/28/id/909139/.

[20] *See* Michael N. Gold, *The Wrong Stuff: America's Aerospace Export Control Crisis*, 87 NEB. L. REV. (2008), https://digitalcommons.unl.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=1025&context=nlr, Mike N. Gold, *Lost In Space: A Practitioner's First-Hand Perspective on Reforming the U.S.'s Obsolete, Arrogant, and Counterproductive Export Control Regime for Space Related Systems and Technologies*, 34 J. SPACE L. 163 (2008), and Mike N. Gold, *Thomas Jefferson, We Have a Problem: The Unconstitutional Nature of the U.S.'s Aerospace Export Control Regime as Supported by* Bernstein v. U.S. Department of Justice, 57 CLEV. ST. L. REV. 629 (2009).

[21] John S. McCain National Defense Authorization Act for Fiscal Year 2019, Pub. L. No. 115-232; *See also* Review of Controls for Certain Emerging Technologies, 83 Fed. Reg. 58201 (proposed Nov. 19, 2018) (to be codified at 15 CFR pt. 744), https://www.federalregister.gov/documents/2018/11/19/2018-25221/review-of-controls-for-certain-emerging-technologies.

[22] *See* Review of Controls for Certain Emerging Technologies, 83 Fed. Reg. 58201.

technologies can and should address concerns over Chinese competition. However, any such regulations should be balanced with rules and reforms allowing U.S. companies to enter into robust partnerships and joint collaborations with NATO and major non-NATO allies. Export controls are a double-edged sword which must be wielded carefully in order to avoid harming the very interests that are meant to be defended.

C. Satellite Servicing and In-Space Assembly

Per Congressional testimony in 2017 from the Director of National Intelligence, Dan Coats, America has never been more dependent upon its orbital assets and they have never been under greater threat.[23] China and Russia are developing directed energy weapons, conducting missile tests, and deploying robotic systems, all with the goal of gaining the ability to disable America's critical public and private sector satellites.[24] Therefore, it's vital that the U.S. take action to bolster the resilience of our space-based infrastructure.

Maxar Technologies is developing robotic systems that will be able to service satellites in orbit. For example, Maxar is supporting NASA's Restore-L mission which, for the first time, will result in a robotic system that will refuel a satellite in low Earth orbit ("LEO"). Maxar is also supporting NASA's In-Space Robotics, Manufacturing, and Assembly ("IRMA") Tipping Point program to build and demonstrate space-based robotics that can assemble parts of a satellite after it achieves orbit. Additionally, DARPA is working on the Robotic Servicing of Geosynchronous Satellites ("RSGS") program to create a robotic vehicle that can repair and refurbish satellites. The capabilities resulting from programs such as Restore-L, Tipping Point, and RSGS will substantially enhance the resilience of all of America's orbital assets, diluting if not eliminating the efficacy of many anti-satellite systems in a peaceful, commercial fashion.

However, for these new systems to come to fruition, continued support from both Congress and the Executive Branch will be required. Therefore, the Commission should recommend to Congress that full funding be provided to programs such as Restore-L and IRMA.

Moreover, the Commission should recommend that NASA, the Department of Defense, and other federal agencies, leverage in-space satellite servicing systems and in-space assembly capabilities as customers. While the federal government is not able to provide direct subsidies and financial support in the robust manner that we see in China and Europe, what government agencies and departments can do is leverage the power of the purse to become an active customer for these capabilities. In the words of Doug Loverro, former Deputy Assistant Secretary of Defense for Space Policy, we eventually won't be able to outspend China in space, but we can 'out entrepreneur them'.[25] If U.S. Government entities purchase satellite refueling, repair, and in-space assembly services, these capabilities will be developed and matured by companies such as Maxar, unleashing the power and efficiencies of the private sector in support of protecting America's orbital assets. For all of these reasons, the Commission should

[23] *Worldwide Threat Assessment of the US Intelligence Community: Hearing on Worldwide Threats Before the S. Comm. On Armed Services*, 115th Cong. (2017) (statement of Dan Coats, Dir. of Nat'l. Intelligence).
[24] *Id.*
[25] Doug Loverro, Dinner Keynote Address before the Commercial Space Transportation Advisory Committee (October 2016).

recommend to the Executive Branch that all relevant agencies and departments take every opportunity to act as customers for American satellite servicing and in-space assembly capabilities.

IV. Conclusion:

China is emerging as a strong competitor in the communications satellite manufacturing field, aggravating the already numerous challenges that domestic companies such as Maxar face. The Commission should therefore strongly recommend that Congress and the Executive Branch work together to resuscitate the Export-Import Bank as quickly as possible. Moreover, the Commission should recommend that future export controls for emerging and foundational technologies must be implemented in a manner that allows U.S. companies to lead and innovate in collaboration with NATO and major non-NATO allies. Finally, the U.S. Congress and the Executive Branch need to move with alacrity to support the development and growth of domestic satellite servicing and in-space assembly programs to enhance the resilience of America's critical orbital assets. If the Commission makes these recommendations and they are adopted by Congress and the Executive Branch, American economic and national security will both be much stronger in relation to China and the rest of the world.

OPENING STATEMENT OF KEVIN J. WOLF, J.D., PARTNER, AKIN GUMP STRAUSS HAUER & FELD

COMMISSIONER MCDEVITT: Thank you very much. Very interesting. Mr. Wolf, over to you.

MR. WOLF: Great, thank you members of the Commission for having me testify today. Opening note, although I'm a partner at Akin Gump, I'm not testifying on behalf of anyone or for or against any piece of regulation or legislation on behalf of someone.

Rather, just given my background as the author of many of these rules, and in the Commerce Department, here to answer your questions about export controls.

Just to level set for everybody, all of export controls in my entire professional life boils down to one sentence. They are the rules that govern the export, re-export, and transfer of physical items, commodities, technology, software, and in some cases services, to particular destinations, end uses, and end users to accomplish various national security and foreign policy purposes.

So that's all of export controls, and every issue flows through that one sentence. And the agencies in the U.S. government that administer that are primarily the State Department's Directorate of Defense Trade Controls, and the Commerce Department's Bureau of Industry and Security.

And there is a web of Executive Orders and regulations that require significant interagency coordination and cooperation and consensus on what is and is not controlled, and when a particular item is or isn't approved.

And thanks to a completely bipartisan bicameral effort of Congress last year, for the first time in several decades, there is a permanent statutory authority for the dual-use export control system, the Export Control Reform Act.

And in the lead up to that hearing, which I testified at HFAC, I wrote out some comments that describe the export control system in more detail, that you can refer there.

Given my time in the government, our principal accomplishment as was referred to, was the reform effort. Where we accomplished with respect to satellites and space craft working closely with Congress, the more rightsizing of controls over commercial satellite and space items.

Basically to move from sort of the one size fits all of everything requires a license everywhere all the time, no matter what, of the ITAR, which was the original rule. To tailoring it so that trade with our NATO and other close allies, about which there are not very many concerns, could be far more flexible.

The red tape that was just referred to, that got rid of. And that for countries of concern, primarily China, to maintain the complete and aggressive embargo.

So that's actually sort of the bottom line with respect to the law and policy and regulations of China and export controls in satellites is that the rules have not changed for decades. It's a complete embargo.

The rules that we adopted at the Commerce Department during our day, adopted all of the same prohibitions, all the same standards, all the same absolute rules that had existed for years at the State Department.

So for example, we adopted into our regulations at Commerce something called a zero de minimis rule. Meaning that if there's a U.S. origin component of any size, of any value, of any capability that's special for a satellite or a space craft, that thingy, whatever it is, is always

subject to U.S. jurisdiction, no matter where it is in the world, and regardless of what it's incorporated into.

Meaning that a foreign-made satellite or space component that has any U.S. origin content of any sort, will require a license from the U.S. government to transfer onto China. And that will be presumptively denied.

And but if it's with respect to a NATO or other close ally, that type of work and joint development and cooperation is to be encouraged. And is in our national security interest, and has a different set of rules to it.

Another type of very strict control that we continued forward into the Commerce regulations is with respect to how we defined export. The concept of export as you would expect, involves the movement of something across the U.S. boundary.

But with respect to satellites in particular, we wrote into our rules that the mere change in registration, control, or ownership of a satellite is per se an export if it's with respect to someone in China or a Chinese company or a Chinese national.

So even more than just the physical movement, the change of registration, ownership, or control is a controlled event. And as we wrote into our regulations, applications for such changes are presumptively denied.

In terms of the reasons why all these rules exist, I just want to adopt all the work that we did. And in particular, there's a report called the 1248 Report that the Defense Department and the State Department filed with Congress, justifying these changes.

And I just want to adopt and incorporate the reasons. Basically it boils down to the acquisition of commercial technologies for diversion for military purposes, which is why these very strict controls remain in place.

And so in terms of what my recommendations are, I don't really have that many. Because the rules and the regulations and the statutes are already as, you know, fairly aggressive.

So, my first recommendation frankly for these rules to be effective is more staff and resources to the enforcement agencies. Because if you already have an embargo, the way to make them effective is to be able to investigate and to enforce. And I describe the enforcement authorities that exist that need more bodies and time.

The sort of second recommendation I would make is that the controls that we impose with respect to parts and components for a commercial satellite are largely unilateral. That is, only the United States has these controls.

And all other -- almost all other export controls we coordinate with our NATO and other close allies so that they have the same controls in place.

But with respect to miscellaneous parts or components that are special for commercial satellites, only the U.S. imposes those. And so I would advocate, and I know the Administration is doing this, greater effort in order to get our regime allies to adopt the same controls.

And then the third recommendation I would make isn't really a recommendation. It's just connecting dots for you.

As part of the Export Control Reform Act that passed last August, there was a provision buried into Section 4812.82(f) that requires the Commerce Department to impose controls on the activity of U.S. persons to the extent that it is a service with respect to a foreign military intelligence agency.

And I know that's not strictly speaking a satellite control, but it's a type of control that would impose the government's ability to regulate assistance to a foreign intelligence agency even if all of the underlying commodities, technology, or software, are not U.S. origin or

otherwise export controlled, or in fact even if they're completely foreign origin.

I was also very quickly asked to speak about Hong Kong. At the end of my time, literally the day before I left, I signed a rule into effect that greatly expanded the scope of controls with respect to Hong Kong, as a result of concerns about diversion from Hong Kong into China.

And -- but I'm no longer there now. I no longer have access to the information about whether that has improved or gotten worse since then. And so all I can say is tell you what I had in mind at the time, which was to use this as leverage to get them to control re-exports into the PRC more effectively.

But you'd have to ask my successors as to how that is working or not. And I made it right on seven minutes. There you go.

I'll stop there and happy to answer your questions.

PREPARED STATEMENT OF KEVIN J. WOLF, J.D., PARTNER, AKIN GUMP STRAUSS HAUER & FELD

Testimony before the U.S.-China Economic and Security Review Commission
Hearing on "China in Space: A Strategic Competition?"

The Honorable Kevin J. Wolf
Former Assistant Secretary of Commerce for Export Administration (2010-2017)
Partner, Akin Gump Strauss Hauer & Feld LLP

April 25, 2019

Chairmen and members of the Commission, thank you for the opportunity to appear before you today. Although I am now a partner in the international trade group at Akin Gump Strauss Hauer & Feld LLP, the views I express today are my own. I am not advocating for or against any potential changes to legislation or regulations on behalf of another. Rather, given my background, I have been asked to testify about and to describe U.S. controls and prohibitions regarding the export and re-export of space-related items to China. My professional life has focused on the law and policy of military and dual-use export and related investment controls for more than 25 years. This includes my service as the Assistant Secretary of Commerce for Export Administration during the Obama Administration.

Export Controls and the Primary Agencies That Administer Them

To level set for everyone, and to reduce my entire career down to one sentence, export controls are the rules that govern

(i) the export, reexport, and (in-country) transfer
(ii) by U.S. and foreign persons
(iii) of commodities, technology, software, and, in some cases, services
(iv) to destinations, end users, and end uses
(v) to accomplish various national security and foreign policy objectives, including human rights objectives.

The primary U.S. government agencies that implement these controls are the State Department's Directorate of Defense Trade Controls (DDTC), which administers the International Traffic in Arms Regulations (ITAR), and the Commerce Department's Bureau of Industry and Security (BIS), which administers the Export Administration Regulations (EAR). Applicable statutes, Executive Orders, and regulations require significant interagency cooperation, primarily with the Defense Department, on what should be controlled and when approvals and denials are warranted. I described the U.S. export control system in more detail to the House Foreign Affairs Committee during its consideration of what became the Export Control Reform Act of 2018 (ECRA), the new authority for the EAR. I incorporate those comments by reference. This effort was part of a broader effort to reform and expand the jurisdictional authority of the

Committee on Foreign Investment in the United States (CFIUS), largely in response to national security concerns pertaining to investments in the United States from China.

The Export Control Reform Effort

As you may know, the Obama Administration largely completed a substantial (and non-partisan) reform of the U.S. export control system, including with respect to the laws and regulations governing space-related items. A key element of the effort involved transferring the jurisdictional control of less-sensitive military items and commercial and dual-use space-related items from the "one size fits all" controls of the ITAR to the EAR, which allow for more tailored controls depending upon the item's sensitivity and ultimate destination. From all indications, these reforms successfully accomplished their national security, foreign policy, and economic security objectives. The Trump Administration has kept the rules in effect and, to its credit, is moving forward with planned updates to account for new technologies and issues, particularly with respect to commercial space-related items. In addition, Congress essentially ratified and codified core elements and policies of the Export Control Reform effort when it passed ECRA last August.

China-Specific Controls in the Export Control Laws and Regulations

With respect to China, the export control prohibitions and presumptions of denial pertaining to military, dual-use, and commercial space-related commodities, software, technology, and services have remained unchanged for decades. There is effectively a complete embargo. For example, as the Commerce Department reported to Congress in response to a requirement imposed by section 1263(a) of the FY13 NDAA, we adopted into the EAR during the reform effort the same presumptive denial licensing policies the State Department had and still has on exports of space-related items under its jurisdiction. In addition, with respect to military- and space-related items, we also adopted into the EAR a zero *de minimis* rule identical to that of the ITAR. This means, for example, that the export to China and other countries subject to arms embargoes from outside the United States of a foreign-made satellite or any other military or space-related item containing any specially designed U.S.-origin component is prohibited by U.S. law unless a license is granted, which will be presumptively denied.

We also carried forward into the EAR a China-specific aspect of the ITAR's novel definition of "export" and "reexport" with respect to spacecraft. The traditional definition of "export" is that there must be an actual shipment or transmission out of the United States of a commodity, software, or technology. A reexport is such a shipment or transmission, but from one third country to another. The definition in the EAR is, however, broader for any type of spacecraft subject to the EAR in that even transferring *the registration, control, or ownership* of a spacecraft subject to the EAR to a person in, or a national of, China or other countries subject to an arms embargo constitutes a controlled export or reexport. 15 C.F.R. §§ 734.13(a)(3)(ii) and 734.14(a)(3)(ii).

Such changes in combination with the creation of conditional license exceptions for close allies were a reflection of one of the motives behind the Obama Administration's reform of the commercial space-related and less sensitive military controls – i.e., to allow for more resources to be devoted to administering and enforcing the prohibitions on the export and reexport of military and space-related items to China and other countries of concern rather than reviewing and rubber-stamping applications for exports and reexports of commercial and less-sensitive military items to NATO and other close allies. Given other controls in place and the nature of the countries, there was a low risk such items would be diverted for inappropriate end uses or end users. Moreover, it was and remains in our national security interests to reduce barriers to military interoperability with our NATO and other close allies. It also was and remains in our national and economic security interest to enhance the U.S. space industrial base by reducing incentives for companies in allied countries to design out or avoid U.S.-origin content or services for end uses and end users not involving countries of concern.

My views on why the China-specific export controls were and remain required are the same as those described in Appendix 4 to the report the departments of State and Defense submitted to Congress pursuant to section 1248 of the FY10 NDAA. Regardless of my personal views, the China-specific export control prohibitions and presumptions of denials are statutory. In particular, section 1261(c)(1) of the FY13 NDAA states that, except for waivers that are issued by the President, "no satellites or related items that are made subject to [the EAR pursuant to the law] may be exported, re-exported, or transferred, directly or indirectly, to [China, North Korea, or a country that is a state sponsor of terrorism] or any entity or person in or acting for or on behalf of such government, entity or person. . . ." Section 1261(d) states that "[a]ny license or other authorization to export satellites and related items to a country with respect to which the United States maintains a comprehensive arms embargo [such as China] shall be subject to a presumption of denial." These prohibitions reinforce those Congress imposed in Title IX of the Foreign Relations Authorization Act for FY90 and FY91 in response to the Chinese government's 1989 crackdown against pro-democracy protesters in and around Tiananmen Square. They also carry forward those imposed in Title XV, Subtitle B of the NDAA for FY99.

The licensing policies I signed into the EAR with respect to satellite and other space-related items track these statutory standards. *See, e.g.,* 15 C.F.R. §§ 742.4(b)(iii) ("When destined to the People's Republic of China or a country [subject to embargo] of the EAR, items classified under any 9x515 ECCN [i.e., space-related commodities, software, and technologies] **will be subject to a policy of denial**") and 742.6(b)(1)(i) ("When destined to the People's Republic of China or a country [subject to embargo], items classified under any 9x515 ECCN **will be subject to a policy of denial**").

Recommendation 1 – More Resources for the Export Control Agencies

Given that the statutory and regulatory China-specific export controls pertaining to space-related items are quite robust and restrictive, I do not have any suggestions for changes to the laws or regulations. Statutory prohibitions are statutory prohibitions and

I have not heard of anyone in industry or government argue that their relaxation would be in the national security interests of the United States. The key to their effectiveness is essentially a matter of enforcement and training resources, and will of the political leadership. Thus, my first recommendation is that Congress and the Administration should devote substantially more resources and personnel to the export control agencies, namely the Bureau of Industry and Security (BIS), the Defense Technology Security Administration (DTSA), the Bureau of International Security and Nonproliferation (ISN), the Directorate of Defense Trade Controls (DDTC), and the National Nuclear Security Administration (NNSA). (Eventually, the export control agencies should be combined into a single licensing agency and the rules should be combined into a single set of export control regulations with one list of controlled items, but that is a subject for another day.) The issues and technologies are more complex than ever and the need for multilateral cooperation, which is time intensive, continues to remain extremely important to the controls' effectiveness. My personal view, that I can describe in more detail separately, is that each agency is understaffed when compared to its mission. Among other things, this leads to increased burdens and delays for industry, reduced time needed for internal training, and the inability to keep the regulations current. Failure to keep the regulations current to novel threats does not advance our national security interests and harms our economic security. A renewed attention to supporting these organizations should include efforts to educate the next generation of export control professionals and to motivate them to join the federal government. Decades of wisdom and collective memory will walk out the door when current senior career staff retire or otherwise leave the government.

Similarly, I would encourage more resources be devoted to export-control-focused enforcement, particularly by the subject matter experts and special agents at BIS's Office of Export Enforcement (OEE). This will not only advance the national security and foreign policy objectives of the controls, but also help keep the playing field level for those companies that do the hard work necessary to comply with the regulations. In addition, there should be more resources dedicated to enhanced DDTC/BIS compliance coordination. This would help with investigations involving items subject to both the ITAR and the EAR.

Recommendation 2 – Continue Working with the Allies to Make Unilateral Space-Related Controls Multilateral

The second recommendation I would make is that the Administration should commit to continue working with our export control regime allies to make the remaining unilateral controls over space-related items multilateral, particularly those in US Munitions List Category XV and Export Control Classification Numbers (ECCNs) 9x515. Most of the items exported in this category, i.e., basic parts and components specially designed for commercial satellites and other space items (ECCN 9A515.x), are not controlled by any of our allies. That is, our allies do not require licenses to export from their countries to China and other countries most commercial space-related parts and components, but the U.S. does. I realize this is a heavy lift because different countries have different views about the issue, but explaining, with evidence, why such common controls would

be in our common national security interest will be key to the effort's success. This is important because the history of space-related export controls is the prime example of the general point that unilaterally controlling widely available dual-use items ends up harming the very industry and items to be protected because it motivates development and production to be done outside the United States. This result eventually leads to less control over the proliferation of the items of concern to the countries of concern, such as China. Congress reflected the lessons learned from this and similar experiences when it wrote into ECRA sections 4811(5) and (6) that multilateral controls are far more effective than unilateral controls and that unilateral controls are discouraged. In addition, ECRA section 4812(b)(3) requires the Administration to work to make its controls multilateral, to the extent possible.

Recommendation 3 – Implement in EAR Section 744.6 ECRA Section 4812(a)(2)(F)

My third recommendation is not *per se* related to China or space-related items, but would address issues that have been expressed in the lead-up to this hearing with respect to whether there are gaps that should be addressed. Specifically, ECRA section 4812(a)(2)(F) requires the President to "control the activities of United States persons, wherever located, relating to specific . . . foreign military intelligence services." Thus, this is not really a personal recommendation given that it is a statutory requirement. I am only connecting the dots for this committee between an obscure statutory subparagraph and a current issue.

As referenced in that ECRA paragraph and as implemented in EAR section 744.6, the EAR already control a range of *services* performed by U.S. persons if with respect to missiles, nuclear explosive devices, or chemical/biological weapons – regardless of whether the commodities, software, or technology involved in the service are subject to the jurisdiction of the EAR. This is a novel control in the EAR because their jurisdiction normally attaches when there is a commodity, technology, or software subject to the EAR, which includes all U.S.-origin items and some types of foreign-origin items with U.S.-origin content or that are the direct product of U.S.-origin technology. Congress added this requirement to close a gap between the ITAR's controls on defense services and services that do not involve defense articles but still warrant control for national security reasons. BIS has not yet implemented this control. It is one that I wanted to implement when I was the Assistant Secretary, but we were unable to develop a clear and enforceable definition of "foreign intelligence service" that would not have unnecessary collateral consequences. Once this and related issues are worked out, the EAR would prohibit, for example, a U.S. person from providing assistance to a Chinese military intelligence agency with respect to the operation of a commercial satellite even if there were no transfers of controlled commodities, software, or technology involved.

Hong Kong

The United States-Hong Kong Policy Act of 1992 effectively requires the U.S. government to treat Hong Kong and mainland China as two separate destinations for export control purposes. In addition, section 103(8) of the Act states that the "United

States should continue to support access by Hong Kong to sensitive technologies controlled under [the then existing multilateral export control regime that is the predecessor to the Wassenaar Arrangement] for so long as the United States is satisfied that such technologies are protected from improper use or export." Because the United States has not made a determination to the contrary, the statutory and regulatory prohibitions pertaining to the export and reexport of space-related (and other controlled) items subject to U.S. jurisdiction that are applicable to mainland China do not apply if the destination is Hong Kong. The export control regulations, however, still require licenses to export and reexport space-related items to Hong Kong. Applications for such exports and reexports are reviewed by U.S. government export control authorities to determine, for example, whether Hong Kong is indeed the ultimate destination and whether the export or reexport otherwise presents any national security or foreign policy concerns.

I was asked to comment on whether items, particularly space-related items, subject to U.S. export controls are being illegally exported out of Hong Kong to China or other countries of concern. I left the government on January 20, 2017 and thus no longer have access to such information, whether positive or negative. I can, however, say that on January 19, 2017, a rule that I signed expressing concerns about the issue remains in effect. The rule imposes additional support document requirements on exports and reexports to Hong Kong. In essence, the rule leveraged the EAR to effectively compel compliance with Hong Kong export and import permit requirements by requiring proof of compliance with Hong Kong law as a support document necessary for shipping under an EAR license or license exception. As stated in the preamble, BIS took "this action to provide greater assurance that U.S.-origin items that are subject to multilateral control regimes . . . will be properly authorized by the United States to the final destination [such as Mainland China], even when those items first pass through Hong Kong." My thought at the time was that if Hong Kong officials could provide regular, robust assurances that diversions of U.S.-origin items were not occurring, then the additional requirements would remain in effect as is or be removed. If not, then the stricter licensing policies, including policies of presumptive denials, would need to be imposed. I would encourage you to ask this question of current BIS officials.

Impact of China-Specific Export Controls on International Collaboration in Space-Related Development and Production Efforts

I was also asked to comment on how foreign space companies and institutions adapt to China-specific U.S. export controls pertaining to space-related items and whether they are adequate to prevent China from acquiring sensitive space technologies through collaboration. Unlike the previous topic, this is something I have current knowledge about given that I am an attorney who advises companies and others on how to comply with the export control rules. In short, the answer is binary – if they are working with Chinese nationals or China, or plan to export their products to China, then they exclude from the effort controlled space-related commodities, software, and technology subject to U.S. jurisdiction. If not, then they generally don't.

As discussed above, the law and the regulations are as strict as they can reasonably get. In addition, U.S. export control rules are, unlike those of most other countries, extraterritorial, meaning that they apply outside the United States. Thus, the answer to the question about how to prevent China from illegally acquiring sensitive space technologies subject to U.S. jurisdiction during collaborative efforts is (i) well-funded enforcement efforts in and outside the United States, (ii) regular efforts to get our allies to cooperate with such efforts and controls, and (iii) massive amounts of well-funded outreach and training efforts for institutions, large and small, in the U.S. and abroad so that they know the rules and know that if they do not create robust compliance programs to avoid violations they run the serious risk of significant and adverse enforcement actions by the U.S. government. This last point is particularly important. It is impossible for any government to monitor every exchange of a controlled item. Thus, those on the front lines, the companies, institutions, and people in and out of the United States working with the controlled items, need to do the hard work to prevent illegal releases through well-resourced, thoughtful compliance programs with management commitment, whether out of patriotism or out of fear of being subject to significant enforcement actions if they do not.

Conclusion

Thank you again for asking me to testify on the law and policy pertaining to China-specific U.S. export controls over space-related items. I am happy to answer your questions on the subject.

PANEL II QUESTION AND ANSWER

COMMISSIONER MCDEVITT: Well, thank all -- thank you to all three of you for very enlightening commentary.

I'll -- I have a couple of questions to start. And then I'm sure my fellow Commissioners will also have some.

Mr. Wolf, you -- since you mentioned Hong Kong, and we earlier in the day there was quite a lot of commentary about the Wall Street Journal article from yesterday about the use of the satellites that were purchased by Hong Kong entities.

So, this is a pretty straightforward question that I -- that perhaps all three of you would take a whack at. Is, should the same rules that we apply to China be applied to Hong Kong with regard to space, satellite, or any other space entity?

Mr. Gold, I have a specific question for you. Is -- I wasn't entirely clear when you talked about the geosatellite business drying up, is that because of technology? Or because of China?

It -- those are -- that's and all three of you can chime in on that too, if you feel compelled. Thank you.

MR. WOLF: So, with respect to the same rules, there's a statute, the Hong Kong -- or the U.S./Hong Kong Policy Act of 1992 that requires for export control and trade and many other purposes the U.S. government to treat Hong Kong differently.

So there would be a statutory issue you'd have to deal with. All I can say is, again, this is -- I no longer have access to that information. And so my information is two and a half years out of date.

But at the time, I was concerned about the topic. And that's why I imposed these extra controls.

And basically, my plan at the time was to give Hong Kong maybe another year or two to get the act straight so that we would have confidence in that items largely, microelectronics that were going into Hong Kong, were being regulated properly and not being diverted.

Whether they have or haven't followed through on what they said to me two and a half years ago, in warranting a change or not to Hong Kong, I thus have no idea. Because I no longer have access.

I would encourage you to ask the same question of my successors who could give you a much better answer since I'm a little bit out of date.

MR. GOLD: So, it's an excellent question. China is not responsible for the down turn in the market.

What's occurring is that there's a lot of excitement about a technological progression to LEO Commercial Satellites, and particularly constellations of LEO Satellites.

And that's caused delays among potential geosatellite operators to purchase new geosatellites. Which has been primarily what's occurred.

I do believe, frankly, that the pendulum is going to swing back with geo. And maybe it's not 20 satellites per year again, but it could be closer to 10 or 12.

Because I always fear these false dichotomies. That ultimately there are going to be things that LEO Constellations are great at. And things that geotelecom is good at. And I think that we're going to see both continue in a robust nature in the future.

However, where China does come to play, is China, as you've heard throughout the day, is great at long term planning.

And when they see a downturn in a market like geotelecom, they take advantage of it.

And say, well, if you know, America or other countries are going to be weak, now is our time to jump.

And that's exactly what they're doing to try to capture market share while U.S. and other companies may be retreating, particularly because we don't have the Export Import Bank.

And the way I would respond to this question is, if we don't get EXIM back into action, this whole issue is going to be moot. Because it's going to be the U.S. that's buying the bandwidth from China versus vice versa.

And we've seen that in market after market. Trust me when I tell you, they're not having the debate in Beijing right now about whether they should use export credit agencies.

China and the rest of the world have already gone on to say, what more can we do beyond traditional financing in terms of sovereign wealth funds, or you know, getting our private sector and merging it with government to have targeted areas.

And here in America, we're still arguing about EXIM. Now, there has been good news. The Senate Banking Committee is moving forward. But again, I implore you, we need to take action on this issue, both from an economic and a national security perspective.

COMMISSIONER MCDEVITT: Mr. Laskai, do you want to chime in on any of these?

MR. LASKAI: Yes. I will chime in on the first question. And I don't have a -- I don't have a strong view of whether we should reconsider the views -- the rules towards Hong Kong.

But I will say that as state money has entered the VC space, and there's more funds investing abroad to -- for M&A purposes, Hong Kong has been sort of an exit way for state owned money, especially in the semiconductor space.

There's plenty of good reporting that shows that various holding companies based in Hong Kong have been used to as sort of snatch up valuable sensitive semiconductor equipment across the world.

So, I do think it's worth studying whether the rules should change to Hong Kong, or whether there are better mechanisms to that source of the money that companies are doing -- or are buying things abroad.

COMMISSIONER MCDEVITT: Okay. And looking at my list of, let me start with Commissioner Wessel.

COMMISSIONER WESSEL: Thank you all for being here. Mr. Gold, you gave an impassioned plea for the EXIM Bank.

There are clearly a lot of other issues that go into the reauthorization regarding content and a lot of other things. But, your points are -- you've made some effective points.

Mr. Laskai, let me ask you a question. And you talked about the state owned capital potentially being the tripwire. And started with a discussion of mil-civ fusion. It's a great term.

Isn't it what China has always done? I mean, you know, this Commission has over many years talked about the fuzzy line to the extent there's any line between state and so-called private sector.

It now seems that we're trying to put a sexy term on it. When in fact, it's what they've been doing all along.

Companies maybe shifting a bit back and forth over the line. But in effect, China will use whatever commercial advantages it can for its national security, because they view their national security as their economic security as well.

Can you, you know, why are we applying a new term when, you know, again, I think they've been doing it all along?

MR. LASKAI: And I think to a certain extent you're right. Like I don't think things have

-- I will leave it open to question where things have qualitatively changed.

I do think what military-civil fusion today denotes is something that is a progression from what the Chinese government has tried to do in the past.

So I think in the past the way of doing this was as follows: you have a big SOE maybe in the defense sector. This, you know, someone high up says we need more commercial competition, and the SOE says, sure, we'll create a subsidiary that will be commercially oriented.

And then the subsidiary will do what the commercial sector is supposed to do. So, basically, you know, all this stays in the defense sector. And there's really not a cross-pollination of talent in all these other things.

What I think they're increasingly doing, and I think that the Central Party is increasingly confident in its ability to use markets to move, you know, work towards strategic goals.

And I do think in the military space in particular, there is this sense that they need to bring other -- they need to bring the commercial economy into the fold.

You know, there are a lot of high tech talent and capital that are doing various things. And some of it useful to the Chinese government, some of it not.

And I think there is a sort of discontent that the private sector is not always doing what it's -- the government would like it to invest in.

So, you know, rather than invest in hard technology so to speak, like the private sector will be investing in the latest app, or some sort of commercial software application.

So, I think there is -- when we talk about military-civil fusion in the contemporary context, I think what we're say -- what we're denoting is this renewed push by the Central Party to create these links.

And to do it in a serious fashion that in some ways resembles the United States. Because we do have these public partner and private -- public partner -- public/private partnerships, excuse me.

COMMISSIONER WESSEL: P3s, yeah.

MR. LASKAI: But --

MR. GOLD: We just call them PPPs.

COMMISSIONER WESSEL: P3s we call them. Yeah.

MR. LASKAI: But I mean, I think arguably military-civil fusion steps far beyond that by basically, you know, fusing together.

COMMISSIONER WESSEL: So, in that -- in that sense what I'm hearing from you is that the mil-civ fusion is actually a way of grabbing more commercial, so-called commercial assets and looking for ways to apply them to strengthening China's military capabilities.

Is that?

MR. LASKAI: Yeah, absolutely.

COMMISSIONER WESSEL: Okay. Mr. Wolf, help me if you can on the issue relating to surveillance technologies.

MR. WOLF: Mm-hmm.

COMMISSIONER WESSEL: And you know, as people know -- as you well know, we've seen a dramatic increase in China's surveillance, the Uighurs, other populations, et cetera.

And certainly satellite technology is a big part of that, those surveillance activities. How does that fall in the continuum of the Export Control Act?

You know, there are a lot of questions about whether U.S. technologies are being used to enhance China's surveillance capabilities. Ground based is, you know, all through the stream.

Where does that fall within the legal context as well as the enforcement context?

MR. WOLF: Sure. To the extent that the issue pertains to physical hardware that's specific to a surveillance, there are controls on physical items in technology for its production or development.

COMMISSIONER WESSEL: But, I'm sorry, but is it surveil -- is the target of the surveillance what triggers it? Or is it the surveillance itself?

MR. WOLF: It could be either. So the way to think -- remember what I said at the beginning, physical items, destinations, --

COMMISSIONER WESSEL: Right.

MR. WOLF: End uses, end users. To answer your question, you have to break it up. And the Export Administration Regulations have the ability to address each of those.

So for example, on the physical satellites or the technology related to build it, strict embargo on the production or development related thereto.

If there's a particular end user, an entity, either government or private that's engaged in bad acts along the lines of a national security, or a foreign policy, or a human rights concern, in the Export Administration Regulations there is the authority to prohibit all exports of any sort, whether it's toothbrushes or satellites to a particular entity.

And there's a list of about a thousand entities, of which there is a complete embargo. And the threshold for listing the names is if there's any national security or foreign policy reason to do so.

It's a very open standard.

COMMISSIONER WESSEL: And does that include the People's Armed Police? So domestic crowd control, et cetera. Do you know whether that is?

MR. WOLF: It can. I mean, the authority -- it's up to the will of those in charge based upon a specific issue in order to identify an entity.

There's complete discretion to name a private company or a government entity on this list. And so it's up to the will of those in charge.

And then there are also end use controls. And that is, regardless of the underlying technology, let's say it's widely available commercial technology. Regardless of whether it's U.S. or foreign origin, there are -- there's the ability to prohibit activities by U.S. persons with respect to military or surveillance or, as I described, in the Export Control Reform Act, there's now a statutory requirement to regulate if an assistance by a U.S. person would be with respect to a foreign military intelligence agency.

And so first you have to identify the problem. And then the Export Administration Regulations have a lot of different tools to address is.

There's no mandatory requirement. It's up to the will of whoever is in charge to impose a regulation to address the problem.

COMMISSIONER WESSEL: So if Google Earth is monitoring Uighurs on a U.S. owned and operated satellite, but providing the data flow to a Chinese end user, let's say it's the People's Armed Police, that's a discretionary restriction for the U.S. government. Is that right?

MR. WOLF: Yes. That fact pattern didn't present an existing control.

COMMISSIONER WESSEL: Right. Right.

MR. WOLF: Because U.S. technology for production or development, there wasn't a transfer of a satellite to gain ownership or control.

COMMISSIONER WESSEL: Right. Right.

MR. WOLF: So there was no trigger there. But, for -- and I don't know anything about this particular case, but --

COMMISSIONER WESSEL: It's a hypothetical.

MR. WOLF: Yeah, so --

COMMISSIONER WESSEL: A hypothetical submerged with Google Earth. Sorry.

MR. WOLF: The authority -- right, the authority exists for the Commerce Department is not a punishment, but rather to affect the national security or foreign policy will of the U.S. government to basically cut off that entity from U.S. trade.

Which creates a significant financial impact on the company, thus leverage over the company to get it to change its behavior. And this is a tool we use quite a bit.

I was the one who implemented the change on ZTE, the listing of ZTE to get them to change their behavior back in 2016. And did so eight hundred or so other times.

And basically when you cut off a company or an entity from the U.S. economy that normally is a significant bit of leverage you have to get them to change whatever bad act they're doing.

And it's broadly defined and open ended and up to the will of whoever is in charge.

COMMISSIONER WESSEL: Thank you for what you did on ZTE. I just wish it had been carried all the way through. But that's --

MR. WOLF: Different type -- separate hearing.

COMMISSIONER WESSEL: Thank you.

COMMISSIONER MCDEVITT: All right, Commissioner Lewis?

COMMISSIONER LEWIS: The Wall Street Journal article yesterday said U.S. law effectively prohibits American companies from exporting satellites to China. But domestic technol -- where domestic technology lags behind American.

But the U.S. doesn't regulate how a satellite bandwidth is used once the device is in space. That has allowed China to essentially rent the capacity of U.S. built satellites.

That's number one. Number two, Boeing is in the process now of building a satellite for a Hong Kong Company. And the Hong Kong company's chairman says while he has great affinity for the United States, he's also a Chinese patriot.

It seems to me that in both of those cases, China is using a loophole to get around export controls. And I guess the question is, does this help the Chinese military or in policing the Uighurs?

And do we need new laws relating to exports to Hong Kong and to companies that rent? If China is in space for peaceful purposes, why do they need to have counterspace programs?

So that's my question to all of you. Do we need new laws or more enforcement to the existing laws? And should we change the role that Hong Kong has?

COMMISSIONER MCDEVITT: Why don't we just start and move on down the table.

MR. LASKAI: I don't have a take on the renting satellite component. I think it's -- the Wall Street Journal article was a little fuzzy on what exactly, where exactly the satellite was being used.

On terms of building a satellite for the Hong Kong company, what I will say is I think what that founder when he was speaking about being a Chinese patriot was actually responding to, is that there is a commercial market in China for him to sort of use this satellite for.

And this is basically I think how military-civil fusion sort of works in practice. Which is like, there's a commercial incentive for him to really lease out his satellite to the BeiDou navigation system constellation, or for some commercial application.

So, yeah, potentially there is a real question to be had. Whether it's okay for an entity to buy up an American satellite, use it for something that's achieving strategic goals of the Chinese

state, even if there's a commercial incentive to do that.

I will leave it to others to say what type of regulation should be in place.

COMMISSIONER LEWIS: Well, can you answer the other part? If China is in space for peaceful purposes, why do they need to build counterspace policies?

MR. LASKAI: I mean, I think that ultimately they do it because of the asymmetrical advantage it gives them in a potential military conflict.

As China potentially relies more and more on space-based communications and other applications, perhaps that will change. But I think for the moment, they are sort of hedging their bets so to speak.

MR. GOLD: So, relative to the Wall Street Journal article, I think the reporter did an excellent job. I had hours and hours of conversations with him, so I'll buy a second subscription.

They were very open. And I think very good.

COMMISSIONER LEWIS: With her. She was a female writer.

MR. GOLD: Kate and Brian Spegele did a great job, so. I think that what was presented though in the article, it's a policy decision that our lawmakers need to look at what they're getting from intelligence, what you're getting from the Department of State.

And then it's a balance. You know, does U.S. industry, over here you have the benefits of jobs, innovation, et cetera. And then over here you have the concerns about human rights, supporting military.

And then a decision has to be made. You know, what I particularly liked about the article is they're not putting that on the doorstep of the private sector.

You know, we don't have an intelligence community. We don't have a Department of State, so we have to depend upon the experts in government to make that decision.

And that's where I think these two issues come to play. And not just for satellites, but you know, I think one of our other big exports is soybeans and aviation.

You know, are we feeding the soybeans to the PLA? Or what are the planes being used for? You know, these are the balancing that has to be done to decide.

My concern though, is that we're not going to export control ourselves to beat China. That I hear a lot of conversation about controls and preventing them.

We're looking backwards. We need to look forwards of a world of technological parity or even potentially superiority by the Chinese.

And that's why my testimony is focused on, what can we do to make sure that we've still got that technical advantage? Because I can tell you, controls are not going to be nearly enough.

And I've harped on the Export Import Bank, but as you talk about counterspace, right, you know, we have satellite servicing systems that I mentioned that can refuel or repair a satellite after it had been attacked.

But here in the U.S., we have debates. We have debates about Export Import Banks. We have debates about whether we should be funding these things.

If we're not aggressive about pushing forward and funding these initiatives, largely via the PPPs that we talked about, public/private partnerships. Again, we will be on the outside looking in.

Too often America holds on, and Export Import is a great example of this, this ideology of pure capitalism so we can't influence things one way or the other. Can't get the government involved.

Well, China's not looking at it that way. Frankly, Europe's not looking at it that way. And if we can't figure out this fusion that we mentioned, because I don't think there is a

difference between civil and military anymore.

You know, Doug Loverro, who was the former Deputy Assistant Secretary of Defense for space policy said China will outspend us in space. Our only hope is that we can out-entrepreneur them.

COMMISSIONER LEWIS: Is Commerce Department the right place to issue licenses?

MR. GOLD: I think Commerce can do a good job for the licenses. Now, are you asking -- the question would be for China or for everyone else, right?

SENATOR TALENT: Keep in mind you are sitting next to a former Assistant Deputy Secretary.

MR. GOLD: Yes. Yes. Who did a very good job on behalf of the industry, by the way.

SENATOR TALENT: Wonderful job.

MR. GOLD: So, I need to be kind. I think Commerce probably is the right place for now.

I think however, this is a dynamic situation. Right? You know, the relationships are changing or evolving.

I think Commerce has done an excellent job in the past. Will do so in the future. And as we almost referenced, both Commerce and State have moved forward with ANPRMs, advance notice of proposed rulemakings for export control reform.

Both in terms of what can we do to create these lower barriers around a wider area, as well as emerging technologies, what do we need to do to create a higher barrier?

And I think the ultimate compromise with export control reform is that when we look at China, we have that higher barrier. But don't do surgery with a chainsaw, do it with a scalpel.

Make sure that we don't hurt ourselves in the process by making it impossible for a company like mine to have a collaboration with Canada or the UK. Because I'll tell you, that's what I've seen from Capitol Hill time and time again, that were far too broad.

And again, in terms of the government backing the American private sector, we're sending us out there, we're going to a gun fight with a knife. And then we're stabbing ourselves with the knife before we even go into that fight.

So, we need to rethink the whole relationship, frankly, between how the government supports the private sector. Because if we can't get that fusion right, China and the rest of the world are going to leave us in the dust.

MR. WOLF: To answer your question directly, the article was correct. The leasing of bandwidth, of technology outside the U.S. that's not U.S. origin, that's not for the development or production of items, et cetera, is not an export controlled event.

Never has been under the State Department, the Commerce Department, any other laws previously. And but I would say it's not really the bandwidth that's the issue.

The movement of information across a satellite per se is not a threat. It's not a problem. In fact it's to be encouraged in many circumstances.

I go back to my earlier point, it's how somebody is doing it. Or what's being done with it. Whether it's a satellite or a telephone or a commercial vehicle.

If somebody is using a cell phone router or a tower in order to engage in the Uighur activities that were described earlier, then those other authorities that are agnostic as to the technology, again, whether it's a satellite or a terrestrial application of any sort, the rules allow the government to go after and impose significant pain on those who are engaged in the bad acts by whatever means.

And that would be my suggestion for how to address concerns regarding suppression of

minorities or use of internal police agencies for suppression of minority groups, et cetera. Which I know is a serious issue.

As opposed to trying to focus on a particular issue involving bandwidth, which one minute may be certain information, and another minute may be Sesame Street. So, it's, you know, focus.

With respect to Hong Kong as such, you know, the way the export control system is set up, in light of the statutory requirements, it's treated separately. But it doesn't mean licenses aren't required.

Every export of a controlled item, which is a very long list of dual use and military technologies, requires review by the Commerce Department, the Defense Department, the State Department, and the Energy Department. And it's not just Commerce, really.

It's not just a commercial equity. It's really by bureau, the Bureau of Industry Reform Bureau, the Bureau of Industry and Security is a national security bureau nestled within the Commerce Department.

So it's a very different mission then trade promotion. It's the opposite of trade promotion in fact.

I was always very unpopular at staff meetings when -- anyway, different topic. The -- and so any of the activities that you described in terms of a movement to a satellite -- of a satellite to Hong Kong or change of registration or ownership by somebody in Hong Kong or even a Hong Kong National outside of Hong Kong would require permission of those four agencies.

And we would review the intelligence that we had regarding the parties, whether they're trustworthy, what the stated end use is. And often there will be conditions.

You may use this satellite for purpose X and Y. And so long as they do it for that good purpose X and Y, then it's to be encouraged. Why otherwise give this work to non-U.S. companies?

But, if they go outside of those conditions, then there are civil and criminal penalties that attach for violating the conditions.

COMMISSIONER LEWIS: Does that mean we have to monitor how it's being used?

MR. WOLF: So, monitor the satellite? Well, it depends upon what the issues are. You can impose obligations on the parties involved to monitor and report. And regularly receive visits from the U.S. government. And we have authorities to do that outside of the United States now.

But, it can't require the U.S. government to monitor every transaction, every technology transfer at every second. I mean, that's physically impossible for any government.

And so what happens, the way the whole system has been built since Thomas Jefferson first created it, was under the -- I was joking about that.

But anyway, there's very little export control humor. So you have to go with me. The -- it's frankly with the very aggressive enforcement and the civil and criminal penalties that I referred to earlier, which scares the crap out of companies to want to do the hard work necessary to comply.

Because if they don't, they get cut off from trade with the U.S. They get cut off from the ability to export. They have civil and up to ten years in jail of criminal penalties.

And so that was going back to my point earlier on. The laws are about as aggressive as they can get. The discretion that exists within the regulations is about as broad as you can already get.

It's all about people. It's all about manpower. It's all about money for enforcement agents to do the hard work to investigate and prosecute.

So, you know, I think the regs are -- give all the discretion. Everything thereafter is political will, money, and manpower.

COMMISSIONER LEWIS: Somebody earlier today said we need more money, we need more resources for the regulators. Do you agree with that?

MR. WOLF: Absolutely. And I can really say that now that I'm no longer at the Commerce Department.

You know, the beauty of the -- and I love these people dearly. But they're severely unstaffed with the mission that's given to them. Particularly now that they're being distracted by so many other policy topics rather than focusing on export controls.

And Commerce has this wonderful set up where they have 129 special agents, which are experts at export controls, but they're also agents. They're investigators with badges and guns and investigative authority, and the power to arrest.

And they focus just on export control issues, given the sensitivity. No other country has this. No other part of the U.S. government has this. The State Department doesn't have this.

And, you know, given that the rules are already so aggressive and given that the other rules are already so flexible, the only way in which they're going to have their national security or foreign policy effect, is for that group to be supported with money and time.

And why would someone from industry advocate this? And the reason is, industry actually should advocate this as well because it keeps the playing field level for all the companies that do the hard work, that spend the money to comply with the regulations, and they should be on the same playing field with those that don't.

And so I know it seems counterintuitive, but it's actually not. Industry should be advocating what I just set forth as well.

MR. GOLD: And if I could say a word on that topic. Industry is. And I chair the Export Control Committee for the Commercial Space Flight Federation. And one of our top points was ensuring that proper resources were available for Commerce, for State, for DTSA, et cetera.

But we got a very interesting response when we made that proposal, by the way. It isn't just the dollar issue. It's a hiring issue.

MR. WOLF: Absolutely.

MR. GOLD: So, we had a bunch of the State and Commerce people around us. We were having a discussion last week at Commerce, doing a joint event.

And they introduced us to someone new from DTSA, the Defense Technology Security Administration. They're like, we hired him on an expedited basis. It only took six months.

MR. WOLF: And that's fast.

MR. GOLD: That's fast. Exactly.

MR. WOLF: And that's very quick, yeah.

MR. GOLD: So, you can throw money at the issue. But if it takes years to hire, money isn't the only part of the solution.

There needs to be reforms relative to hiring, relative to merit. Like look, you know, Kevin left service. We weren't paying him enough there, you know.

That too will happen. But, even firing, you know, more freedom. We were talking about 2024 with NASA. You may have heard that we're going to try to go back to the moon by then.

If we can't get the government to be more flexible in terms of hiring and firing, and pay, we're not going to be able to achieve any of the goals that we set out as a country.

COMMISSIONER LEWIS: Thank you for your advice. Thank you.

COMMISSIONER WESSEL: Just a quick follow up, Mr. Wolf, as it relates to end use reviews. China is a major problem.

I mean, we can't get to the places often that we want to do the end user reviews, correct?

MR. WOLF: Absolutely. And there's a -- in fact just last week the Commerce Department added 37 Chinese companies to a list called the unverified list.

COMMISSIONER WESSEL: Right.

MR. WOLF: Which is a role that I largely created when I was there. Which worked -- which basically says, if we're unable to visit you, and if the Chinese government won't allow us to visit you, then we're going to impose a lot more burdens on you.

And then the entity list rule, and there are other rules, et cetera. So, we have staff in China that conduct onsite investigations.

But to the extent that the government or the companies are not cooperative, then the authority exists in this administration, and previous administrations have used it, to cut off those companies who fail to cooperate.

COMMISSIONER WESSEL: And they are often take six weeks to get into a place so they can clean up their activities. They have to get governmental approval, and I assume they're not bringing their own U.S.-based weapons into those facilities?

MR. WOLF: Well, that's for a physical visual inspection. There are other ways to know what's going on inside a company.

COMMISSIONER WESSEL: No, no. I understand.

MR. WOLF: Yeah.

COMMISSIONER WESSEL: I understand. Yep. Thank you.

COMMISSIONER MCDEVITT: Let me turn now to Commissioner Bartholomew.

CHAIRMAN BARTHOLOMEW: Thank you. Thank you to all of our witnesses. Very interesting.

There are so many challenges. Both Mr. Laskai, how do we pronounce your -- Laskai?

MR. LASKAI: Yes. It's Laskai.

CHAIRMAN BARTHOLOMEW: Laskai, and Mr. Gold, I sort of thank you both for pointing out, this is a -- this pattern that we see of the building of a national champion in China to the detriment of U.S. companies, some of us have been pointing that out for several decades now.

And it's very frustrating to see again, Mr. Gold, you talk about the need for us to confront some things. You know, we have been, some of us have been trying to talk about the fact that China has an industrial policy.

And in this country when you mention industrial policy, people have an allergic reaction. So, it is -- but, you know, I mean, this is the cost that we pay for all of this.

A couple of different questions. One is, for all of you, what are the consequences for the U.S. if we lose our U.S. commercial space industry?

What are the implications of us losing the commercial space industry? But before I get you to answer that, Mr. Gold, I have a specific question for you.

You guys manufacture satellites. Are the components that you use in the manufacturing of those satellites made here in the United States?

MR. GOLD: A great deal of them are. There are some key components that aren't. And again, this is where industrial policy matters.

For example, plasma thrusters. The Russians do a great job on plasma thrusters. They've

always focused on that.

And this is a place where if you had more U.S. investment, if you had an actual R&D industrial policy, we could do so much better.

I would also say that in terms of export control reform, again, just to go back to the good work Kevin did back in the day, that it wasn't the component assembly or the companies that we were losing due to bad export control policies, it was those component pieces.

So, it's a very insightful question that those secondary and tertiary suppliers that were going out of business because they couldn't participate in the global marketplace due to overly broad export control reforms.

And that's when not only commercial providers, but the Pentagon found, they were buying their component pieces completely from overseas, because their domestic industrial base had atrophied to the point where we were dependent on other people, which is the exact opposite effect of what the export controls are supposed to have.

So, we've still got a base. But again, when you drop from 20 to eight orders, you know, and then we don't move quickly on export/import, you're going to quickly lose those secondary and tertiary suppliers, forcing us to go overseas.

So again, I understand we can't be China in terms of industrial policy, but there are things that the U.S. can do in terms of the government being a smart customer.

You know, I talk about satellite servicing in space assembly, the government could purchase these services from companies. We would be investing in them.

There's a lot that we can do there that we're not doing right now, because we need more frankly, Congressional direction, leadership, and funding on these matters.

CHAIRMAN BARTHOLOMEW: I want to follow up with a question that you might not be able to answer. Or not -- in an open forum or for proprietary information.

But, do you have concerns about security of the components that you use? About components that are going into the satellites that could be used or manipulated or something in a way that's detrimental to the use of the satellites?

MR. GOLD: I think that if you are, certainly if you were purchasing them from China, you know, or some place like that, you know, there would be concerns about the components.

Which is why it's important that we maintain a domestic industrial base so that you don't have to go overseas. And then when you are going overseas, it's to major NATO and non-NATO members.

There is a policy for the Department of Defense not to use Chinese components or Chinese manufactured, you know, satellites. So you've got a bit of a firewall there.

But ultimately again, and forgive me for keeping to harken back to this, I worry about the more macro issues. That if we lose the manufacturing industry, you know, this is going to go away.

If we can't keep a robust demand, and a continual demand, we lose those secondary and tertiary suppliers. And then we get into trouble.

And then you might have to go overseas for them. So, I think it is a real concern. And one that we need to focus on our industrial policy to make sure that demand is sufficiently stable, that we don't lose those parts suppliers.

CHAIRMAN BARTHOLOMEW: And is anybody tracking Chinese acquisition of some of the kinds of companies that would be making these things in other countries, right?

I mean, sometimes we know what the Chinese are acquiring here, or trying to acquire. But if they are acquiring a manufacturer that makes a piece that is one of the only countries that -

- one of the only companies that can do it.

Is there anybody who's tracking that sort of thing?

MR. GOLD: I have seen no unified effort to look at either the component level or even the larger level relative to industries being pursued by China or any other rival nation.

We are singularly ill prepared, in my estimation, for the kind of struggle that we're in, not only with China, but really for the global economy as we see it today.

Where you see governments teaming up with their own industries, and then working together as a unit. The U.S. does not function like that, which is why you don't have that data. I guarantee they have that overseas.

I was at a joint AFRL-DIU conference. We were looking at these very issues. I can tell you there's some people in the Air Force, there's some people at the Pentagon and in the industrial base that are looking at this.

But, there is no consistent or overall strategy in place. At least that I've seen.

CHAIRMAN BARTHOLOMEW: All right. Thank you. And forbearance, can we have the other witnesses answer the question about the consequences for the U.S. losing our U.S. commercial space industry?

MR. WOLF: I spent two years of my life lobbying Congress to get Congress to agree to change the rules in order to help the defense industrial -- or the satellite industrial base for exactly that reason. I and my colleagues from State and Defense were up here a lot.

What Congress did in 1990 is in response to a diversion of commercial technology for military application in China, was to basically clamp down on all U.S. commercial satellite, spacecraft, and related items, regardless of significance. Regardless of destination. Regardless of anything else.

And at that time we had about a 70-plus percent share of the world market. And the Defense Department had, you know, very robust suppliers in the U.S. making the things they needed to keep their birds alive and active in space.

But once you clamp down and cut off the ability and impose regulatory burdens on trade with our NATO and other close allies, what that did was to create incentive for our European and our Japanese friends to build their own competing parts and components manufacturers that otherwise would not have existed but for Congressional action.

So, it was a well-intentioned action. But it's an example of what happens when you impose unilateral controls.

And it basically forced, we went from like 20 to about -- 70 to about 20 percent of the world market because this Congressional action motivated competitors to evolve in our allies.

And so what the reform effort did, what I'm very proud of, is -- and Congress agreed with us, is in order to keep the U.S. satellite industrial base healthy, you need that robust demand from the allies.

And so it's -- on one hand it feels really good, really tough to be able to cut off everything everywhere all the time always, because it will never make it to China that way.

But, you end up like squeezing a ball of sand in your hand. You end up with nothing at the end of the day. And hurting the very industry that you're trying to protect.

So, in order to preserve the industrial base that you just described, which is so vital, the key is very low regulatory burdens with trade by and among our allies. To keep that demand alive so that we're the platforms upon which they build, as opposed to the other way around.

And, in order to address the China national security threat, the controls are multilateral. That means that the U.S. and Germany and Japan and the other spacefaring nations work and

align their controls, and share enforcement and intelligence, in order to address a common threat.

And so that's how you keep the U.S. satellite industrial base secure and robust, while at the same time addressing the concerns that have been well articulated previously with respect to China.

CHAIRMAN BARTHOLOMEW: Mr. Laskai?

MR. LASKAI: Yeah. So, I just want to echo your remarks on the allergic reaction to industrial policies. As I tried to outline in my testimony, and I hope I'm successful, is that the Chinese are just very intentional at doing things related to industrial policies. And they studied the United States. And in the case in military-civil fusion, there is a deep study of what the U.S. has done, just we haven't done it intentionally. We haven't been conscious of it. So, in some ways, I'm sure there are people are China who are more experts on what we've done than people we have in the United States, speaking hyperbolically. But to some extent it's true.

So, I mean, this military-civil fusion is not something that was created in a villain's lair. It was created, you know, by studying and replicating what other countries have done. And that brings me to also your question about the loss of the commercial space sector.

I mean, I will say that we are currently so far ahead that the idea of losing out seems pretty remote and almost hard to conceptualize. But I think it is easy to imagine that with the Chinese because they are so intentional at looking at the supply chain and finding critical links where they can snatch up one European company or one company from somewhere else and thus dominate that part of the supply chain.

We don't think that way. And, yeah, I mean, there seems to be a case where the Chinese are able to start chipping away at the supply chain and thus making, you know, other countries more reliant on them. And I think this goes to one thing I recommend in my recommendations section, which is I think there really needs to be an inter-agency process to look at the industrial base in a holistic way, and look at where Chinese companies are investing elsewhere abroad, and really draw attention to it before it's too late.

COMMISSIONER McDEVITT: Mr. Gold, would you care to respond to the how far ahead we are? The first thought that crossed my mind is that's what they said in Detroit in 1985, but, anyway --

MR. GOLD: I'm a very poor poker player, as you can tell from my expression on that. I mean, look, China can launch their people to space right now. We can't. I mean, we're looking at more robust financing, as I described in my testimony, on the satellite field. We can't.

In the areas where there isn't parity, there's soon going to be parity and then they're going to exceed us. So I think they've actually reached parity in many, many fields. And, again, not just China, others. And, again, I just have to keep circling back around to we're not going to export control our way out of this problem.

Frankly, I think we need to be looking more internally than at China in terms of what are we doing as a nation to answer the fusion that has been described in China. What are we doing with public-private partnerships? Are we monitoring our industrial base for threats? And then, when we see those threats, are we taking action?

You know, I think we have to ask a lot more questions about our system, because ultimately the IP is going to get out there, right, and particularly with China we've seen this. It's going to leak, it's going to be stolen, it's going to be copied. You have to continue to innovate and have the workforce, which we haven't talked about a little bit here, which is whole other problem to innovate.

So we really have to be thinking, I think, aggressively about what we're doing here in this

country to stay ahead, because I think that we're at parity in many areas and in threat of losing our edge in many others.

CHAIRMAN BARTHOLOMEW: Thank you.

COMMISSIONER McDEVITT: Senator Talent.

SENATOR TALENT: Well, I'll just piggyback a little bit, because Carolyn asked basically the questions I was going to ask. How important is it, in your view, in terms of sustaining this aspect of the industrial base, is the robust and consistent funding of the Department of Defense?

It's been my impression, when we talk about civil-military fusion in the United States, that where that's really worked it's more military-civil fusion in the sense that the Department knows what it wants to do, basically, and it's driving research and development towards that purpose.

And then, once that is achieved, then the technology gets into the civilian sector and there's all these great spin-offs and the rest of it.

So, that's another. At the same time that we were doing the probably overly-strict export control regime, we also went through years of a sequester in the defense budget and not passing defense appropriations bills. So, give me your opinion on that and then I'll be done.

MR. WOLF: So, excellent point. Remember, though, that commercial applications are going to generally, in just about every area, outstrip the defense demand by volume and numbers. So you can never completely depend upon Defense Department funding to keep an entire sector alive and healthy and robust.

In fact, that very point is why the Defense Department was with me at all of these meetings up here on Congress to give us back the authority to regulate differently controls on satellites, because that was their point. We can do as much as we can, whether it's with or without sequestration. We'll never be able to keep up with commercial demand as a Defense Department to keep the supply chain healthy that we need, that we depend upon. So, therefore, we need to robust demand and low regulatory burden on trade with allies.

And so it's absolutely a very important point. Sequestration had a horrible negative impact, but more Defense Department money to keep the commercial lines open is not really the solution. It really must come from demand from abroad.

MR. GOLD: Although it couldn't hurt.

MR. WOLF: It couldn't hurt. Yes, it couldn't hurt.

SENATOR TALENT: Well, and you can use those funds, I mean, in a different area. I remember, when I was in the Senate, there was an issue about sustaining the ability to design nuclear submarines, and Joe Lieberman and I put some money in the budget just basically to keep that workforce in place so it wouldn't get laid off.

So there's a flexibility to the Department's budget. But you're right. In terms of in gross, it can't support a whole industry like this.

MR. GOLD: But per the point that was made about the industrial base, for example, if we were looking at this holistically and we did see that there was a particular area or particular components that we were about to lose out on, DoD, if they had the funding, could then move to shore that up and make sure that that track continued.

But I'll tell you, I think the best fusion or public-private partnership that I've ever seen in government actually occurred at NASA with the COTS and CRS program, Commercial Orbital Transportation Services and the Commercial Resupply Services.

Under that program, there was less than a billion dollars spent. We got two medium lift

vehicles, the Falcon 9 and the Antares, and then two capsules, the Dragon and the Cygnus, both of which have flown, both of which are delivering cargo to the International Space Station today.

And, with the Falcon 9, we actually had a market in terms of commercial satellite launch that had gone almost entirely overseas, almost entirely to Europe, to China, to Russia and then came back to American shores.

A billion dollars. And what was done there? Fixed price contracting as opposed to cost plus. Having the private sector come in, put a little skin in the game, and keeping the government honest in terms of not changing their requirements constantly, and the government coming to the private sector saying, this is our need, not how you should design the vehicle.

And if you leverage the power of the purse, if we have the Department of Defense, if we have NASA coming to companies like mine and saying, "we will pay for satellite servicing, we will pay for in-space robotics," you will see an explosion of innovation and diversity like never before.

So I think it's not only getting the money that is important, but it's on how you're spending it and releasing the entrepreneurial aspects of the private sector. And I think that NASA program was a great example.

MR. LASKAI: Yeah, and I would just -- I mean, I agree completely with Mr. Gold. I think it's more about a technique than anything inherent to the Department of Defense, and I think we've seen it through NASA, through ARPA-E, IARPA.

It's a technique of basically creating these public-private partnerships where there's a market that can be tapped, providing the support to get those enterprises off the ground, and then letting really the market drive innovation and development of scale and efficiency.

And, you know, I think the solution's not necessarily just to give DoD more money. It's to ensure that these institutions are prioritizing these type of partnerships. And, I think, in DoD there's a lot of great work going on with DIU and other like institutions.

I think in some ways we also need to think about how to scale up. Like it's one thing to do fast iteration with a small startup in Silicon Valley. It's a little more difficult to do that with something that's developing real hardware. And, I mean, I think that's where NASA's really succeeded with Space-X.

So, thinking how we scale up, how we provide more capital for hardware-intensive startups to really find their market. I think these are things that we should be thinking about when we're deciding how to fund these institutions.

COMMISSIONER McDEVITT: Thank you. Commissioner Cleveland.

VICE CHAIRMAN CLEVELAND: Thank you. You may be the fastest-talking group of witnesses that we have ever had, and I talk fast.

I have two questions, one I think probably for Mr. Wolf. We've talked a lot about Hong Kong. I'm wondering if Israel has ever come up in the context of concerns about re-export.

MR. WOLF: Oh, sure, of course. Israel's a very close, trusted ally that's made substantial improvements in the quality of their domestic export control system, and the U.S. Defense Department worked with them for a very long time to help capacity-building.

And whereas there may have been an issue a long time ago, at least in my experience, it was extraordinarily cooperative and good faith, and the issues you may be thinking of were long before my time and with a completely different set of personnel over there.

And so, at least in my experience, I had no such concerns about diversion, internal or external, with respect to the topic at hand. So, different topic altogether.

VICE CHAIRMAN CLEVELAND: Okay. Last year, in Colorado Springs, Acting

Defense Secretary Shanahan, in a keynote address, said, "The threat is clear: we're in an era of great power competition, and the next major conflict may be won or lost in space."

I'm interested, given your different perspectives, what do you think would be the key reasons why we would win or lose in space? Is it workforce innovation, as you mentioned, Mr. Gold? Is it money? Is it regulatory restrictions? Is it a specific capability, like anti-satellite?

So, if you could use that broad statement as a way of kind of lining up what you think the critical components are that would contribute to winning or losing. Thank you.

MR. LASKAI: Yeah, I mean, I think there's a number of valuable perspectives to answer that question.

From my perspective, I think, and as someone who studies the way that China looks at the market strategically, to me, where I think this potential conflict, if you want to call it that, can be lost is by not adopting the same perspective that the Chinese are using towards how the commercial market and strategic implications intertwine.

I think, you know, we saw this with telecommunications and the rise of Huawei. I think the United States didn't think of its telecom industrial base as a critical national security risk and, you know, we effectively let it be exported abroad, while China very much considered this to be very strategic and important and allowed for domestic national champions to arise, like Huawei. Now we're, of course, in a situation where we're responding to Huawei's advances abroad.

So I think it's important that we think this way about the commercial space industry and not allow a similar situation to arise, you know, 10-15 years down the road. I mean, I think if we do lose out in the commercial space sector then, you know, there might not even need to be a conflict. That sort of will provide some type of dominance.

MR. GOLD: So, I think there's a policy and a technological answer to your question. On a policy basis, as was just said, I think we're going to lose or win that conflict on the basis of how effective we are infusing government and the private sector.

If we can get our public-private partnerships to work like was done in COTS and CRS -- and, by the way, that wasn't just Space-X, you know. That was Orbital, now Northrop Grumman. Boeing is in commercial crew. When you implement good systems, you can get good results almost regardless of the company.

And I think we have to be very careful on the export control front, and in terms of regulations that backfire on us. As Mr. Wolf described, you know, we've had policies that have actually ended up having the absolute opposite effect of what we wanted. We could almost afford to stumble back then, but, per the parity argument, I think our margin of error is very small right now.

Which is why, again, I think it's great that we're having this conversation. But our zeal for export controls with China, we have to be extraordinarily cautious about not being overly broad. Again, surgery with a scalpel, not the chainsaw. And, unfortunately, nuance is not necessarily what Congress is known for a lot. So we have to be cautious.

Then, on the technological front, I would say it's space-based robotics. You know, we're going through an entire transformation where you've got satellites that can build themselves, repair themselves, service themselves.

I mean, we've all got cars, right, and I know we're all doing pretty well here. But when your car runs out of fuel do you throw it away and then buy another? No. Yet that is exactly what we do in the satellite industry. So, imagine now when you can refuel that satellite, keep the platform going, refresh the technology, this is a whole new era.

If we fall behind the international competition in China, Russia, and Europe, you know, I

don't like our odds in terms of any kind of a conflict.

MR. WOLF: Fascinating question, and I guess my short answer is all of the above. I was going, they're like ten different areas of law and policy that go to answering your question.

It starts, you know, from STEM education at the middle school stage of getting people excited about this. It's visa policies, so that we encourage the best and the brightest from all over the planet to want to come and work for our companies as opposed to the adversary's companies.

We already talked about the industrial base support, the DoD-tailored support, the study of what companies connect to what in order to be able to know whether to focus care and attention.

And then, on the kinetic side, on the military side, obviously it's, you know, significant DoD money, both for intelligence and surveillance and anti-satellite weapons.

So, yeah, I mean, the answer to your question is basically all law and all policy. It all feeds into that. There's no one area of law or policy or regulation that's going to address or kill what you're trying to reach there. That's my first reaction. Great question.

COMMISSIONER McDEVITT: Our ace, crackerjack staff here just showed me a tweet, I think it was a tweet, from Secretary of Transportation Chao announcing that the FAA Office of Commercial Space Transportation has been directed to undertake an extensive reorganization. Is that something related to what we're talking about right now?

MR. GOLD: So, I haven't seen this tweet, but as Chair of the Commercial Space Transportation Advisory Committee, we are looking at a major refresh and revision of the launch regulations right now. There was a Notice of Proposed Rulemaking that was coming out.

Again, careful what you ask for, right? We've always advocated for reform. Now I stay up nights and weekends responding to ANPRMs that we've been so active in trying to get these things going.

I think also the challenge that we face at Transportation is the integration of commercial space activities with the aviation and the national air space. And there, again, it's a difficult balancing act in terms of, you know, how do you get these two things to coexist and live together and benefit? You know, there's a lot of issues in terms of Outer Space Treaty implementation, Article 6, which requires the authorization and continuing supervision of space activities.

We really haven't identified an agency to address that. We've been working through AST so far and they're doing a great job, and perhaps we should be ensconcing that there. We've talked about the Department of Commerce. Again, we need to get the regulations right. The technology is important, but if we don't have a good regulatory structure that will be a tremendous drag.

So I applaud Secretary Chao for moving forward aggressively with those reforms, for being supportive of commercial, and I hope that we in industry can be helpful and do more.

COMMISSIONER McDEVITT: I have, I think, a wrap-up question here, unless something pops up. We have about seven or eight minutes left here.

Listening to the discussion writ large, you walk away with the feeling that China really has taken a huge march on us, and that it's going to take an awful lot of -- it seems like an awful lot of effort to put us back on the right track.

So the question I have for you is, China's apparent advantage, does this mean that inexorably they're going to continue to move in a way that's going to be difficult for us to ever catch up?

And so what are the weaknesses? If any of you, or all of you, have looked at China in that sense, what are the weaknesses that will make it less likely that the sense, at least that I have

taken away from what you've had to say, is that it's going to be too hard? Where are they going to stumble?

MR. LASKAI: So this, for me, is a great question, because, frankly, we talk about China's successes, but as someone who studies this, I'm often looking at the failures, because, frankly, especially when it comes from the military-civil fusion, there's more cases where it's not been successful than successful.

And, you know, I think we usually pay most attention to China when it has its breakout moment in a surge of industry and it seems unstoppable. But getting there there's a lot of stumbling, and I think in many ways we have a much stronger foundation to work on.

I mean, in China, I can go through a list of things that they don't have, like a lack of IP protection, especially between the commercial sector and the military. A huge problem. There isn't a legal framework to deal with, like, to impartially arbitrate disputes or anything like that.

So if you're a commercial company with, you know, some killer new technology, you don't really want to work with the military, I mean, unless that is your chosen customer or if you have some personal networks that tie to that, you know. I mean, I think with the United States, if you have a new microsatellite application, like DoD's a great client and people are eager to work with the Defense Department.

I mean, similarly, I think there's a strong bias towards SOEs. I mean, right now we're seeing these commercial players rise up and like there is this real push by the Central Military Commission and high-ranking parts of the government to, like, come off as impartial, allow these companies to really use -- you know, really launch their own technology and make the appearance of a balanced playing field.

But there really is a situation in which if there's a downturn in the industry and a lot of these private enterprises, you know, have to go bankrupt, a big SOE might come up and just buy them all up. And that's just not a problem we have as much in the United States, because we don't have these large conglomerates that dominant an entire sector. And that's what China's really done, you know. China hasn't really ever done SOE reform to the fullest extent.

Lastly, there's just too much government meddling. I think it's going to be really interesting to see if there is a separate approval process for private sector rocket launches. So far, there's been really muddled discussion. There's not clear like process to, you know, launch a rocket. You have to go through the military, and I think there's probably some bureaucratic infighting over who gets that control.

Whereas I think, in the United States, very often we often think of, well, it's best to promote the private sector. So, at the end of the day, China's quite new to this. There's plenty of places they can stumble before they have their sort of breakout moment, especially in the commercial space sector.

COMMISSIONER McDEVITT: Mr. Gold.

MR. GOLD: Two words: diversity and liberty. Who we are as Americans is our greatest fundamental defense, that we come from so many different cultures, so many different perspectives, so many different places that we simply innovate better than China and a lot of other countries do.

That's where China lags behind, on the innovation, which is why again, quite frankly, I'd worry a little bit less about controls, and more about leaning into our advantage, that we innovate, we do R&D.

And liberty is a part of that as well. We're a free nation and we think freely. We're creative. We go beyond the bounds. That's not the environment in China. So I think if we lean

into what makes us great as a country and as Americans, there's hope.

MR. WOLF: Hear, hear, everything Mr. Gold just said. I'd add into that respect for the rule of law. We're a destination country for the best and the brightest all over the planet to come work for us. That will allow us to out-innovate and a low regulatory burden with a situation where there's IP protection and a culture of innovation and growth, and ultimately, culturally, systematically, structurally, we will ultimately prevail.

So, it sounds a little bit like a campaign speech, but I think the answer to your question is, frankly, the institutional structure that we have that they don't, regardless of any other particular detail. And that's where we will ultimately prevail --

CHAIRMAN BARTHOLOMEW: So, Mr. Wolf, are you using this opportunity to announce you're running for president?

MR. WOLF: I would be the only Democrat who isn't running, if I were. But, no, I'm not campaigning for anything. Thank you.

COMMISSIONER McDEVITT: Thank you all. I must say though that, despite all of these things that we've said that are so good about us, that we seem to be losing. So, Mike, over to you.

COMMISSIONER WESSEL: Thank you all. And, Mr. Gold, certainly having been involved in war chest financing and many other issues in the past, the activities of China, JETRO, and others, very sympathetic to the questions of export financing.

But there's a fine line between export financing and subsidies, and one of the principal issues, I think, that creates a problem for you and so many other U.S.-based industries is China's non-market actions, the subsidies it uses to support its national champions and just about anyone else.

So, Mr. Wolf, you were there during the ZTE issues, as well as Huawei, and Huawei was was F1 or whatever it was in the indictments. F7, thank you. The Commerce Department had played around at one point with an AD/CVD case around Huawei because of its underpricing foreign competitors and U.S.-based competitors in the market.

It seems to me, when you look at ZTE, you look at Huawei, you look at any kind of satellite-based services that are being sold in the U.S. to U.S. interests at less than market rates, despite how much we're using our trade laws right now, that's an area that's really lacking.

If we want to go after Huawei, it's partially the question about standards, it's partially the question of a 5G rollout. But at its core, isn't it a financial issue, that they've been cleaning our clocks, because they've been giving their products away? Mr. Gold, do you have a view on that?

MR. GOLD: Again, this is the challenge that we face. Not only subsidies, but particularly as we look at the launch sector, for example -- and, again, it's opaque to us so I can't say with certainty -- free launches will be attached. These are things that my company, no other company in the U.S. can offer.

And, ultimately, if we can't compete in the international marketplace, no matter how much funding we get from the Department of Defense, you know, that's going to hit the industrial base hard and hit innovation hard.

COMMISSIONER WESSEL: But you can't compete if you're trying to compete against a company that doesn't -- it doesn't care about profit.

MR. GOLD: Absolutely.

COMMISSIONER WESSEL: Right.

MR. GOLD: And in my written testimony you'll see references to the fact that we don't even know if China cares if they generate a profit on some of these satellite sales. It could be

revenue-negative and they'll simply take the strategic and technological benefits.

And, again, this is why I talk about we're ill-prepared for this. The systems are completely different. And at a time when I'm talking about Export-Import Bank, you're talking about not even making a profit, simply for the strategic gain.

And that's why I think we really, in America, have to take a hard look in the mirror at how we frankly function fundamentally as a country and how government interacts with the private sector, because we can't afford to wait. We can't afford not to evolve and change. I don't have the answers, but I know we need to move and move quickly.

COMMISSIONER WESSEL: Thank you. Mr. Wolf.

MR. WOLF: The short, quick answer is, frankly, they're not the only other country in the world. There are other countries which are allies. And you can isolate them through something, for example, of aligning all of the Pacific nations together in a Trans-Pacific Partnership or something or --

(Laughter.)

COMMISSIONER WESSEL: I'm happy to take that one on, Mr. Wolf, if you'd like.

MR. WOLF: Well, seriously, really it's -- sure, if they're selling at below fair market value, et cetera, or there's subsidies that are state funded, you have the rules in place for CVD and AD actions. Go get them, great. Happy to support. But that's not going to be the only solution if they're not based on market considerations.

COMMISSIONER WESSEL: Agree.

MR. WOLF: And then, frankly, that comes into making sure that our allies have similar concerns with the same information and work with us. And getting allied cooperation in something like this, both from a national security and an economic security and an attitude towards China, frankly, requires a lot of work and respect with our allies on a regular, ongoing basis.

COMMISSIONER WESSEL: I agree.

MR. WOLF: And so, actually, I think that is the solution to your question. When you can't deal with it through traditional rules of law, you have to actually work with allied cooperation and, frankly, surround them with people who have like minds and like interests, and you work together under the same set of rules.

COMMISSIONER WESSEL: I think China's actions are helping to bring all of us together. MR. WOLF: I would hope so, yes, yeah.

COMMISSIONER McDEVITT: Well, thank you, all three of you, for terrific presentations and then great answers during our Q and A. So, I will call this session to a close. But, again, thank you very much for your participation and your very helpful commentary.

CHAIRMAN BARTHOLOMEW: And we'll be back at 3:10.

(Whereupon, the above-entitled matter went off the record at 3:01 p.m. and resumed at 3:11 p.m.)

PANEL III INTRODUCTION BY CHAIRMAN BARTHOLOMEW

CHAIRMAN BARTHOLOMEW: All right. We're moving on to our last panel today. Welcome to our witnesses. And before we move into that, I really wanted to express our appreciation to Alex Bowe, who put this together for us, a terrific staff member. He did a great job of digging around to find some new witnesses as well as some of the people who we've heard from before. So, Alex, thank you.

Our last panel today will address China's military space activities. Our first witness will be Kevin Pollpeter, Senior Research Scientist at CNA. Mr. Pollpeter is an internationally recognized expert on China's space program and is widely published on Chinese national security issues, focusing on Chinese military modernization, China's defense industry, and Chinese views on information warfare.

I have a very long-titled publications, which he's done some extraordinary publications, and has done contracted reports written for this Commission. A Chinese linguist, he holds an M.A. in international policy studies from the Monterey Institute of International Studies, and is currently enrolled in a Ph.D. program at King's College, London. Kevin, we're always glad to have you back.

The second expert on this panel will be Mark Stokes, Executive Director of the Think Tank Project 2049 Institute. Previously, he was the founder and president of Quantum Pacific Enterprises, an international consulting firm and Vice President and Taiwan Country Manager for Raytheon International.

He has served as executive vice president of Laifu Trading Company, a subsidiary of the Rehfeldt Group; a senior associate at the Center for Strategic and International Studies; and member of the Board of Governors of the American Chamber of Commerce in Taiwan.

A 20-year U.S. Air Force veteran, Stokes also served as team chief and senior country director for the People's Republic of China, Taiwan, and Mongolia in the Office of the Assistant Secretary of Defense for International Security Affairs.

I think sometimes when we read these things the titles are getting longer and longer, and I just have to think about how anybody fits it on a business card.

So, Mark holds a B.A. from Texas A&M and graduate degrees in International Relations and Asian Studies from Boston University and the Naval Postgraduate School. Mark, it's always good to see you.

And our final expert today will be another returning witness, Jonathan Ray, Chief of Analysis in the Special Programs Division of SOS International. Mr. Ray previously served as an Associate Deputy Director at Defense Group, Inc. He has led research on Chinese science and technology fields including semiconductors, hypersonic weapons, robotics, unmanned systems, nuclear weapons, and space military doctrine.

He was the lead author of a research report for the Commission. He completed his bachelor's at Cornell, his M.A. at the Middlebury Institute of International Studies, and Chinese Language Training at BYU. Thank you, again, to all of our witnesses. Kevin, please begin.

SENATOR TALENT: Madam Chairman, before we start, can I just say what you said before? We've had all these new witnesses today, and now all these old friends and we've seen often before. So it's great to have them back.

CHAIRMAN BARTHOLOMEW: It's a nice mix, very nice mix. Thank you.

OPENING STATEMENT OF KEVIN POLLPETER, SENIOR RESEARCH SCIENTIST, CNA

MR. POLLPETER: Okay. Good afternoon, Commissioners. Thank you for inviting me to speak on this important topic. Although my written testimony goes into much greater detail on China's space program, I would like to limit my spoken remarks to the Chinese military's progress in counterspace and its implications for deterrence and escalation. The views I present today are strictly my own.

The Chinese military has an extensive set of capabilities that either have exclusive counterspace applications or can be used in a counterspace context. In short, the Chinese military is developing a suite of counterspace capabilities that appears intended to threaten U.S. space assets from the ground to geosynchronous earth orbit.

To this analyst, it appears that China's developing a counterspace architecture that is intended to deter the United States at the nation state level, while also designed to achieve operational goals should deterrence fail. In other words, China's counterspace architecture, like the rest of the PLA, is being designed to deter the United States from entering into an armed conflict with China.

If that goal fails, however, China expects to use these capabilities to achieve warfighting objectives. China's counterspace capabilities include direct ascent kinetic kill vehicles to destroy satellites in orbit, possibly up to geosynchronous earth orbit.

It is developing co-orbital capabilities that could allow one satellite to attack another satellite. China's developing directed energy weapons and intends to field a ground-based laser system for use against satellites in low earth orbit by 2020.

Finally, China has been involved in computer network attacks against U.S. space systems, most recently against a satellite communications operator and a geospatial imaging and mapping organization.

China's apparent intention to create a comprehensive counterspace architecture raises questions about whether China can be deterred from using its counterspace capabilities. The short answer is, "I don't know." I think we in the China-watching community still have too little understanding of how China's political and military leadership make decisions and assess risk. However, there are several factors which suggest that our ability to deter China's use of counterspace capabilities is limited.

First is the Chinese Communist Party's stake in successfully defending what it sees as its core interest. It is likely that the Chinese Community Party leadership views success in an armed conflict as critical to maintaining its legitimacy with the Chinese people. This may result in the Chinese Community Party being more forceful and less limited in the types of actions it is willing to take against the United States. Second is the importance of achieving information superiority and the view of space as the U.S. military's Achilles' heel. China views information superiority, the ability to use information and deny its use to an adversary, as the key determiner of battlefield success. It also views space as a critical component of the U.S. military's C4ISR infrastructure that, if degraded, will produce decisive effects.

Third is an emphasis on striking first. Chinese military analysts write that offensive military actions, including preemptive strikes, are permissible when defending their perceived core interests. The focus of these first strikes is on an adversary's center of gravity, and are intended to have a direct impact on the overall situation of the campaign, or to produce an overall effect.

The authors of one Chinese book called "The Study of Space Operations," for example, conclude that China will do all it can at the strategic level to avoid firing the first shot, but recommend that China should strive to attack first at the campaign and tactical levels in order to maintain the space battlefield initiative, and that the PLA should "conceal the concentration of its forces and make a decisive, large-scale first strike."

A fourth factor influencing whether China can be deterred is China's view of itself as a more principled country than the United States, and as a peaceful country that only fights wars of defense. The strong tendency of the Chinese to believe that their country is more peace-loving than other countries has led to a widespread belief in China in what Andrew Scobell calls the "Cult of the Defense." This perception may make Chinese more prone to supporting a war on the premise that their cause is just.

Finally, misguided assumptions or a lack of deep analysis of space warfare may make China more likely to strike U.S. space assets. For example, Chinese analysts do not discuss how space warfare differs from other types of warfare. Although space debris is an acknowledged problem in general, the generation of space debris by kinetic attacks is infrequently acknowledged. Chinese analysts do not discuss the PLA's own growing vulnerabilities as it becomes involved in space.

Finally, there appears to be an assumption, not only in regards to discussions of space deterrence, but Chinese writings on deterrence in general, that an adversary will simply back down after China escalates. There's no consideration that an adversary may become more invested in winning a conflict after China takes escalatory actions.

This analysis has some important caveats, however. As I said before, we lack a sufficient understanding of the decision-making process of China's political and military leadership. That leads to significant gaps in our understanding of how China assesses the risk of war. In addition, the Chinese understanding of deterrence, especially space deterrence, may still be evolving.

Finally, space warfare can occur across a spectrum of capabilities, not all of which will result in the destruction or permanent debilitation of space assets. China, for example, could conduct localized jamming of satellite communications and the GPS signal, or temporarily blind reconnaissance satellites as they orbit over Chinese territory. In short, China's counterspace actions could occur along an escalatory ladder that would require a range of responses from the U.S. military.

Despite these caveats, the U.S. military must prepare for the likelihood that during an armed conflict China will engage in some form of space warfare.

Possible steps to mitigate the effects of such an attack could be to have a more distributed space architecture, hardening satellites against attack, reducing our dependence on space and developing our own offensive and defensive space control capabilities.

Again, thank you, Commissioners, for your time today. I look forward to answering your questions.

PREPARED STATEMENT OF KEVIN POLLPETER, SENIOR RESEARCH SCIENTIST, CNA

CNA
ANALYSIS & SOLUTIONS

April 2019

Testimony before the U.S.-China Economic and Security Review Commission Hearing on "China in Space: Strategic Competition"

Kevin Pollpeter

This research represents the author's own personal views.

Introduction

The Chinese military has embarked on a series of organizational and doctrinal reforms to improve its ability to fight modern war. Prominent among these reforms is a growing emphasis on space and counterspace operations to enable long-range precision strikes and deny adversary space capabilities. The People's Liberation Army (PLA) has officially designated space as a new domain and established an organization to command space forces. With this increased focus on space, the PLA may begin to develop a doctrine to govern the use of space in military operations.

Chinese analysts writing on space make the oft-repeated statement that "whoever controls space will control the Earth" and argue that outer space is the new high ground of military operations. They assert that the center of gravity in military operations is now transitioning to space. Explicit in these arguments is the assumption that space has become so vital to fighting modern war that no military can do without the benefits of space-based capabilities. At the same time, Chinese military analysts regard space as a great vulnerability that, if denied, can debilitate an enemy and secure victory.[1]

According to Chinese sources, the goal of space operations is to achieve space superiority (*zhitianquan*; 制天权), defined as "ensuring one's ability to fully use space while at the same time limiting, weakening, and destroying an adversary's space forces."[2] Space operations play a key role in the PLA's ability to conduct asymmetric strikes against the US military, enabling long-range precision strikes against land, air, and naval targets and denying adversaries the use of space assets.

This paper argues that China is taking a dual-use approach to its space program that integrates military and civilian capabilities to pursue national security and economic goals. China is developing a space-based command, control, communications, computer, intelligence, surveillance, and reconnaissance (C4ISR) network to extend the PLA's power projection capabilities while promoting its economic interests. China's counterspace efforts appear to be directed toward developing an operational capability to threaten an adversary's space assets from the ground to geosynchronous orbit (GEO). The PLA's priority on space, especially space control, increases the possibility of warfare in space, the risk of escalation, and the risk that efforts to deter Chinese counterspace actions may have little chance of success.

[1] Jiang Lianju and Wang Liwen, eds., *Textbook for the Study of Space Operations* (*空间作战学教程*), (Beijing: Military Science Publishing House, 2013), 44.

[2] Ibid., 14.

China's Space Capabilities

The Chinese military is developing three broad capabilities that either have direct military application or are inherently dual-use in nature: operationally responsive space launch capabilities, space-based C4ISR, and counterspace capabilities.

Operationally responsive launch capabilities

China can launch satellites into all orbits and is developing the ability to rapidly reconstitute or augment satellite constellations. It has a new generation of liquid-fueled launch vehicles that can launch bigger and more capable satellites as well as smaller, solid-fueled, road-mobile launch vehicles that can conduct launches within shorter timelines. The new generation of liquid-fueled rockets is divided into light, medium, and heavy-lift versions that can send 1 to 25-metric-ton-payloads into low Earth orbit and 1 to 14-metric-t on-payloads into GEO orbit.[3] The addition of heavier lift capacity facilitates the orbiting of China's long-term space station and robotic missions to the moon. China can also use these new rockets to launch heavier satellites, such as larger remote sensing satellites with better imagery resolutions.

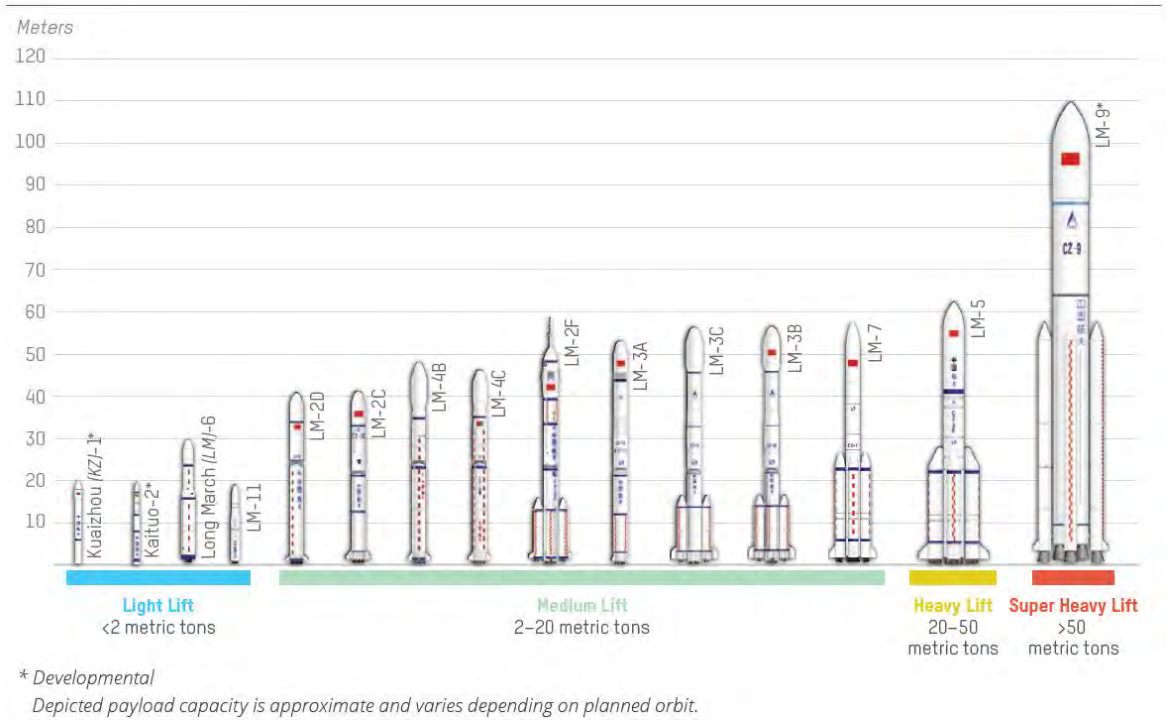
China has also developed solid-fueled rockets that provide launch capabilities at the lower end of the lift spectrum. Solid-fueled rockets do not require fueling before launch and can be transported by ground vehicles, enhancing responsiveness and survivability. The Long March 11, reportedly based on the DF-31 ICBM, can carry a payload of 700 kilograms into orbit.[4] The Kuaizhou launch vehicle, reportedly based on the DF-21 medium-range ballistic missile, is advertised as being capable of launching 300 kg into orbit with just four hours of preparation.[5]

[3] Zhang Feng, "China's Long March 5 Launch Vehicle" (中国的长征五号运载火箭), *Satellite Application* (卫星应用), 2012/5, 29.

[4] "Long March 11" (长征十一号), China Academy of Launch Vehicle Technology, May 12, 2016, http://www.calt.com/n482/n498/c4962/content.html.

[5] "Guancha Net on the Frontlines of the Zhuhai Airshow: Feitian-1 Triggers Attention That it Can Launch in Four Hours," (观察者网珠海航展前线：飞天一号火箭引发关注 4 小时即可"飞天), http://m.guancha.cn/military-affairs/2014_11_12_285792.

Figure 1. Chinese space launch vehicles



Source: Defense Intelligence Agency, "Challenges to Security in Space," 16.

Space-based C4ISR capabilities

PLA analysts describe space-based C4ISR systems as a critical part of a modern military's sensor-to-shooter network. The PLA's development of long-range precision-strike capabilities requires a robust space-based C4ISR network to locate, track, and target enemy installations and ships hundreds of kilometers from Chinese territory and coordinate forces from multiple services in joint operations. Space-based C4ISR supports these operations through the application of reconnaissance, meteorology, missile early warning, communication, and navigation capabilities that can help monitor the activities of potential adversaries, enable communication between friendly units, and provide positioning, navigation, and timing data.

According to the Union of Concerned Scientists Satellite Database, as of November 2018, China had 284 operational satellites. These included 134 remote sensing satellites, 41 communication satellites, and 40 navigation satellites.

Remote sensing satellites

China plans to establish a high-resolution Earth observation system capable of stable all-weather, 24-hour, multi-spectral, various-resolution observation by 2020. China operates 28 different types of ISR satellites. These include satellites with electro-optical (EO) sensors for remote sensing during daylight and moderate weather conditions, synthetic aperture radar (SAR) for observations at night or during inclement weather, and video cameras to capture movement. China's remote sensing satellites also feature a variety of resolutions, from sub-meter for discrete imagery to 800 meters for imaging broad swaths of territory. China also has a number of satellites that are apparently equipped with electronic intelligence (ELINT) payloads to collect electronic transmissions.[6]

China plans to deploy remote sensing constellations that will add redundancy, flexibility, and timeliness to its remote sensing capabilities. The Superview series of satellites is planned to form a 24-satellite constellation made up EO and SAR satellites and several mini-satellites by 2022.[7] A second constellation made up of the Jilin-series of satellites is planned to consist of 60 satellites by 2020 and 138 satellites by 2030. The constellation consists of satellites with EO and video payloads and, by 2030, will have a revisit rate of 10 minutes.[8]

Communication satellites

China owns and operates over 40 communications satellites, with four dedicated to military use. According to the Defense Intelligence Agency (DIA), "China produces its military-dedicated satellites domestically and its civil communications satellites incorporate off-the-shelf commercially manufactured components." [9] China is planning two large communication satellite constellations. The Hongyun constellation, built by the China Aerospace Science and Industry Corporations, will consist of 156 satellites and is planned to be operational in 2020.[10] The Hongyan constellation, built by the China Aerospace Science and Technology Corporation,

[6] "China Adds to Yaogan-30 Reconnaissance Constellation via Successful Long March 2C Launch," *Spaceflight 101*, January 25, 2018, http://spaceflight101.com/yaogan-30-04-launch/.

[7] Zhao Lei, "High-resolution satellites begin operation," *China Daily*, January 13, 2017, http://www.chinadaily.com.cn/china/2017-01/13/content_27943139.htm.

[8] Ma Si and Liu Mingtai, "Jilin group sets goal of putting 60 satellites in orbit by 2020," *China Daily*, March 28, 2017, http://www.chinadaily.com.cn/business/2017-03/28/content_28700107.htm.

[9] Defense Intelligence Agency, "Challenges to Security in Space," 2019, 19.

[10] Andrew Jones, "China to Launch First Hongyun Low Earth Orbit Communication Satellite Late on Friday," *GBtimes*, December 21, 2018, https://gbtimes.com/china-to-launch-first-hongyun-low-earth-orbit-communication-satellite-late-on-friday.

will consist of around 320 satellites.[11] Both constellations will provide global communications and internet connectivity, especially to underserved regions. According to Yao Fahai, vice president of China Satcom, China is pursuing communication satellite constellations at this time in order to claim orbital slots in the already crowded low Earth orbit.[12]

Navigation

China has launched 47 navigation satellites since 2000. At the end of 2018, China had 33 operational navigation satellites in orbit—18 third-generation satellites and 15 second-generation satellites. The third-generation satellites offer better accuracy and stability than the second-generation satellites. In 2018, the Beidou program started to provide global service for the first time, covering 50 countries with 10-meter accuracy globally and 5-meter accuracy in the Asia-Pacific.[13] When fully deployed, the Beidou program will consist of 35 satellites.[14]

Counterspace

Counterspace operations are conducted to deny, degrade, disable, or destroy an opposing side's space capabilities. This can include attacks against ground-based and space-based space assets with kinetic and non-kinetic means. Counterspace operations not only include offensive and defensive operations in space against an adversary's space forces, but also air, ground, and naval operations against space assets.[15] Although Chinese strategic writings indicate a cautious

---

[11] Andrew Jones, "China to Launch First Hongyan LEO Communications Constellation Soon," *GBtimes*, November 13, 2018, https://gbtimes.com/china-to-launch-first-hongyan-leo-communications-constellation-satellite-soon and Zhao Lei, China begins space-based broadband project, *China Daily*, December 22, 2018, http://www.chinadaily.com.cn/a/201812/22/WS5c1d82d6a3107d4c3a002337.html

[12] Caleb Henry, "China Satcom's LEO, HTS projects driven by desire not to fall behind foreign counterparts," *Space News*, July 11, 2018, https://spacenews.com/china-satcoms-leo-hts-projects-driven-by-desire-not-to-fall-behind-foreign-counterparts/

[13] Zhao Lei, "Beidou Navigation System Begins Global Operations," *China Daily*, December 28, 2018, http://www.chinadaily.com.cn/a/201812/28/WS5c247a52a310d912140514b9.html and "BDS to Provide Navigation Services to BRI Countries from Next Month," China Space Navigation Office, November 19, 2018, http://en.beidou.gov.cn/WHATNEWS/201811/t2018112316656.html.

[14] Stephen Clark, "Expansion of China's Beidou Satellite Fleet Continues with Successful Launch," *Spaceflight Now*, September 20, 2018, https://spaceflightnow.com/2018/09/20/expansion-of-chinas-beidou-satellite-fleet-continues-with-successful-launch/.

[15] Jiang and Wang, *Textbook for the Study of Space Operations*, 14.

approach to space warfare,[16] writings on the operational level of war suggest a predilection for strong offensive actions at the beginning of a conflict. The authors of the *Study of Space Operations*, for example, conclude that China will "do all it can at the strategic level to avoid firing the first shot,"[17] but recommend that China should "strive to attack first at the campaign and tactical levels in order to maintain the space battlefield initiative,"[18] and that the PLA should "conceal the concentration of its forces and make a decisive large-scale first strike."[19]

According to the US Defense Department, China is developing a number of counterspace and counterspace-related technologies. These include direct-ascent kinetic-kill vehicles, co-orbital satellites, and directed-energy weapons and jammers.[20] China's development of counterspace technologies appears to be aimed at developing the capability to put at risk adversary satellites from earth's surface to GEO.

Table 1. Counterspace-related testing and operations

Type	Year	Description	Comments
Direct Ascent			
	2007	KKV test	
	2010	Mid-course ballistic missile defense test	
	2013	Mid-course ballistic missile defense test	
	2013	KKV test	Test to GEO. China called it "high altitude science mission"
	2014	KKV test	China called it ballistic missile defense test. US called it ASAT test.
	2015	Unknown test	
	2017	Unknown test	

[16] China Academy of Military Science Military Strategy Studies Department, *Science of Military Strategy* (战略学), Beijing: Military Science Press December 2013), 92.

[17] Jiang and Wang, *Textbook for the Study of Space Operations*, 42.

[18] Ibid., 52.

[19] Ibid., 142-143.

[20] Office of the Secretary of Defense, *Military and Security Developments Involving the People's Republic of China 2016*, 37.

Type	Year	Description	Comments
	2018	Mid-course ballistic missile defense test	
Co-orbital			
	2010	Two Shijian satellites involved in close proximity operation, causing slight change in one satellite's orbit	
	2013	Three satellites involved in close proximity operation to test space debris removal and robotic arm technologies	
	2016	Aolong-1 tested robotic arm to remove space debris	
	2016	Shijian-17 rendezvous with ChinaSat-5A	
	2019	TJS-3 satellite released probable subsatellite	
Cyber			
	2012	Computer network attack against Jet Propulsion Laboratory	Allowed "full functional control" over JPL networks
	2014	Computer network attack against NOAA	
	2017	Computer network attack against Indian satellite communications	
	2018	Computer network attack against satellite operators, defense contractors, and telecommunication companies	
Directed energy			
	2006	Lased US remote sensing satellite	Intent unknown

Sources: Brian Weeden and Victoria Sampson, eds., *Global Counterspace Capabilities: An Open Source Assessment*, April 2019 and Todd Harrison, Kaitlyn Johnson, and Thomas G. Roberts, *Space Threat Assessment 2019*, April 2019.

Kinetic tests

According to the Director of National Intelligence, "the PLA has an operational ground-based antisatellite (ASAT) missile intended to target low-Earth-orbit satellites, and China probably intends to pursue additional ASAT weapons capable of destroying satellites up to geosynchronous Earth orbit."[21] In 2010 and 2013, China conducted mid-course tests of a missile defense system that has been widely regarded as having counterspace implications.[22] In July 2014, China again conducted what it called a missile defense test. The Department of Defense, however, characterized the event as a non-debris producing ASAT test[23] and assesses that development of this system continues.[24] In November 2015, China conducted an unacknowledged missile intercept test of an unknown type.[25]

In 2013, China conducted what it called a "high altitude science mission" with a sounding rocket that released a barium cloud at an altitude of more than 10,000 kilometers to study the Earth's magnetosphere.[26] The Department of Defense, however, concluded that the launch was a test of direct ascent counterspace technologies and stated that the rocket "appeared to be on a ballistic trajectory nearly to GEO" and "was not consistent with traditional space-launch vehicles, ballistic missiles or sounding rocket launches used for scientific research."[27] This test demonstrated an expansion of China's counterspace capabilities to GEO, which would allow China to threaten GPS and communication satellites with a direct ascent kinetic kill vehicle.

[21] Dan R. Coats, "2019 Worldwide Threat Assessment of the U.S. Intelligence Community," January 29, 2019, 17.

[22] Brian Weeden and Victoria Sampson, eds., *Global Counterspace Capabilities: An Open Source Assessment*, April 2019, 1-9.

[23] Office of the Secretary of Defense, *Military and Security Developments Involving the People's Republic of China 2015*, 14.

[24] Office of the Secretary of Defense, *Military and Security Developments Involving the People's Republic of China 2016*, 37.

[25] Bill Gertz, 'China Tests Anti-satellite Missile,' *Washington Free Beacon*, 9 November 2015, http://freebeacon.com/national-security/china-tests-anti-satellite-missile/.

[26] "China Again Conducts a High Altitude Science Mission: Higher Altitude and More Data," (中国在高空科学探测实验：高度更高数据更多), China News (中国新闻网), May 14, 2013, http://www.chinanews.com/gn/2013/05-14/4817925.shtml.

[27] *Military and Security Developments Involving the People's Republic of China 2015*, 14.

Co-orbital operations

China has also conducted a number of close-proximity operations between spacecraft.[28] In 2008 as part of the Shenzhou-7 human spaceflight mission, the Banxing-1 satellite (BX-1/Companion Satellite) flew around the Shenzhou-7 space capsule taking images of the spacecraft.[29] In August 2010, in what may have been a test of docking procedures for the future Tiangong space station, a Shijian-12 satellite likely bumped into the Shijian 6F satellite.[30] In an apparent test of robotic arm technologies for a future space station, in August 2013, China tested a satellite equipped with a robotic arm to grapple a target satellite.[31]

Directed energy

According to acting Secretary of Defense Patrick Shanahan, the PLA will "field a ground-based laser system aimed at low-earth orbit space sensors by [2020]."[32] In 2006, China lased a US military reconnaissance satellite. The action temporarily blinded the satellite but caused no permanent damage, leading to speculation that China may not have been intentionally trying to interfere with the satellite.[33]

---

[28] Office of the US Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2012*, 9.

[29] "Small Companion Satellite Will Chase After the Shenzhou 7 Orbital Capsule After Separation," (伴飞小卫星将"追赶"分离后的神七轨道舱), Xinhua, September 24, 2008, http://news.xinhuanet.com/newscenter/2008-09/24/content_10104787.htm; 'Shenzhou-7 Launches Small Monitoring Satellite,' *Xinhua*, September 27, 2008, http://news.xinhuanet.com/english/ 2008-09/27/content_10123015.htm; "Small Companion Satellite Will Take Photographs of Shenzhou 7," (伴飞小卫星将给神七"照相"), Xinhua, September 24, 2008, http://news.xinhuanet.com/newscenter/2008-09/24/content_10104656.htm.

[30] Brian Weeden and Victoria Sampson, eds., *Global Counterspace Capabilities: An Open Source Assessment*, April 2019, 1-2.

[31] Kevin Pollpeter, "China's Space Robotic Arm Programs," SITC News Analysis, October 2013, http://igcc.ucsd.edu/assets/001/505021.pdf.

[32] Patrick M. Shanahan, "Remarks by Acting Secretary Shanahan at the 35th Space Symposium, Colorado Springs, Colorado," April 9, 2019, https://dod.defense.gov/News/Transcripts/Transcript-View/Article/1809882/remarks-by-acting-secretary-shanahan-at-the-35th-space-symposium-colorado-sprin/

[33] Elaine M. Grossman, 'Top Commander: Chinese Interference with U.S. Satellites Uncertain,' *World Politics Review*, 18 October 2006, http://www.worldpoliticsreview.com/articles/267/top-commanderchinese-interference-with-u-s-satellites-uncertain

Computer network operations

China has also conducted computer network operations against US computer systems involved in space operations. According to NASA, in 2012 hackers traced to Chinese IP addresses gained "full access to key Jet Propulsion Laboratory [computer] systems and sensitive user accounts" and "full functional control over… networks," [34] although it is unclear whether the compromised networks were involved in the control of spacecraft. In November 2014, the National Oceanic and Atmospheric Administration (NOAA) reported that its agency's networks had also been compromised. Although NOAA did not identify the perpetrator of the attack, Congressman Frank Wolf stated that NOAA had told him that China was behind the hack.[35] If accurate, the attack suggests preparation by the Chinese military to deny important meteorological forecasting data not only to the US military, but also to civil weather forecasting agencies. More recently, cyber security company Symantec in 2018 revealed that attacks coming from Chinese IP addresses had targeted a satellite communications operator and a geospatial imaging and mapping organization.[36]

Jamming

China also has the ability to jam satellite communications and GPS receivers. The GPS signal, in particular, can be easily jammed [37] and even low-power jammers can be effective over distances of hundreds of kilometers.[38] According to DIA, "The PLA routinely incorporates jamming and anti-jamming techniques against multiple communication, radar systems, and GPS satellite systems in exercises. China continues to develop jammers dedicated to targeting SAR aboard military reconnaissance platforms, including low Earth orbit satellites.

[34] Statement of Paul K. Martin, Inspector General, National Aeronautics and Space Administration, "NASA Cybersecurity: An Examination of the Agency's Information Security," February 29, 2012, 5.

[35] Mary Pat Flaherty, Jason Samenow, and Lisa Rein, "Chinese Hack U.S. Weather Systems, Satellite Network," *Washington Post*, November 12, 2014, http://www.washingtonpost.com/local/chinese-hackus-weather-systems-satellite-network/2014/11/12/bef1206a-68e9-11e4-b053-65cea7903f2e_story.html.

[36] "Thrip: Espionage Group Hits Satellite, Telecoms, and Defense Companies," Symnatec, June 19, 2018, https://www.symantec.com/blogs/threat-intelligence/thrip-hits-satellite-telecoms-defense-targets.

[37] Congressional Budget Office, "The Global Positioning System for Military Users: Current Modernization Plans and Alternatives," October 2011, 4.

[38] Defense Science Board, "Report of the Defense Science Board Task Force on Tactical Air Warfare," November 1993, 12.

Additionally, China is developing jammers to target SATCOM over a range of frequency bands, including military protected extremely high frequency communications."[39]

Strategic Support Force

The PLA Strategic Support Force (SSF) is a functional command that unifies strategic-level space, cyber, and electronic warfare operations.[40] China's leader, Xi Jinping, has described the SSF as "a new type operational force to maintain national security" and "an important growth point" for the PLA's "new quality operational capability."[41]

The SSF has two subordinate operational departments: a Network Systems Department responsible for conducting strategic cyber and EW operations and a Space Systems Department responsible for space operations.[42] A major goal of the SSF appears to be to improve the PLA's joint operational capability by integrating strategic-level C4ISR and counter-C4ISR capabilities with service and theater command capabilities.[43]

More than three years after its founding, we still know relatively little about the SSF. The SSF does command China's space launch centers and satellite control centers. However, its role in coordinating or commanding the operations of civilian satellites and counterspace operations is unknown.

[39] Defense Intelligence Agency, "Challenges to Security in Space," 2019, 20.

[40] Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2017*, 1.

[41] Wang Shibin and An Puzhong, "Xi Jinping Confers Military Flags to Chinese People's Liberation Army Ground Force, Rocket Force, and Strategic Rocket Force,"习近平向中国人民解放军陆军火箭军战略支援部队授予军旗并致训词), *China Military Online*, (中国军网), January. 1, 2016, http://www.81.cn/sydbt/2016-01/01/content_6839896.htm.

[42]"Class-A Qualification List for Integrated Information System," (涉密信息系统集成甲级资质单位名录), National Secrecy Science and Technology Evaluation Center, (国家保密科技测评中心), http://www.isstec.org.cn/zzpg/zwsx/jgzz/zzml/352934.shtml.

[43] Defense Intelligence Agency, "Challenges to Security in Space," 2019, 14.

Implications for Coercion

China's increasingly capable space program raises questions about how China may use space as a part of a coercive campaign and whether the US can deter China from taking counterspace actions. According to acting Secretary of Defense Patrick Shanahan speaking at the 35th Space Symposium on April 9, 2019, "We are not going to sit back and watch. We are going to act. We are going to deter conflict from extending into space, and ensure we can respond decisively if deterrence fails."[44]

Any discussion of Chinese views on deterrence must first start with definitions. One source defines the Chinese term *weishe* (威慑), commonly translated as deterrence, as "the use of momentum or force to create submission."[45] Another source states that it is the use of "military strength and will to create pressure on the enemy's psychology in order to reach the goal of delaying or preventing combat."[46] According to the 2013 edition of the *Science of Military Strategy*, a book published by the Chinese military's top think tank, the Academy of Military Sciences, *weishe* is a "strategic activity of a country or political group for the purpose of achieving certain political goals to influence an opponent's strategic judgement in order to make them believe that goals will be difficult to achieve or that the cost of achieving them will be too high."[47]

Regardless of the specific definition, *weishe* is described as an "important means" to contain war, prevent escalation, and maintain peace.[48] It has two basic uses: to prevent the enemy from taking an action and to force an enemy to take an action.[49] Based on these discussions, the

[44] Patrick M. Shanahan, "Remarks by Acting Secretary Shanahan at the 35th Space Symposium, Colorado Springs, Colorado," April 9, 2019, https://dod.defense.gov/News/Transcripts/Transcript-View/Article/1809882/remarks-by-acting-secretary-shanahan-at-the-35th-space-symposium-colorado-sprin/

[45] Chen Jie. "Discussions of the Use of Deterrence in Preparation for Military Struggle." *University of Electronic Science and Technology of China (Social Science Edition)* 2006 04, 75.

[46] Jiang Yibin. "The Use of Information Deterrence and Joint Operations in Battle." *Journal of Xi'an Politics Institute*, 2011, 24(5), 32.

[47] *Science of Military Strategy*, 2013, 134.

[48] China Academy of Military Science Military Strategy Studies Department, *Science of Military Strategy* (战略学), Beijing: Military Science Press December 2013), 92 and Peng Guangqian and Yao Youzhi, *The Science of Military Strategy*, (Beijing: Military Science Publishing House, 2005), 215.

[49] Liu Huijun, "The China- India Border Dispute: A Study from the Deterrence Perspective," *South Asia Studies,* 2011 (3), 4.

concept of *weishe* takes on a broader set of measures than the Western concept of deterrence by including both deterrence and compellence measures. In Western literature, deterrence is defined as "prevention or discouragement, by fear or doubt, from acting."[50] Forcing a side to take an action, on the other hand, is referred to as compellence.[51] In short, deterrence is to prevent an action while compellence is intended to force an action. Taken together, deterrence and compellence are more broadly defined as elements of coercion.[52] However, whether the term is translated as coercion, deterrence, or compellence can depend on context.

According to Chinese sources, coercion is conducted to achieve a political goal by raising the threshold of war so that the costs of entering into armed action against China will exceed the benefits.[53] Coercion, therefore, involves controlling the other side's strategic evaluation, most importantly its assessment of risks and rewards. Chinese writers also describe coercion as conforming to Chinese strategic thinking and the Sun Zi concept of subduing the enemy without fighting.[54]

Role of space in coercion

Recently, Chinese writers have paid increasing attention to the role of space coercion. The 2013 *Science of Military Strategy* notes that modern society and military activities are increasingly dependent upon space systems, which increases the coercive value of the means to disrupt them.[55] It also advocates "constantly strengthening space deterrence capabilities, grasping different deterrence mechanisms, innovating deterrence methods" and upholding various principles to restrict adversaries' space interests, to counter activities that threaten China's own space security, and to form a strategic deterrent.[56]

---

[50] Gary F. Wheatley and Richard E. Hayes, *Information Warfare and Deterrence*, (Washington DC: NDU Press, December 1996), iv.

[51] Thomas C. Schelling, *Arms and Influence* (New Haven and London: Yale University Press, 1966), 70-72.

[52] Ibid., 71.

[53] *Science of Military Strategy* (2013), 133 and 135 and Wang Huan, Guo Yanying. "Conditions Strategic Selections for Our Country's Path of Peaceful Development," *International Forum*, March 12, 2010, 4.

[54] Gao Baoxi,. "The Value Selection of Military Deterrence," *Journal of Xi'an Politics Institute,* October, 2001, 88 and Liu Huijun, "The China- India Border Dispute: A Study from the Deterrence Perspective," *South Asia Studies,* 2011 (3). 3.

[55] *Science of Military Strategy* (2013), 181.

[56] Ibid., 85-187.

Coercion methods

Chinese writers discuss coercive activities and methods for use during times of peace and conflict. *Study of Space Operations* lists four types of coercive activities based on the intensity of the conflict, from peace to outright conflict.[57]

Revealing space forces[58]

During peacetime and the initial stages of a crisis, China may demonstrate opposition to an adversary's actions by revealing its own space forces and capabilities. This low intensity coercive activity can include counterspace tests.

Space military exercise[59]

If revealing space forces is not enough to deter an adversary or prevent a crisis from escalating, it may be necessary to conduct space military exercises. Exercises may demonstrate offensive, defensive, and supportive capabilities; current state of readiness; and operational resolve in order to demonstrate to an adversary the ability and resolve to win. These include ballistic missile defense exercises, counterspace exercises, and space war games.

Space force deployment[60]

As a crisis worsens, it may be necessary to deploy space capabilities. This includes deploying additional space assets or repositioning existing space assets.

Space shock and awe attack[61]

If the previous three non-violent coercive methods are insufficient to achieve China's goals, it could demonstrate its resolve by conducting a punitive strike that may be either kinetic or non-kinetic. The Chinese literature describes kinetic strikes as having more shock and awe value that can create psychological effects that can weaken an adversary's resolve. The 2013 *Science of Military Strategy* notes that China should cautiously consider the use of kinetic methods to warn an adversary to "prevent losing control of the situation and conflict escalation."[62]

[57] *Study of Space Operations*, 127-129.

[58] Ibid., 27

[59] Ibid., 127

[60] Ibid.

[61] Ibid.

[62] *Science of Military Strategy* (2013), 186.

Can China be deterred from attacking US space assets?

Whether China can be deterred from attacking US space assets is unknown. My own personal opinion is that a number of factors suggest that the ability of the United States to deter Chinese action against US space assets is limited.

The Chinese Communist Party's stake in successfully defending core interests

Although China is not a democracy, the Chinese Communist Party is aware that its continued rule requires maintaining its legitimacy with the Chinese people. This is most apparent in its commitment to maintaining economic growth and improving the economic situation of its citizens. Another component of this is defending China's perceived interests, including through the threat of or use of force. It is likely that the Chinese Communist Party leadership views success in an armed conflict as critical to maintaining its legitimacy with the Chinese people. This may result in the Chinese Communist Party being more forceful and less limited in the types of actions it is willing to take against the United States.

Importance of achieving information superiority and the view of space as the US military's Achilles' heel

A second factor that may limit the ability of the United States to deter Chinese attacks against space assets is the PLA's characterization of modern war. The PLA plans to fight what it calls "informatized local wars"[63] wherein information superiority—the ability to use information and deny its use to an adversary—is the key determiner of battlefield success.[64] In this respect, a central component of China's strategy is to conduct asymmetric strikes against an opponent by targeting critical C4ISR nodes, the debilitation or destruction of which would have decisive effects.[65]

---

[63] State Council of the People's Republic of China, *The Diversified Employment of China's Armed Forces,* April 2013, http://english.gov.cn/archive/white_paper/2014/08/23/content_281474982986506.htm

[64] Wu Changde, "Actively Adapt to the New System and Effectively Perform New Duties," (积极适应新体制 有效属性新职能), *China Military Science* (中国军事科学), no. 1 (2016). 37.

[65] *Science of Military Strategy* (2013), 127–29.

Chinese analysts conclude that space is a primary component of informatized local wars. Indeed, China's 2015 defense white paper states that space is a "commanding height in international strategic competition" and designates space as one of four critical warfighting domains, in addition to the maritime, cyber, and nuclear domains. Chinese analysts assess that the US military relies upon space for 70–90 percent of its intelligence[66] and 80 percent of its communications.[67] The reliance of the US military on space leads Chinese analysts to conclude that the loss of these capabilities could so debilitate the US military that it would be unable to achieve victory.[68] As a result, achieving space supremacy, including the use of counterspace capabilities against the US military, may play a central role in Chinese warfighting. The 2013 *Science of Military Strategy* for example, concludes that "achieving space superiority and cyber superiority are critical for achieving overall superiority and being victorious over an enemy."[69]

Emphasis on striking first

A third factor limiting the effects of US deterrence actions is China's strategy of active defense. Despite its name, active defense is strongly weighted towards offensive action. Within the context of the active defense strategy, Chinese policy states that military action is limited to the defense of China's core interests. But Chinese military analysts also write that offensive military actions, including preemptive strikes, are permissible when defending these core interests.[70]

The focus on seizing the initiative at the beginning of a conflict has led to an emphasis in Chinese writings on the concept of "gaining mastery by striking first" that takes into account preemption and surprise attack.[71] Indeed, numerous Chinese strategists emphasize achieving victory through surprise by striking at an unexpected time and place[72] and conducting the

[66] *Textbook for the Study of Space Operations* (空间作战学教程), 50.

[67] Chang Xianqi, *Military Astronautics* (军事航天学), (Beijing: National Defense Industry Press, 2002), 257–58.

[68] See, for example, Wang Liping and Zhang Ya, "Development of Space War Based on Space Operation Exercises," (从太空作战演习天战的最新发展), *Aerospace Electronic Warfare* (航天电子对抗), 27/3 (2011), 4–6, 13.

[69] *Science of Military Strategy* (2013), 96.

[70] See, for example, *The Science of Campaigns*, (战役学), Zhang Yuliang, ed., (Beijing: Military Science Press, 2006), 82.

[71] Peng Guangqian and Yao Youzhi, eds., *The Science of Strategy*, (Beijing: Military Science Press, 2001), 108-110.

[72] Ibid.

strongest first strikes possible.[73] These first strikes focus on an adversary's center of gravity[74] and are intended to have "a direct impact on the overall situation of the campaign or to produce an overall effect."[75]

The concept of "gaining mastery by striking first" is also apparent in Chinese military writings on space. The authors of the *Study of Space Operations* conclude that China will "do all it can at the strategic level to avoid firing the first shot,"[76] but recommend that China should "strive to attack first at the campaign and tactical levels in order to maintain the space battlefield initiative" and that the PLA should "conceal the concentration of its forces and make a decisive large-scale first strike."[77] Indeed, seizing the initiative in space is so important that the 2013 *Science of Military Strategy* states that wars may begin in space and cyberspace.[78]

Misguided assumptions

China's political and military leadership may also approve strikes against US space assets due to misguided assumptions or lack of deep analysis by their advisors.

- Chinese analysts do not discuss how space warfare can differ from other types of warfare. Although space debris is an acknowledged problem, the generation of space debris by kinetic attacks is infrequently acknowledged.
- Chinese analysts do not discuss China's own vulnerabilities that may lead it take actions without full knowledge of the consequences. For example, Chinese analysts do not discuss the PLA's growing vulnerabilities as it invests more in space.
- Chinese analysts do not discuss how tactical actions against individual satellites may trigger a broader space war.
- Chinese writings do not discuss the possible escalatory ramifications of attacking certain satellites, such as early warning satellites that the United States uses for nuclear warning.

---

[73] Dai Qingmin, *Integrated Network Electronic Warfare*, (网点一体战), (Beijing: Liberation Army Press, 2002), 57.

[74] He Dingqing, *A Course on the Science of Campaigns*, (Beijing: Military Science Press, 2001), 244.

[75] Wang Houqing and Zhang Xingye, eds., *The Science of Campaigns*, (Beijing: National Defense University Press, 2000), 90, 96.

[76] *Study of Space Operations*, 42.

[77] Ibid., 52.

[78] *Science of Military Strategy* (2016), 96.

- In the broader Chinese literature on coercion (as well as in discussions of space warfare), there appears to be an assumption that an adversary will back down after China escalates. There is no consideration that an adversary may become more invested in winning a conflict after China takes escalatory actions.

China views its use of force as more principled than the Western approach

A fifth factor influencing whether China can be deterred is China's view of itself as a more principled country than the United States and as a peaceful country that only fights wars of defense.[79] Although the case can be made that nations normally believe that they only fight just wars, the strong tendency of Chinese to believe that their country is more peace loving than other countries has led to a widespread belief in China in what Andrew Scobell calls the "Cult of the Defense."[80] This belief, coupled with a victimization narrative instilled in the Chinese psyche over foreign aggression and efforts by the Chinese Communist Party to convince the people that only it can return China to its rightful place in the global order may make it difficult for the Party to be able to ratchet down public demand to not back down from foreign conflicts.

[79] See, for example, State Council of the People's Republic of China, "China's Military Strategy," May 2015, http://english.gov.cn/archive/white_paper/2015/05/27/content_281475115610833.htm and State Council of the People's Republic of China, "China's Peaceful Development," September 2011, http://www.china.org.cn/government/whitepaper/node_7126562.htm

[80] Andrew Scobell, *China's Use of Military Force: Beyond the Great Wall and the Long March*, (New York: Cambridge University Press, 2003), 27.

Implications

Space plays a prominent role in China's efforts to establish a military capable of winning informatized wars through an asymmetric strategy directed at critical US military platforms. China's use of space-based C4ISR to enable long-range strikes, offensive space control measures to deny the acquisition of space-based C4ISR capabilities by an adversary, and cyber and kinetic attacks against other C4ISR nodes could delay the flow of US military forces to the region and hinder the ability of US military forces already in the region to conduct operations effectively. This strategy could be even more effective when coupled with the PLA's predisposition to gaining the initiative at the beginning of a conflict. These capabilities, when directed at less capable militaries, would have an even more salient effect on overall military operations.

China's space program leverages a dual-use strategy to meet national security objectives while fulfilling economic goals. As a result, even nominally civilian or commercial space activities can have military applications. This is due in part to the dual-use nature of most space technologies, but it is also due to an explicit strategy of civil-military integration. This approach is evident in solid-fueled rockets marketed for commercial space launch that can also generate operationally responsive space capabilities. Civilian remote sensing capabilities that can gather intelligence. Satellite navigation services offered to countries participating in the Belt and Road Initiative also serve PLA needs. The development of communication satellite constellations to deliver global communications and internet could also support the PLA presence globally. China's space program is thus one indicator of its growing economic influence and power projection capabilities.

While China's use of space to coerce other countries is growing, the ability of the United States to deter Chinese counterspace operations is less certain. This analysis has some important caveats, however, that should make us cautious about reaching definitive conclusions. PLA thinking on coercion and escalation may still be evolving, especially when applied to space warfare. Moreover, the attitudes of China's top political and military leaders towards risk are not well understood. Despite decades of study, the China-watching community still has an inadequate grasp of how China's political and military leaders make decisions.

Finally, space warfare can occur across a spectrum of capabilities, not all of which result in the destruction of US space assets. China could conduct localized jamming of satellite communications and the GPS signal or temporarily blind reconnaissance satellites as they orbit over Chinese territory. In short, China's counterspace actions could occur along an escalatory ladder that could require a range of responses from the US military.

Unfortunately, the lack of understanding of how China's political and military leadership reach decisions (and their level of risk tolerance) suggests that the United States should have a low level of certainty in its ability to deter China from attacking US space assets. This conclusion suggests that the United States needs to take steps to make its space-based C4ISR infrastructure less vulnerable. These steps include increasing redundancy by creating a more distributed satellite network, increasing resiliency by hardening satellites to attack, developing defensive and offensive space control capabilities, and lessening the US military's dependence on space-based systems.

This report was written by CNA's China and Indo-Pacific Security Affairs Division (CIP).

CNA's China and Indo-Pacific Security Affairs Division provides its sponsors with timely, data-based analyses on a wide range of security issues across the Indo-Pacific region, providing decision-makers the context they need to make informed choices and plans.

3003 Washington Boulevard, Arlington, VA 22201

www.cna.org • 703-824-2000

CNA is a not-for-profit research organization that serves the public interest by providing in-depth analysis and result-oriented solutions to help government leaders choose the best course of action in setting policy and managing operations.

OPENING STATEMENT OF MARK STOKES, EXECUTIVE DIRECTOR, PROJECT 2049 INSTITUTE

MR. STOKES: Ms. Chairman, Vice Chairman, members, it's an honor and a pleasure to be back to present before you again today. Actually, it's been a year or two, I think. Admiral, good to see you, as always. My written statement can, I think, stand on its own. What I thought I'd do is extract some of the more relevant elements and condense those and present those here this afternoon.

Three parts. First, I'll talk a little bit about the military space ecosystem. Secondly, address or re-introduce an issue on space and counterspace command and control. And then, finally, address the issue generally of the PLA's research, development, and acquisition system.

Starting with the military space ecosystem, it's been well-documented, Kevin among others has done very well in terms of establishing some of the structure of the PLA Strategic Support Force.

What I thought I'd do is emphasize how significant this restructuring is, and the potential operational effects that this has. In years past, before December 2015, the space enterprise was relatively -- it was centralized within the former General Armaments Department, China Launch and Tracking Control General, CLTC for short.

They did the launch tracking and control, as well as the maritime tracking control function. That aspect has remained intact. But what they've done is integrated and brought over elements that were under the old General Staff Department, particularly the Operations Department and Intelligence Department.

For example, the rough counterpart to the National Reconnaissance Office, bringing that over and integrating that with the former CLTC, as well as aspects that used to be under the Operations Department. So, for example, the meteorological, hydrological, you know, the maritime satellite aspects, as well as some of the signals intelligence, or, in Chinese lexicon, their technical reconnaissance aspects.

Centralized all these under one particular force, the Strategic Support Force. Along with this, they've established an architecture, because now the PLA's Strategic Support Force has the Standards Department, the PLA Strategic Support Force Staff Department, their Political Work Department and then Logistics Department.

But, added to this, are the two key subsystems for operations. One is the Space Systems Department and then the Network Systems Department. The Space Systems Department similarly has a staff department and then a political work department, and then a logistics department, and then an equipment department. The most relevant here is going to be the staff department, and then the equipment departments. Underneath the Space Systems Department you're going to have the system of bases, the same bases you've had for quite a while. The base out in Jiuquan and then Taiyuan, Xichang, and then of course Wenchang, which generally, I think, is assumed to be subordinate to Xichang for geosynchronous launches.

But also you have two tracking control bases, each one of these bases roughly equivalent to an army corps or slightly smaller. So these are fairly large establishments. But you have a tracking and control base headquartered in Xichang, and then a maritime, you know, the Yuan Wang ships headquartered out in the eastern part of China.

But what you also have now is the establishment of two -- possibly -- the establishment of two bases, corps level organizations, that are dedicated to space applications. One, notionally -- there's not a lot of information on either one of these yet. But, notionally, you can say one

dedicated to sort of like the ground segment of BeiDou or survey mapping and navigation, and the other one for all others category. Let's say, for example, the old PLA General Staff Department, Intelligence Department, you know, their version of NRO, bringing that over for operations.

But that's only on the space systems side. The network systems department has a potential counterspace role. The kinetic kill vehicle aspects of counterspace gets a lot of attention and there's been a lot of reporting on that. But within the new network systems department they've brought over the old -- their rough version of the National Security Agency, but also merged that with a strategic command, the former Fourth Department, which is responsible for electronic countermeasures and radar systems.

This is significant because one of the most, in terms of doing some preliminary research into this, this is significant because the electronic countermeasure aspects of countermeasure, I think, are significant, if not maybe, you know, if not perhaps the most significant and emphasized part of their counterspace infrastructure.

It's not just for electronic counter-measures, but you also look at the directed energy weapon aspect, high-powered laser. There are indications, it's not confirmed yet, indications that there is a new base under the network system department that has brought in different parts of the ECM system and integrated it with what used to be a testing and training site for high-powered lasers and high-powered microwave, those sorts of exotic systems, under one particular command. That's something to be watched.

On command and control, put simply, this is a big question. Command and control, operational command and control for routine launches, probably is not an issue. But when it comes to counterspace issues, it probably would be a key question, as to how those -- who would order, for example, the jamming of a U.S. satellite or, even more significant, the launch of a kinetic kill vehicle to go after a U.S. satellite, and how that system would work vertically.

But also very significant, the PLA Strategic Support Force probably plays a significant role in the Central Military Commission joint operations command center itself, when you look at all the different functions inside.

I will save the research, development, and acquisition system remarks for another time.

But I will say that it is significant in terms of the achievements they've made in reducing the time that it takes to go from a concept all the way out to production and operation. Thank you very much.

PREPARED STATEMENT OF MARK STOKES, EXECUTIVE DIRECTOR, PROJECT 2049 INSTITUTE

Prepared Statement of
Mark A. Stokes
Executive Director
Project 2049 Institute
Before
The U.S.-China Economic and Security Review Commission

Hearing on "China in Space: A Strategic Competition?"

Thursday, April 25, 2019

Dirksen Senate Office Building, Room 419
Washington, DC

Chairman, Vice Chairman, and members of the U.S.-China Economic and Security Review Commission, thank you for the opportunity to participate in today's hearing. It is an honor to testify on an issue that is important to U.S. interests in peace and stability in the Indo-Pacific region. The evolving capacity of the People's Republic of China (PRC) to leverage space assets presents challenges for the United States, allies, and friends in the region. Today, China is second only to the United States in the number of operational satellites. In my presentation, I will address Chinese investment into military space and counterspace capabilities, and potential effects on the U.S. ability to project power in the Indo-Pacific region.

Buoyed by successes in its lunar exploration and manned space programs, the PRC is emerging as a leading space player. China's space enterprise is complex. It encompasses organizations in the People's Liberation Army (PLA), defense industry, and commercial sector. In early 2016, the PLA initiated an ambitious reform and reorganization program intended to mold a joint force capable of fighting and winning future wars. The restructuring has consolidated military space capabilities under a single command – the PLA Strategic Support Force (PLASSF). The PLASSF, supported by a robust defense industrial establishment, is gradually improving China's capacity to project military power vertically into space and horizontally beyond its immediate periphery. Senior civilian and military leaders view the aerospace sector – the space and missile industry -- as one aspect of a broad international competition in comprehensive national strength and science and technology (S&T).

The historical legacy of China's space and missile program, along with a record of success, underpins its space ventures. Its unique organizational and management system sets China's space program apart from other defense industrial sectors. Moreover, the special status of the space industry and military requirements of its primary customers—the PLASSF, PLA Navy, PLA Air Force, and PLA Rocket Force – are driving growing investment to sustain this burgeoning industry. With increasing access and ability to leverage technologies, Beijing is building up its space technology base to ensure a nuclear retaliatory capability, promote the legitimacy of the Chinese Communist Party (CCP), and enforce sovereignty and territorial disputes at lower cost.

Among the strategic drivers, perhaps most prominent is the ability to use force against Taiwan decisively and, by extension, complicate U.S. and other foreign intervention. China also is

developing the capacity to enforce its territorial claims in the East and South China Seas. The PLA's ability to strike targets is likely restricted by the range of its persistent surveillance. To expand its battlespace awareness, the PLA is investing in space-based command, control, communications, computers and intelligence, surveillance, and reconnaissance (C4ISR) capabilities that could enable it to persistent situational awareness of activities in the Western Pacific, South China Sea, and Indian Ocean.

Space-based assets would serve as a critical component of a broader C4ISR architecture. China is fielding increasingly sophisticated electro-optical, synthetic aperture radar, and electronic reconnaissance capabilities. Additional data relay satellite systems or the expansion of ground stations abroad could further improve China's near-real-time targeting capability. The PLA also has been modernizing its satellite communications infrastructure, space-based survey, mapping, and navigation systems, and an increasingly diverse range of space launch vehicles.

In addition, a growing body of Chinese military-technical literature addresses a requirement for a counterspace capability. Technology demonstration testing of kinetic kill vehicles, high-powered lasers, co-orbital satellites, electronic jamming, and, possibly, cyber attacks reportedly have been carried out since at least 2005. The opacity of China's space programs suggests other clandestine counterspace weapons programs may also exist.

The PLA Space/Counterspace Ecosystem

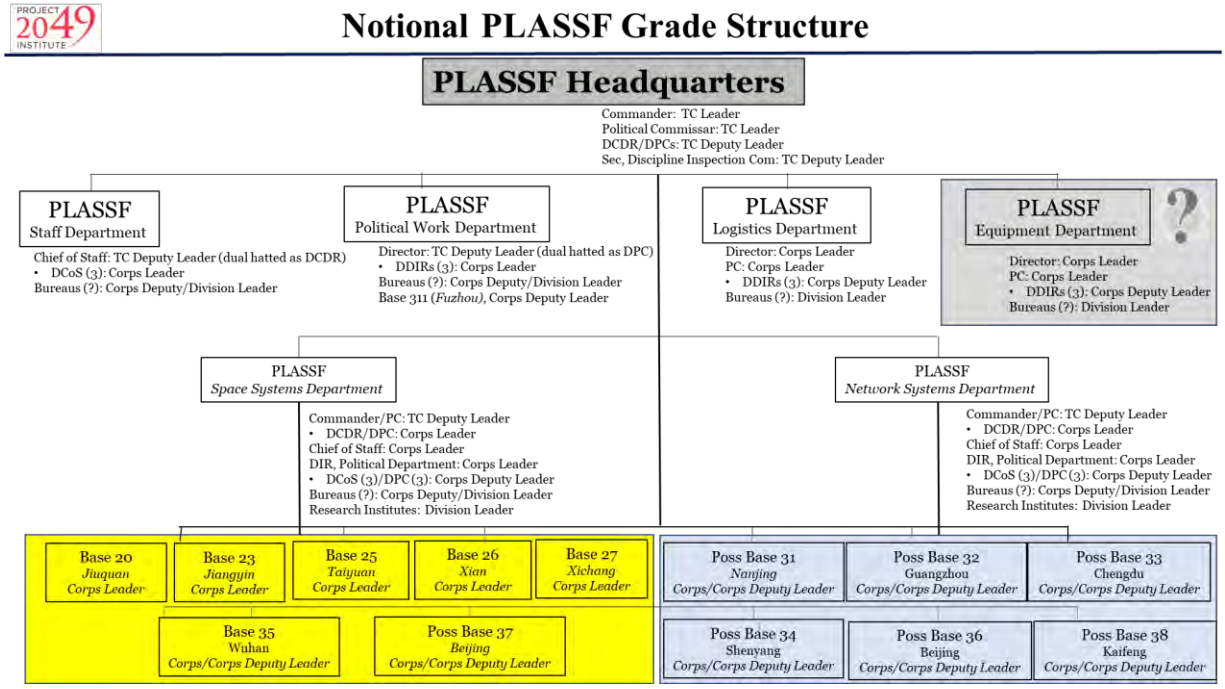
The PLASSF, established in December 2015, is central to China's ability to compete in space. The PLASSF's first-level departments — Staff, Political Work, Logistics, Space Systems, and Network Systems — are responsible for structural integration of space and network operations. The PLASSF Space Systems Department was created through the merger of the former General Armaments Department (GAD) China Launch and Tracking Control General (CLTC) and space-related organizations previously under the General Staff Department (GSD) Operations Department and GSD Intelligence Department.[1]

The Space Systems Department oversees at least six corps or corps deputy leader-grade operational commands responsible for space launch, tracking, and control. The PLASSF tracks and controls space assets through the Xian Satellite Control Center (Base 26) and the Beijing Space Command and Control Center in the northern suburbs of Beijing, which integrates space tracking data from ground- and sea-based units. Three corps leader-grade space launch base commands in Jiuquan (Base 20, aka Shuangchengzi), Taiyuan (Base 25, aka Wuzhai), and Xichang (Base 27). Base 27 probably oversees the launch complex on Hainan Island. These space

[1] For background on the PLASSF, see Kevin L. Pollpeter, Michael S. Chase, and Eric Heginbotham, *The Creation of the PLA Strategic Support Force and Its Implications for Chinese Military Space Operations* (RAND Corporation: Wash DC, 2017); Elsa Kania, "PLA Strategic Support Force: The 'Information Umbrella' for China's Military," *The Diplomat*, April 1, 2017; Rachael Burton and Mark Stokes, "The People's Liberation Army Strategic Support Force Leadership and Structure," Project 2049 Occasional Paper, September 25, 2018, at https://project2049.net/wp-content/uploads/2018/09/180925_PLA_SSF_Leadership-and-Structure_Stokes_Burton.pdf; John Costello and Joe McReynolds, "China's Strategic Support Force: A Force for a New Era," *China Strategic Perspectives* (Issue 13), October 2, 2018, at https://ndupress.ndu.edu/Media/News/Article/1651760/chinas-strategic-support-force-a-force-for-a-new-era/.

launch centers also support ballistic missile and kinetic space interceptor testing. The end user of anti-satellite (ASAT) kinetic kill vehicles remains unclear.

Other base commands are responsible for space tracking and control. The Xian Satellite Tracking and Control Center (Base 26) is a corps leader grade organization responsible for ground-based space tracking, telemetry, and control. Although unconfirmed, Base 26 may oversee the Beijing Space Flight Command and Control Center and its subordinate entities. The China Satellite Maritime Tracking and Control Department (Base 23, Jiangyin) is a corps leader-grade organization that is responsible for sea-based satellite tracking, control, and launch vehicle transportation to Hainan.



The PLASSF Space Systems Department integrates the launch, tracking, and control of satellites with the services these systems provide. New corps deputy leader-grade base commands responsible for space applications have been formed in Beijing and Wuhan. These bases may have integrated ground segment operations managed by division leader-grade units previously subordinate to the General Staff Department, including the former GSD Intelligence Department (GSD Second Department, or 2PLA) Space Reconnaissance Bureau. Roughly analogous to the U.S. National Reconnaissance Office, the former Space Reconnaissance Bureau is responsible for processing and distributing downlinked electro-optical (EO) and synthetic aperture radar (SAR) imagery. The bases may also have absorbed portions of the former GSD Operations Department Survey and Mapping Bureau (including the Beidou ground segment), former GSD Operations Department Weather and Oceanography Bureau, GSD Informatization Department satellite communications (SATCOM) command, and the former GAD Data Relay Satellite Control Center.

Potentially supporting counterspace missions, the PLA and supporting defense industry appear to have tested systems capable of space rendezvous and proximity operations. For example, the Shijian-12, boosted by a Long March-2D from Jiuquan on June 15, 2010, is believed to have carried out a space rendezvous mission. Shijian-15 and Shiyan-7 satellites, launched from Taiyuan on a Long March-4C on July 20, 2013, reportedly carried out space debris mitigation testing. The Aolong-1 "Roaming Dragon" was launched from Hainan on a Long March-7 on June 25, 2016. The Shijian-17 was boosted by Long March-5 from Hainan to a geosynchronous orbit on November 3, 2016. In addition to demonstrating new technology as a communications platform, the satellite also is capable of space-based optical observation of space debris.

The PLASSF Network Systems Department is central to China's counterspace mission. The Network Systems Department incorporated the former GSD Electronic Countermeasures and Radar Department (also known as the GSD Fourth Department) and former GSD Technical Reconnaissance Department (GSD Third Department). Before the reorganization, the former GSD Fourth Department oversaw two electronic countermeasures (ECM) brigades and a satellite ECM command headquartered in Beijing's northern suburbs. The two ECM brigades consisted of subordinate battalions distributed throughout eastern China. Technical articles published by members of the satellite ECM command suggest the unit, at least in part, is responsible overseeing research, development, and acquisition of electronic counterspace systems. The command oversees at least one regimental-level unit on Hainan Island. The former GSD Third Department oversaw a division leader-grade unit, headquartered in Shanghai, responsible for intercept of SATCOM and SAR transmissions. Equipped with at least one large phased array radar system, the unit presumably supports China's space surveillance network.

The Network Systems Department possibly may have established a new PLASSF corps deputy or division leader-grade base command in Henan's Kaifeng City. While speculative, the base could integrate the two former GSD Fourth Department ECM brigades, satellite ECM command, directed energy counterspace capabilities, and testing and training functions. Within the next five years, the PLASSF is expected to field a ground-based directed energy system capable of dazzling electro-optical reconnaissance satellites in low earth orbit. The former GAD Base 21's New Technology Testing Department was responsible for R&D and testing of advanced directed energy systems, including high powered microwave and lasers. The PLASSF Electronic Equipment Test Center (former GAD Base 33), headquartered in Luoyang, has been noted carrying out research into advanced technologies for countering U.S. early warning satellites.

Counterspace operations at the theater level remains unclear. PLA Army, Air Force, and Navy components under each of the five Theater Commands oversee ECM brigades. Specialized battalions under Theater Command ECM brigades, trained and equipped for counterspace missions, are possible. In addition, the PLA manages offensive cyberspace capabilities that could support military operations against space-based assets.

Space/Counterspace Command and Control

The Central Military Commission (CMC) presumably exercises control over PLASSF space/counterspace operations through the CMC Joint Operations Command Center. The CMC Joint Staff Department Operations Bureau probably manages the center's day-to-day operations.

However, PLASSF officers reportedly perform rotational duty within the Joint Command Center. Operations duty officers would be responsible for transmission of operational orders and coordination with PLASSF Command Center duty officers in Beijing. The PLASSF Command Center is probably staffed by the PLASSF Staff Department, with a deputy chief of staff serving as the chief duty officer. Officers from the PLASSF Space Systems Department Staff Department probably man an intermediate command center. While unclear, the PLASSF Space Systems Department Command Center likely would be separate and distinct from the PLASSF Beijing Space Flight Command and Control Center.

PLASSF officers may also provide critical command support functions at higher readiness levels. As part of the reform and reorganization, CMC Joint Operations Command Center leaders have direct authority over 10 cells, or groups (*dadui*) responsible for mission planning, battlespace situational awareness, survey and mapping, navigation (eg. Beidou), network/electronic countermeasures, spectrum management, airspace management, meteorology and hydrography, and communications. PLASSF officers presumably are assigned duty within these functional cells during higher readiness levels, or perhaps even under normal conditions. Newly established PLASSF corps-level units suggest possible direct operational support to Theater Command leaders in contingency.

Military Space/Counterspace Research, Development, and Production

The PLASSF military space and counterspace operations depend upon a research, development, and acquisition (RD&A) system capable of fielding increasingly sophisticated systems. The PLASSF's RD&A system is guided by general policies promulgated by the CMC Equipment Development Department (CMC/EDD) and supported by the CMC Science and Technology (S&T) Commission, Academy of Military Science (AMS), China Academy of Sciences, and the State Administration for Science, Technology, and Industry for National Defense (SASTIND). The CMC/EDD administers China's manned space program while SASTIND reportedly manages the lunar exploration program. The CMC Science and Technology Committee manages specialized space-related expert working groups, and guides technology development laboratories within the defense industry and academic institutions. Expert working groups have been increasingly able to leverage expertise from across China's S&T community and break down institutional barriers that have inhibited technological progress to date.

The PLASSF Space Systems Department Equipment Department is responsible for drafting of technical requirements for military space systems. However, the PLASSF relies heavily upon two state-owned defense industrial establishments engineering R&D and manufacturing of space and counterspace systems -- the China Aerospace Science and Technology Corporation (CASC) and China Aerospace Science and Industry Corporation (CASIC). CASC is China's primary supplier of satellites and large launch vehicles, while CASIC appears to serve as a lead systems integrator for tactical microsatellite and space intercept systems. The China Electronics Technology Corporation (CETC) likely supplies the PLA with satellite sensor sub-systems. Under joint CMC and State Council sponsorship, defense industry and civilian universities are exploring more advanced means of space transportation, such as trans-atmospheric vehicles.

CASC/CASIC academies may compete for PLA-sponsored R&D and manufacturing contracts. For example, the CASC First Academy (China Academy of Launch Technology, or CALT) and CASC Eighth Academy (Shanghai Academy of Space Technology) launch vehicle products (e.g., LM-2C and LM-4D) appear to compete for launch of small remote sensing satellites. The CASC Fifth Academy (China Academy of Space Technology, or CAST) and CASC Eighth Academy may compete on certain satellite programs. Specific research institutes with CETC may compete for counterspace R&D contracts. Competition may also drive defense industrial enterprises to seek cooperative ventures with foreign partners. Cooperation includes satellite sales and launch services, space-related technical exchanges between universities supporting military R&D, and establishment of ground stations overseas.

Presumably influenced in part by the U.S. Planning, Programming, and Budgeting System (PPBS) and Soviet design system, basic principles for China's space-related RD&A were established in the 1960s and, with some exceptions, appear to have changed little over time. How much China spends on military space/counterspace R&D remains unclear. Based on CMC/State Council planning, programming, and budget guidance, PLASSF-managed space systems R&D may consist of four phases, with variants of the same basic space system in the R&D cycle at any one time.

Preliminary research is focused on initial development of basic technologies that eventually could be applied to multiple programs. A strong preliminary research program helps reduce engineering R&D time and risk. Preliminary research can also focus on technologies applicable to a specific system, for instance, a movable spot beam antenna for a communications satellite or a new launch vehicle propulsion system. Funded in part through national-level technology development efforts such as the 863 Program, the CMC/EDD, CMC S&T Commission, PLASSF, and other end users function as important supervisory bodies for projects in this phase.

The PLASSF leverages universities and commercial enterprises to support basic and applied research on military space and counterspace systems. CMC/State Council military-civil fusion policies play a prominent role in facilitating collaboration. Among the most prominent civilian academic organizations supporting basic and applied research into space technology include the Nanjing University of Aeronautics and Astronautics, Harbin Institute of Technology, Northwest Polytechnical University, Beijing University of Aeronautics and Astronautics, and Huazhong University, just to name a few.

During the *concept development and program validation phase*, the PLASSF Space Systems Department and Network Systems Departments, working in conjunction with defense industry, identify key technologies, determines the feasibility of a program, and assesses alternatives that could meet basic operational and technical requirements. The program validation phase draws heavily on results from preliminary research projects. PLASSF research institutes, supported by a restructured AMS, appear to play a major role developing concepts and validating major space/counterspace R&D programs.[2] Major programs likely require CMC/State Council-level approval before investing in engineering R&D.

[2] PLASSF research institutes and centers supporting space/counterspace program validation may include the Space Equipment Integrated Technology R&D Center (former GAD Space Equipment Bureau); Weapons and Equipment Validation Research Center (former Beijing Institute of Systems Engineering; BISE); Beijing Institute of Tracking and

During the *engineering R&D phase*, CASC and CASIC support the CMC/State Council and PLASSF in the R&D and production of space and counterspace systems. CASC and CASIC research academies specialize in certain space-related core competencies, such as heavy lift launch vehicles, tactical solid fueled launch vehicles, and satellites. A research academy is roughly analogous to a US defense corporate business division. CASC/CASIC academies are organized into design departments (or systems engineering institutes); research institutes focusing on sub-systems, sub-assemblies, components, and materials; testing facilities; and manufacturing plants.

CASC is China's primary supplier of satellites and large launch vehicles, while CASIC appears to serve as a lead systems integrator for tactical microsatellite and space intercept systems. Other defense industrial enterprises, such as the China Electronics Technology Corporation (CETC), may supply sub-systems, such as space-based electronic reconnaissance receivers or data links. Increasingly accountable for profit and loss reporting, trends indicate growing competition between research academies in securing R&D and manufacturing contracts.

Engineering R&D programs are managed through a dual command system that divides administration and technical responsibilities. Administrative responsibilities reside with a program manager, while technical aspects of a program are the responsibility of the chief designer and his/her design team. The program manager, or literally *general commander*, ensures timeliness standards are being met, quality is assured, schedules testing, and manages the program budget. Program managers of major satellite and launch vehicle projects often are dual hatted as deputy directors of CASC research academies.

Members of the technical design team appear to have concurrent positions within an academy's design department and research institutes. For example, chief designers of major satellite programs usually hold concurrent positions within the CASC Fifth Academy General Design Department and CASC Eighth Academy's Institute of Satellite Engineering. Chief designers are also assigned for space launch vehicles, including those delivering anti-satellite kinetic kill vehicles. Chief designers of major electronic counterspace programs may reside within CETC's systems engineering department and specialized research institutes. To ensure requirements are met, PLASSF end users probably maintain industrial representative offices within CASC and CASIC design departments, research institutes, and factories.

During the *design finalization phase*, end users and industrial program managers evaluate whether a design satisfies operational and technical requirements. For major programs, a design finalization committee is comprised of members of the CMC and State Council (Premier or Vice Premier). A joint CMC-State Council standing office appears to support the design certification committee.

Telecommunications Technology (BITTT); Beijing Institute of Remote Sensing Information (under the former GSD Second Department Space Reconnaissance Bureau); Jiangnan Institute of Remote Sensing Applications (under the former GSD Third Department 12th Bureau); 54th Research Institute (North Institute of Electronic Equipment); 56th Research Institute (Jiangnan Institute of Computing Technology); 57th Research Institute (Southwest Institute of Technology Electronics and Telecommunications); Beijing Institute of Applied Meteorology; and the PLASSF Information Engineering University Geospatial Information Academy.

Conclusion

The PLA has the potential to rival the United States in key areas of space technology by 2035. U.S. space assets, including space command and control facilities, are or likely will be vulnerable to disruption by China. Counterspace operations may target the communications, reconnaissance, and global positioning satellites upon which U.S. depends for force projection. Chinese space systems may have the ability to rendezvous or physically interfere with U.S. space assets.

Given the PLA's ambitious military modernization and uncertain strategic intent, China's focus on space technology is of great concern to American strategists. In short, the PLA is embarked on a concerted effort to develop competitive advantages in selected high technology industries, and space in particular. While China has achieved successes in testing and deploying advanced space and counterspace systems, questions remain over the direction of its technology development and potential operational effects. An increasingly congested, contested, and competitive outer space underscores the need for a better understanding of the opportunities and challenges that arise from advances in expanding Chinese access to this unregulated global common. Furthermore, the United States' future as a leader in the Asia-Pacific region is linked with its ability to maintain a competitive edge in power projection capabilities that depend upon uninterrupted access to the space domain.

OPENING STATEMENT OF JONATHAN RAY, RESEARCH DIRECTOR, SPECIAL PROGRAMS DIVISION, SOS INTERNATIONAL LLC

CHAIRMAN BARTHOLOMEW: Jonathan.

MR. RAY: First of all, I thank the Commission for having me today. It's an honor to be invited back. My testimony today focuses on the PLA strategy and activities in the space and cyber domains, and looking at those two in particular.

There are three issues that I want to highlight today for you all. First is that China views space and cyberspace as two closely interlinked parts of a broader information domain that it wants to dominate and deny its adversaries.

Two is that China's military space doctrine is aggressive, and that its capabilities are advanced enough that I think it's likely that China would conduct cyberattacks against U.S. space assets in any conflict.

And, finally, the creation of the Strategic Support Force, as Mark described, demonstrates the Chinese political and military's leadership to operationalizing this strategy.

First, China takes a very holistic approach to the broader information domain. That encompasses space, cyber, and electromagnetic domains. Now, the streams of information data for modern military systems rely on all three of these domains. Many PLA writings actually don't use "cyber," but rather use the word "network," to reflect the broader networks of systems that are all in play. Future conflicts will be a confrontation of such systems, with each relying on linkages between computers, satellites, sensors, and other information assets.

In this context, the early goal of any strategy is superiority in both domains to maintain intelligence flows and operating systems while attacking the adversaries. They write that space in particular has a "decisive effect on the traditional domains of land, air, and sea."

Now, these assessments are not a recent development but rather a culmination of a quarter century of Chinese military thinking. Their assessments of this information domain started right after the 1991 Gulf War. Then, later in Kosovo, they saw how C4ISR capabilities provided a decisive advantage to U.S. military and allied forces.

Before long, the PLA strategic thought shifted towards determining how best to prepare to fight and win informatized wars. China's defense white paper in 2015 issued the military strategic guideline of "winning local informatized wars," and declared outer space and cyberspace in particular to be "the new commanding heights in strategic competition among all parties." So, obviously, they think space and cyberspace are pretty important.

Second, on whether or not China would conduct cyberattacks on U.S. satellites, I think it's useful to think through the problem deductively, and look at it as a question of motivation, means, and opportunity. On motivation, they clearly think of space as important, and, from what the military writings that I have read show, China's military doctrine on cyberattacks in particular is pretty aggressive.

In my reading, they see the U.S. military as overly-dependent on satellites for C4ISR capabilities. Based on this dependency, China strategy planners, I think, assume that threatening degrading and destroying such systems would force the United States to stand down or face tremendous delays getting forces into theater in any crisis or conflict.

Cutting off information flows would disrupt any forces in theater, and negate advantages of standoff weapons like long-range precision strike systems that are dependent on data flows. When one source describes "strategic level cyber-deterrence," the first example they use is threatening C4ISR capabilities. That, to me, is significant.

PLA writings also describe cyberattacks as a "soft kill method" that's not as escalatory as a hard kill or kinetic attack. Hacking and disabling a satellite or a ground station doesn't produce debris 2007 ASAT test or the recent Indian test did.

Cyberattacks are also better for concealment and surprise. They can paralyze a whole system instead of negating one asset, and can interfere with basic operations like communications, intelligence, and guidance and navigation. So, to me, the motivation to strike these systems is clearly there.

The next question is whether China has the means to conduct such cyberattacks or even hijack a satellite. Back as early as 2007, I've read some PLA authors speaking candidly about hackers can use satellite signals to take over a schematic control network, and then give commands over a basic internet connection.

That year, and in 2008, as Kevin already described, hackers took control over but refrained from issuing commands to NASA and USGS satellites. In the last few years, Chinese media has also reported on a team's hacking of DoD satellites by stealing user credentials. So, from their standpoint, it does look technically feasible.

At the same time, we've also seen hacks of government groups like NOAA and the NASA Jet Propulsion Laboratory, and last year Symantec reported on a hacking campaign against satellite operators, defense contractors, and telecommunications companies in the United States and Southeast Asia.

So, in my view, if you couple intelligence on the satellite specs and operations with China's rapidly advancing capabilities in telemetry, tracking, and control, I think China clearly has the means to conduct cyberattacks against U.S. satellites.

And then finally on opportunity. The PLA authors openly describe the inherent vulnerability of satellite antennas as being exposed, open, and frail. In other words, when a satellite is that far away and has to transmit that much data, it's very, very hard to harden against a lot of attacks.

Moving on to my third point, it's just looking at the creation of China's Strategic Support Force. And, to me, the SSF looks like a true political and military commitment to operationalizing this holistic approach to information warfare.

I'm not going to go into the details that Mark did. The big takeaway, to me, is that instead of having the space and cyber missions chopped up across competing parts of the bureaucracy of the PLA, this whole organization is structured around the domains themselves.

Now, that structure, to me, is incredibly significant, because it could provide China's leadership with one centralized entity for a whole suite of options across all of these domains. That, to me, is a scalable model, where you can look at it scaling across domains, and you can also potentially see it scale across the world as China's interests expands and they decide what role the SSF will have for securing China's interests abroad.

And then, finally, one or two quick observations, and the recommendations you can read in my written remarks. One observation is that the threat is not limited to U.S. military satellites. Civilian satellites are very much in play, and I think that's very apparent in their writings.

Two is that there's a glaring lack of awareness that China might also be vulnerable to these very same issues. As they launch more birds and they rely on more satellites, you would think that they would think about these issues, because they've been thinking about how to attack them for a very long time. That, to me, is interesting.

On the recommendations, just three key quick takeaways. One is incredibly self-serving. We need to continue to monitor these developments and have, you know, guys like Kevin and

maybe even me continue to write reports about the SSF and China's information operations writ large.

Second is just resiliency in C4ISR capabilities. In any conflict or anything, the U.S. military will operate under degraded information conditions. We have to be prepared. Finally, the last panel covered it, but I think that the supply chain issue is fundamentally -- it's very important.

I think that having half of the DoD's microelectronic supply chain being sourced from China is a major, major problem. With that, I look forward to the questions and discussion.

PREPARED STATEMENT OF JONATHAN RAY, RESEARCH DIRECTOR, SPECIAL PROGRAMS DIVISION, SOS INTERNATIONAL LLC

Prepared Statement before the U.S.-China Economic and Security Review Commission

Hearing on "China in Space: A Strategic Competition?"

April 25, 2019

Jonathan S. Ray
Research Director
Special Programs Division
SOS International LLC

I would like to thank Chairman Bartholomew, Commissioner McDevitt, and other members of the Commission for inviting me to speak today. It is an honor to be invited back.

My testimony focuses on the PLA's strategy and activities in the space and network (or cyber[1]) domains, and their implications for strategic competition between the United States and China in those domains. To me the top issues for strategic planners and policymakers are:

- China's holistic view of the space, network, and electromagnetic domains as part of a broader information domain;
- An aggressive military doctrine for China to use network attack methods against U.S. space assets in steady state and early in any conflict; and
- The implications and challenges posed by the creation of the Strategic Support Force (SSF).

I conclude with recommendations for Congress that prioritize constant monitoring of Chinese activities in the information domain and resiliency for U.S. C4ISR capabilities.

How China Views the Space and Network Domains

China considers the space and network domains to be closely interlinked, with both being part of a broader concept they call the 'information domain'.[2] The information domain refers to the streams of information and data that underpin all modern systems relevant to a military conflict. It contains "systems of systems" built on and dependent upon network linkages between computers, space assets, sensors, and other information assets. This type of confrontation requires space superiority (制天权) and network superiority (制网络权), or the enabling of one's own operations in these domains while denying them to an adversary. In any future conflict, "seizing space superiority and network superiority will be key to obtaining comprehensive superiority on the battlefield."[3] Space superiority is particularly important, as it has "a decisive effect on network

[1] Although many Chinese sources may use the Western term "cyber" (赛博 / *sai bo*), most military writings use "network" (网络). While the definitions largely match, the PLA definition of "network" emphasizes the widespread end-users and nodes comprising networks, making it a useful term and construct for the information domain that comprises myriad platforms across multiple domains.

[2] The electromagnetic domain is also part of this broader information domain. Though my comments focus only on two legs of this information triad, it is impossible to understate the importance of electromagnetic means affect both.

[3] Shou Xiaosong, ed., *The Science of Military Strategy* (Zhanlue Xue / 战略学), Beijing, AMS Press, 2013, p. 96. The *Science of Military Strategy*, published by the Academy of Military Science, is a military teaching text and reference material for senior PLA officers, and offers authoritative views of PLA strategy. Another version, published in 2015

spaces and other military domains," and without it the dominance of any other domains is out of the question.[4]

China's emphasis on dominance in both domains traces back to the 1991 Gulf War, when it observed the role of C4ISR capabilities in the U.S. military's decisive victory. This interest grew when the role of satellites in U.S. C4ISR capabilities became even more apparent in the Kosovo War. Chinese military theorists described these conflicts as constituting a new 'informatized' mode of warfare, in contrast to the previous 'mechanized' mode. Before long PLA strategic thought shifted toward determining how best to prepare for fighting and winning informatized wars. In 2004, then paramount leader Hu Jintao issued the PLA its 'New Historic Missions' (新的历史使命), which in part called on PLA forces to defend China's interests in the new domains of distant oceans, outer space, and cyberspace. The 2013 revision of the influential *Science of Military Strategy* emphasized the centrality of conflict in the information domain.[5] By 2015, China's authoritative defense white paper on military strategy codified this prioritization by stating that "outer space and cyberspace have become new commanding heights in strategic competition among all parties."[6]

China's Aggressive Military Doctrine for Network Attacks against U.S. Space Assets

China's views of the space and network domains and the nature of informatized war inform an aggressive counterspace doctrine against U.S. C4ISR capabilities and for utilizing network attacks. In many of China's military writings, I would argue there are three key assumptions. First is that information systems depend on space-based assets and serve as the "brains" or "minds" for all U.S. forces in the Pacific theater. The second and corollary assumption is that if the PLA sufficiently threatens, degrades, or destroys such systems, the United States will stand down or its forces will face substantial delays entering the theater. The third assumption is that network attacks can be deployed effectively and with smaller risks of escalation. As an observation, what is also striking to me is that as China fields more satellites and projects power abroad, there is little to no acknowledgement that China may face these same vulnerabilities.

Many sources emphasize the importance of C4ISR capabilities, particularly those in the space domain, and how devastating their loss would be for a military force. Borrowing from British military historian and strategist J.F.C. Fuller, one text argues war has evolved from a "war of bodies," or one military organization versus another, into a "war of minds" (头脑战争), in which the objective is to attack command and control systems.[7] Other sources describe space-based communication links as the "backbone" of modern militaries and joint operations, and attacking space reconnaissance systems as "covering up the eyes and ears" of military forces. Targeted attacks against space-based assets can "paralyze command and control systems" and negate

by China's National Defense University, is also authoritative. This testimony draws from both, referring to them as the 2013 *SMS* and 2015 *SMS* respectively.

[4] Xiao Tianliang, ed., *The Science of Military Strategy* (Zhanlue Xue / 战略学), Beijing, NDU Press, 2015, p. 137

[5] Shou, ed., *The Science of Military Strategy*, 2013.

[6] The State Council Information Office of the People's Republic of China, "China's Military Strategy," May 2015.

[7] Jiang Lianju and Wang Liwen (eds.), *Textbook for the Study of Space Operations* (空间作战学教程), Beijing, Military Science Publishing House, 2013, p. 14

advantages of long-range precision strikes and carrier groups by cutting off information flows.[8] The bottom line is that (in the Chinese view) space and network capabilities can deliver a devastating blow that will negate or severely limit the U.S. military's ability to operate in theater.

The 2015 *SMS* describes network attack capabilities against space-based assets as providing both strategic and tactical-level deterrent value. "Strategic-level network deterrence" (战略级网络威慑) is defined as network attacks and demonstrations of capabilities against an enemy's political, military, and economic targets. C4ISR is the first example, followed by national transportation hubs and communication backbones. "Tactical-level network deterrence" (战术级网络威慑) emphasizes small-scale network attacks and network intrusions in order to "safeguard national security in peacetime."[9]

Network or cyberattacks on space assets are frequently mentioned as an ideal non-kinetic attack method in Chinese military writings on counterspace operations. PLA texts on space operations list network attacks as one of three primary types of "soft kill" or "non-kinetic" methods for attacking satellites,[10] and are well-versed in their advantages and disadvantages. Network attack methods are better for surprise and concealment compared to hard-kill methods such as kinetic kill vehicles (KKVs), and can paralyze an entire system instead of destroying one platform.[11] Additionally, KKVs produce a tremendous amount of space debris, as seen in China's ASAT test in 2007 and the recent Indian test.

Network (and electromagnetic) methods are "information weapons" (信息武器) that can capture, interfere with, block, and deceive adversary space-based information systems to the point of blockading, destroying, or paralyzing them.[12] According to one military textbook, the two primary types of network attack methods are: [13]

> (1) Breaking satellite signals to obtain their data link parameters and communications protocols, and using them to transmit viruses, logic bombs, and false information signals to cause malfunctions and paralysis of systems.
>
> (2) In advance of conflicts, placing viruses in enemy satellite information system computers, and when necessary activating the virus to destroy the system.

These weapons support "information blockades" (信息封锁), a type of space operation that envisions using all methods of information warfare to interfere with and destroy communication links between an adversary's space assets and ground stations and end-users. Other listed objectives are blinding surveillance equipment, disrupting space-based communications and operational links, and interfering with guidance and positioning signals.[14] The last objective deserves emphasis as the U.S. Navy mandated that probes of potential cyber tampering and cyber

---

[8] Chen Baoquan, Yang Guang, and Li Xuefeng, "Research on System Combat Effects and Develop Policy of Space Electronic Attack" (空间电子攻击的体系作战效用及发展对策), *Aerospace Electronic Warfare* (航天电子对抗), No. 28, Issue 1, 2012, pp. 11-13, 22-23.
[9] Xiao, *The Science of Military Strategy*, 2015, p. 147.
[10] The other two types are electromagnetic attacks and low-energy (such as laser and microwave) attacks.
[11] Jiang and Wang, *Textbook for the Study of Space Operations*, p. 48.
[12] Deng Jiekun, Shi Tongye, and Xie Jing, "ECM Capabilities of Space Information System" (空间信息对抗能力分析), *Aerospace Electronic Warfare* (航天电子对抗), No. 28, Issue 4, 2012, p. 4-6, 28.
[13] Jiang and Wang, *Textbook for the Study of Space Operations*, p. 121
[14] Ibid., pp. 134-135

intrusions be made standard parts of accident investigations following the 2017 collisions involving the USS *John S. McCain* and the USS *Fitzgerald*.[15]

One alarming aspect of China's military writings on space warfare strategy is the justification of targeting civilian satellites. According to *Study of Space Operations*, civilian assets are more numerous and may be more advanced than military systems, and carried 40% of U.S. communications in the Gulf War and 60% in the Kosovo War.[16] In a Taiwan scenario, a professor and graduate students with the former Second Artillery Engineering University clearly consider any "blue" satellites supporting "grey" Taiwanese "separatists" to be legitimate targets.[17] Recently, U.S. scholars and industry partners have raised the alarm that many new small satellites use unencrypted communications channels while operating in high-value orbital regimes, and are calling for industry self-regulation to encrypt such channels for some degree of protection from unauthorized users.[18] Any steps by the growing space industry to 'bake in' security measures should be encouraged as orbits become more crowded with increasingly capable commercial satellites.

Evidence of Chinese Network Attacks on Space Assets

As early as 2007, PLA authors spoke candidly about how hackers can use satellite signals to take over its command control network, and then give commands over a basic internet connection.[19] Notably, in that year and in 2008 at least two U.S. government satellites (Landsat 7 and Terra (EOS AM-1) satellites) operated by NASA and USGS.[20] Since then, China has been suspected of multiple hacks against entities responsible for managing space assets, though no hack of a satellite has been reported in the open source. Reported events include:

> 2010 to 2011: The NASA Jet Propulsion Laboratory suffered an attack involving IP addresses based in China, and confirmed that intruders had full access to key systems and sensitive user accounts. "In other words, the attackers had full functional control over these networks."[21]

---

[15] Sam LaGrone, "Cyber Probes to be Part of All Future Navy Mishap Investigations after USS John S. McCain Collision," *USNI News*, September 14, 2017. https://news.usni.org/2017/09/14/cyber-probes-part-future-navy-mishap-investigations-uss-john-s-mccain-collision

[16] Jiang and Wang, *Textbook for the Study of Space Operations*, p. 73.

[17] Yu Ming, Bi Yiming, and Deng Penghua, "Research on Capacity Demand of Kinetic Energy Anti-Satellite Maneuver" (地基动能反卫星作战能力需求研究), *Ordnance Industry Automation* (兵工自动化), No. 9, 2012, pp. 1-3.

[18] A. Kurzrok, M. Diaz Ramos, and F. S. Mechentel, "Evaluating the Risk Posed by Propulsive Small-satellites with Unencrypted Communications Channels to High-Value Orbital Regimes," 32nd Annual AIAA/USU Conference on Small Satellites.

[19] Xiao Wenguang and Li Yuanlei, "Computer Networks in Future Wars" (计算机网络于未来战争), *Jiangsu Aviation* (江苏航空), No. 1, 2007, p. 31.

[20] U.S.-China Economic and Security Review Commission, *2011 Report to Congress of the U.S.-China Economic and Security Review Commission: One Hundred Twelfth Congress, First Session*, Washington, DC, U.S. G.P.O., p. 216. https://www.uscc.gov/sites/default/files/annual_reports/annual_report_full_11.pdf

[21] "NASA Cybersecurity: An Examination of the Agency's Information Security," Statement of Paul K. Martin, Inspector General, National Aeronautics and Space Administration, testimony before the Subcommittee on Investigations and Oversight, House Committee on Science, Space, and Technology, February 29, 2012. https://oig.nasa.gov/docs/FINAL_written_statement_for_%20IT_%20hearing_February_26_edit_v2.pdf

2014: NOAA reported that its networks were hacked, "forcing cybersecurity teams to seal off data vital to disaster planning, aviation, shipping and scores of other crucial uses." According to Rep. Frank Wolf, NOAA confirmed to him that China was responsible for the attack.[22]

2018: Security researchers at Symantec Corp reported on a hacking campaign from China against "satellite operators, defense contractors and telecommunications companies in the United States and southeast Asia." [23]

Another worrisome threat in the network and space domains is China's development of generative adversarial networks (GANs), an emerging artificial intelligence (AI) method for tricking computer programs into seeing objects in imagery that are not there. According to one expert, China is already using GANs "to manipulate scenes and pixels to create things for nefarious reasons."[24] If successful, GANs could poison data feeds of imagery collection for analysts and raise doubts in force planning.

The Strategic Support Force: Force for Informatized Warfare

In the last five years, China has dramatically reoriented its armed forces in response to this reality. The establishment of the Strategic Support Force reflects both a culmination of military thinking on these (and other) domains, as well as an acknowledgement of China's growing interest in them. Applying a holistic approach to information warfare, the SSF bridges gaps within and between domains (especially network and space), and provides China's leadership with a centralized entity for deploying a whole suite of non-kinetic options for information operations that can scale across domains and across the world.

The SSF utilizes an organizational structure that is domain-centric rather than function or discipline-centric, with the bulk of its forces divided into its Network Systems Department (网络系统部) and Space Systems Department (航天系统部).[25] In a contrast with the previous GSD model, wherein the former GSD Third Department (3PLA) generally handled espionage and the former GSD Fourth Department (4PLA) handled offensive computer network operations, these functions are integrated under the SSF Network Systems Department. Meanwhile, the Space Systems Department resolves the bureaucratic competition between the PLA Air Force, the former General Armament Department, and other entities for the space mission by taking control of many space-based and space-related assets.

In theory, this domain-centric model facilitates the broader strategy of Mao's dictum to "integrate peacetime and wartime" (平战结合), meaning that peacetime organization and activities should

[22] Mary Pat Flaherty, Jason Samenow, and Lisa Rein, "Chinese Hack U.S. Weather Systems, Satellite Network," *Washington Post*, November 12, 2014. https://www.washingtonpost.com/local/chinese-hack-us-weather-systems-satellite-network/2014/11/12/bef1206a-68e9-11e4-b053-65cea7903f2e_story.html?noredirect=on&utm_term=.aa9ccd99601b

[23] Joseph Menn, "China-based Campaign Breached Satellite, Defense Companies: Symantec," Reuters, June 19, 2018. https://www.reuters.com/article/us-china-usa-cyber/china-based-campaign-breached-satellite-defense-companies-symantec-idUSKBN1JF2X0

[24]

[25] Elsa Kania and John Costello, "The Strategic Support Force and the Future of Chinese Information Operations," *The Cyber Defense Review*, Vol. 3, No. 1, Spring 2018, pp. 109-110.

reflect as much as possible their wartime counterparts.[26] Prior to the SSF's establishment, one author described "space information network conflict" (空间信息网络对抗) as being about "integrating space technology and network countermeasure technologies as a strategy to seize network superiority as a goal." The required methods span (and indeed blur) the lines between peace and wartime measures, such as surveillance of enemy networks; the use of wireless intrusion tactics to identify weak links in enemy information network systems and their transmissions; the use of integrated network and electronic warfare (INEW / 网电一体战), including malware and electromagnetic signals, to disrupt enemy information systems; and preparations for soft (such as network-based) and hard kill methods against space-based assets. [27]

The SSF's structure is well-suited at least on paper for all of the above missions and operations. However, the success or failure of the SSF to achieve the goals set out for it will ultimately depend upon the PLA's ability to effectively command and coordinate these forces to achieve desired effects. The SSF is still relatively new, and likely experiencing growing pains of any new bureaucracy. Some challenges or disadvantages to this model could include:

(1) The creation of the SSF clearly reflects Chinese strategic thinking, but it is not yet proven that the new structure is better than the previous one. Any reorganization produces winners (SSF, PLA Rocket Force) and losers (PLA Army, GSD). In this case, is the SSF a full-fledged service/branch, with its own institutional agenda and bargaining power, or is it a loose agglomeration of assets and capabilities culled from other services, branches, and organizations? The answer to this question will go a long way in determining how effectively the PLA will develop and employ its capabilities in the new domains.

(2) If everything is strategic, nothing is strategic. Efficiency and decisiveness can be impeded if central leaderships determines that all or most of the PLA's space, network, and electromagnetic operations require centralized command. It is not clear yet clear who would exercise command authority over SSF operations in wartime.

(3) As the PLA expands its operations abroad, it will feel the growing pains of becoming a global military force, and expanded deployments could exacerbate any existing challenges. Currently it is unclear what role the SSF will play in overseas operations and how it will be deployed to support China's interests abroad.

Recommendations

China is clearly exerting tremendous efforts to compete and win in the space and network domains. In response, I offer three policy suggestions for the United States Congress:

1. Prioritize constant monitoring and vigilance in the information domain.

Congress should ask the Department of Defense and entities like the USCC to prioritize studies of China's information warfare strategy and programs at both the classified and unclassified levels.

[26] He Quansheng (贺全胜), "On the Development and Implications of Mao Zedong's People's Militia Thought" (论毛泽东民兵思想的发展与内涵), CCCPC Party Literature Research Office, 2016, https://www.wxyjs.org.cn/ddwxzzs/wzjx/201605/201610/t20161015_218637.htm.
[27] Huang, "Study on the Space Network Countermeasures."

The establishment of the SSF is China's most forceful move to date in a new domain that will play a decisive role in any future conflict. The lack of discussions on China's own vulnerabilities in the space domain also warrants monitoring, as the silence may indicate a lack of awareness, a higher acceptance of risk, or censorship. Technical experts are also needed for these efforts, as both domains are already technologically demanding and now face new threats from emerging technologies like artificial intelligence. The U.S. military, political leaders, and diplomats need high-fidelity assessments of China's intent and progress in the information domain in order to inform strategy, any potential military exchanges, and strategic signaling in a potential crisis or conflict.

2. Support resiliency of C4ISR and all information support systems.

Congress should support any DOD or other agency efforts that build resiliency into information support systems. Measures could support existing C4ISR capabilities, such as enhancing capabilities for rapid launch of replacement satellites, or could improve U.S. forces' ability to operate under degraded information conditions with alternatives to space-based assets. In monitoring and evaluating the readiness of U.S. forces, the ability to operate under degraded information conditions should be the gold standard of readiness.

3. Support measures for supply chain security of U.S. information systems.

Congress should prioritize supply chain integrity in government and defense procurement policies. The globalization of technology industries and supply chains has brought tremendous innovation and economic growth, but key sectors like semiconductors require a calibrated policy that accounts for security risks and invests in the on-shoring of core manufacturing capabilities. Today, China poses a threat to the DOD's microelectronics supply chain, with over 50 percent of the Pentagon's purchased microelectronics being sourced from the country.[28] At the same time, China is investing vast resources into research, development, and manufacturing for advanced sectors like advanced computing and semiconductors. The entire information domain rides on such systems, and demands greater supply chain integrity measures. The Foreign Investment Risk Review Modernization Act of 2018 (FIRRMA) is a good start at protecting key capabilities from being acquired and outsourced, but more is needed. A 2018 report by the DOD's Office of Industrial Policy provides an excellent assessment of current risks and options for remedying them.[29]

[28] John Harper, "China Threatens Microelectronics Supply Chain, DoD Official Says," *National Defense Magazine*, December 19, 2017. http://www.nationaldefensemagazine.org/articles/2017/12/19/china-threatens-microelectronics-supply-chain-dod-official-says

[29] Department of Defense, Office of Industrial Policy, "Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States," September 2018. https://media.defense.gov/2018/Oct/05/2002048904/-1/-1/1/ASSESSING-AND-STRENGTHENING-THE-MANUFACTURING-AND%20DEFENSE-INDUSTRIAL-BASE-AND-SUPPLY-CHAIN-RESILIENCY.PDF

PANEL III QUESTION AND ANSWER

CHAIRMAN BARTHOLOMEW: Great. Thank you very much. We'll start with Commissioner Wessel.

COMMISSIONER WESSEL: Thank you, gentlemen. Welcome back, although you scared the hell out of me. Mr. Ray, you talked about the Chinese having the means. I think, you know, the first concern on the horizon is a Taiwan scenario, and walk me through what you think Chinese capabilities there would do to our abilities to respond.

You know, you talked about preparation. Mr. Pollpeter, you talked about first-strike issues. If China decides it wants to go into Taiwan, could they degrade our capabilities to an extent that we might not be able to help our friend? Mr. Ray, do you want to start?

MR. RAY: Well, I guess it's your turn to scare me now.

(Laughter.)

MR. RAY: Oh, we do think a lot about a Taiwan contingency, and I think that you hit the nail on the head in terms of the real question is, could they degrade our capabilities enough to deter us. That is a question that I'm not prepared to answer because I don't, I can't speak to the resiliency of our capabilities very well. That's a question I'd ask other audiences.

But in terms of strategy, I think that, going back to the cyber component, if they can make satellites malfunction and they don't have to worry about space debris triggering a full-scale response, to me that's a very appealing option for them to remain below certain thresholds that could trigger a more forceful U.S. response.

When you put civilian satellites at play, if that starts disrupting the U.S. economy and they haven't even fired a shot, then I think that they already have a pretty appealing option for raising the cost for supporting a friend.

I hope that that would not -- I hope that we would still respond. I hope that we would, sure as anything, still intervene and support them. But that to me would be the big questions to look at.

COMMISSIONER WESSEL: Mr. Stokes, Mr. Pollpeter.

MR. STOKES: I would say certainly China's growing capacity to conduct space operations is significant and could complicate the U.S. ability to intervene in a Taiwan scenario. I would add, though, that U.S. law, the Taiwan Relations Act, does state it's in the U.S. interest to maintain the capacity to resist use of force and other forms of coercion.

The way I interpret this is that we'd better be able to, if it's U.S. law, that we'd better be able to -- be able to intervene on behalf of Taiwan.

COMMISSIONER WESSEL: But as I've heard throughout the day, I mean you know we -- China has accelerated its capabilities. We are waking up. We are providing new assets, you know, focused. But it sounds like to me we've got a window of vulnerability. I don't know how long that is, I don't know whether it exists. I don't know how long that is.

I understand TRA, but it seems to me that there's this period that China has, may have an upper hand. Do you agree or --

MR. STOKES: That by itself would require a major study. I would hope that we are, that we had the ability, maintain the capacity to resist use of force and other forms of coercion. A lot depends on the specific scenario. If you're talking about a major scenario of annihilation, you know, amphibious invasion scenario, high intensity, that's one thing.

If you're looking at lower-end coercion scenarios, that's another. But I would hope that we have that capacity.

COMMISSIONER WESSEL: Mr. Pollpeter.

MR. POLLPETER: For me it boils down to long-range precision strike, and also naval warfare in which C4ISR capabilities are a primary component of winning naval warfare, and where the first shot can often be the deciding shot. In that sort of context, a scenario where the Chinese can take out our C4ISR infrastructure and hamstring our naval capabilities, considering that they're playing a home game -- we're playing the away game -- will always put us at a disadvantage.

Now is there a window of vulnerability right now? I would suggest that they probably have some capability. If you look at the statements put out by the Defense Department and the intelligence community about how China has really basically just stood up a direct-ascent ASAT unit, that they won't have a ground-based laser ASAT capability until next year suggests that they're still in the initial stages of standing up this capability.

So could they have some, if war started tomorrow, could they have some effect? Yes. The extent that that could be debilitating may be up for question.

COMMISSIONER WESSEL: Thank you.

CHAIRMAN BARTHOLOMEW: Commissioner McDevitt.

COMMISSIONER McDEVITT: Thank you, all three of you. I've got questions for each of you that I hope that, not only that all of you will respond to since you most -- you all three covered much of the same material here.

Kevin -- and this one really relates to what you said and what Jonathan Ray said -- is this growing mutual vulnerability in space because China increasingly seems to be hellbent for leather, to improve their informationized warfighting capability.

Which means depending upon networks and space and what have you. So that they're quickly building their own vulnerabilities in. So at least that's my assessment.

If that is the case, does this provide some sort of space stability, because it's the equivalent, space equivalent potentially of mutually assured destruction, that to attack -- to attack one country's space systems would engender an attack on the other country's space systems, and both militaries would be hamstrung because of their overdependence on space systems?

So that's -- I don't know. That's an interesting one, at least to me, to think about. And Mark, your rundown on the Strategic Support Force was very helpful I think.

Earlier today we heard from General Cartwright, who seemed to be saying by indirection that one of the problems that the U.S. used to have was Space Command, and until they got -- until he got it folded into Strategic Command, it was a stand-alone entity that had its own vocabulary and its own processes and what have you.

And in modern warfighting across the main competition, it is not the sort of system that you need. In fact, you need to have all of the combatant commanders -- speaking U.S. side now -- have the ability to access and use our space capabilities.

So the question is, is China again, working, copying an old model? Are they going the wrong way, I hope actually, where in fact that the Strategic Support Force is going to make them more isolated in terms of space capabilities, and make it more difficult for the theater commanders to actually do their job using space capabilities, or not?

I mean this is speculation now. I'm not, it doesn't have to be fact. And Jonathan, listening to you talk about the cyber reminded me, God this is a long time ago, voicesat, satellite coms when I was out operating in the San Diego Op Areas, where we used to get taxi calls from Tijuana just as often as anything else.

I'm not making this up, that would wipe out the satellite voice networks. And so in

modern parlance, it sounds to me like you're suggesting that gray zone cyber or cyber attack on space systems could be characterized as gray zone ops in space. Is this a rash conclusion on my part, or is this a fair characterization? Kevin, why don't you start?

MR. POLLPETER: Sure. On the mutual vulnerability aspect, I remain pessimistic that there will be some sort of space MAD, sort of tacit agreement. I'm just concerned that China views it too much as a tempting target. I think there is some -- I think it does add a layer of instability to any conflict with China, in that -- in that China has a reason to go after our space assets.

But we are also rapidly coming to a realization that China's space-based C4ISR systems, you know, present a danger to us. If the situation is such that you have to strike first in order to win, are both sides then incentivized to strike first in space to take out the other side's C4ISR infrastructure? So I see an instability on both sides.

While we don't see Chinese analysts discussing their own vulnerabilities, what I do see is that China seems to be developing what is called an operationally responsive space capability: the ability to launch satellites in short periods of time; they've developed a couple of mobile satellite launchers that are based off of their road-mobile ballistic missiles. They can launch fairly small satellites anywhere from probably about 300 to 700 kilograms.

But then you also see that they're investing in constellations of smaller satellites, both communications satellites and remote sensing satellites.

This is a trend globally anyway, but in the same way that we're discussing about the U.S. should have a more distributed satellite architecture, while the Chinese aren't necessarily talking that way, they seem to be going in that direction.

So these sorts of trends make me worry that we won't be able to come to some space MAD, mutually assured destruction, accommodation.

COMMISSIONER McDEVITT: When people ask me how does -- how is the U.S., how can the U.S. Navy or how can the U.S. deal with A2/AD, my first response is always, if we take down China's surveillance system, they can't shoot you if they can't find you.

So presumably the incentive for taking down somebody else's satellites rests on us if we expect to ride to the rescue to Taiwan or East Asia and what have you, because otherwise they can use it to target ships, vector submarines, vector aircraft, et cetera, et cetera. Mark.

MR. STOKES: So, I should be much better educated on our own Space Command and Strategic Command, but in terms of a Strategic Support Force and how they are now being increasingly integrated into the command and control structure, when you look at notionally what's in a joint command center at the national level and at the theater command level, there's been --

I think it's fairly well established there's going to be ten support groups or cells that would be in a command center. So I'm not sure at what point, at what readiness level they would come into play, whether or not they're there 24/7 or they would just go there at the next, you know, the next readiness level.

But ten of them, I won't go into detail on a lot of them, but you look at mission strategic planning or mission planning and targeting. You look at the survey and mapping and navigation, positioning, network ECM that's going to be in there in that national level command center, battle space situation -- I view that sort of as intelligence stuff. Spectrum management, air space management, communications, weather, space, all these functions. When you think of every single one of these functions -- except maybe air space management, but even though there may be some, the Strategic Support Force, or at least the services they provide -- are going to be

critical for each and every one.

SSF at a minimum will have a duty officer that will be sitting watch there, both in terms of normal readiness conditions and then as you go up. I'm guessing they beef up as they go along.

COMMISSIONER McDEVITT: You could be a busy dude.

MR. STOKES: Yes sir, absolutely. The same, the same structure would exist at the Theater Command level as well, for example Eastern Theater Command. So this restructuring appears to have better integrated these functions that will be provided by the Strategic Support Force into the actual operational command and control.

MR. RAY: First, just a comment on the question about mutually assured destruction. I think that the fundamental question there will be, where would the conflict be taking place. Because if it's local, then China will have more resilient architecture, ground-based systems. Drones can supplement a lot of the same functions as satellites, and that is a severe disadvantage of being the away team.

But if you put them where they're both the away teams in a different theater, than all of the sudden they do have the same vulnerabilities. So I think that that's an important note. In the short term, I don't think we're looking at the same mutually assured destruction, but in the long term, yeah, I think we'll get there.

And then looking at the structure of the SSF, that's a question that I've been asking. Is this sort of a rebadging exercise and is it going to be efficient, or is this just bureaucratic satisficing, trying to break through gridlocks. That's why in the future it will be important to look at operationally how effective are they being and how are they being used.

But just one note there is that I think it's interesting that they've put all this expertise and made it domain-centric. I know a couple of other authors have highlighted that, because that solves the problem that you raised about satcoms.

So if you wanted to jam anything say out of Tijuana, you don't care if you have to use cyber or electromagnetic means. You just want it to turn the thing off, and the operator is not going to necessarily know, oh, it's being hacked, or oh, it's being jammed.

You just want -- you want the effects to be delivered. So I think that when you centralized all those capabilities across these domains that are so interlinked, that to me is pretty sophisticated thinking, and I think can make a lot of sense in our own model, whenever, however we want to take on space and these same issues that they're addressing.

COMMISSIONER McDEVITT: Thank you.

CHAIRMAN BARTHOLOMEW: Senator Talent.

SENATOR TALENT: Well, Mike asked the question I was going to ask, how this was actually going to work and whether the theater commanders would have control. So I'll ask a variation of that and then raise one other point with you.

I guess the variation is, have they been able, and I've been in some briefings with the Air Force Space Command people, and it's very difficult to get your head around this concept of how space is going to be used. And now maybe that's because of my age, whatever.

But a lot of the top commanders about my age, maybe a little bit younger, and sure they've got a lot more training, et cetera. I wonder if their, what you think of the ability of their theater commands, their battlefield commands, people that are actually drawing up plans in the event of a Taiwan contingency, and having to anticipate the United States coming in, if they have any greater level of familiarity?

And then this relates to the second question. So we had a hearing earlier this year on

potential Chinese vulnerabilities, and we had testimony about the actual capabilities, the operational capabilities of the PLA.

We had a witness who was pretty skeptical, and he said the Chinese leadership is very skeptical, and he talked about the five incapables, that they are very concerned about their ability to actually perform in the field and particularly against American forces.

So do you, do you share that view of their perceptions, and would that apply to space?

MR. POLLPETER: So I think it's important that as far as, do the theater commands really understand space and know how to use it, I think at a time when they are learning in some cases even how to do combined arms operations, where joint operations are still difficult for them, trying to bring in something technical like space, I think, may be a bridge too far.

Now having said that, it could be that much of the space capabilities are at the strategic level. So when you get up to the CMC, Joint Operations Command Center, and there I would expect that they would have that expertise and how to use space and when to actually maybe use counterspace measures.

So I think at that level, you'll probably have a lot more expertise. That would sort of coincide with what -- they don't talk about it a lot, but there's been a couple of references to engaging in counterspace activities as a strategic-level decision, you know. It's going to have to be something that Xi Jinping would order. Now the one caveat to that is maybe more --

SENATOR TALENT: If I can interrupt. Do you think in general or only if it were to be used against the United States?

MR. POLLPETER: I would think in general. But the one caveat to that would be maybe more localized counterspace. If there's GPS jammers, maybe some sort of satellite communication jammers that wouldn't be so technically complex and would be more of an operational or tactical-level decision.

I know there is a second part to your question, oh about the -- yeah. I think, I think the PLA has acquired a lot of new and advanced equipment, and when you see the criticisms of the PLA all the way up to Xi Jinping, it is about the human capital issue. So I think it's a serious problem for them, and it's one reason why I think that China is not prepared to go to war at this time.

I think they will if they have to, but I think we see in their actions where they're trying to do everything possible short of war to get what they want. But they've got -- they're absolutely not spoiling for a fight. I think it's also important to remember that, you know, they have stated that by 2035, they want to have a modern military.

Well, what does that mean? There's some indications that what that means is that they would like to be at the level that the U.S. military is at now. But of course we're going to keep marching ahead. So if by 2035 they're a 2019 U.S. military, they're still far behind.

So that's why they go out to the mid-century, and if you look at any sort of reform effort in any military usually, it takes about a generation to get these reforms through, not only with the technology but also to train those people up, and if you look at a generation, that would be about mid-century.

MR. STOKES: First, the space assets. If you divide it up between the satellites, the space assets themselves, launch, tracking and control and then the application, the satellites themselves and the tracking and control I think is going -- they're national level assets. Kind of hard to see theaters having much authority over these particular assets.

But for the applications, my impression is that a lot of the information, the take from space systems, whether it's electro-optical satellites, synthetic aperture radar satellites, things like

this, would feed into -- and I'm sitting next to what I consider the authority on this, feed into the Joint Command platform, which would be sort of a common operational picture that would exist at the theater level and national level as well.

But secondly, something very -- a key issue to watch is I've talked about basically core grade or core deputy leader grade organizations that exist in the PLA SSF. For each theater command, there is -- there's been established a new corps or corps deputy leader grade entity.

It's not clear whether or not these are dedicated to, let's say for example, technical reconnaissance, you know, like their former third department or NSA-like organizations, or whether these entities are dedicated to support theater-level support. This isn't exactly clear yet.

I'd also offer that theater commands have their own -- I mean it's not Strategic Support Force, but they have their own organic ISR assets, both Army, Navy and Air Force, ECM as well as radar, maritime surveillance, a whole range of other assets on their own.

I would also highlight that it's possible that at the theater level, the key organization you have command, control and communications. The communications part of this at the theater level linking theaters with the national level command authorities may now also be under the Strategic Support Force. It hasn't been completely confirmed yet, but that would be another element I think to watch.

MR. RAY: Hard to add when you have to follow these guys.

(Laughter.)

MR. RAY: Nothing really to add on SSF. I think Kevin and Mark covered it, and that's one of the reasons why I think it would be great to keep monitoring as developments continue. We have gotten great eyes on a lot of organizational issues at the front end, and now the question is how are they going to use it.

But getting to the vulnerability question, I think that's, those are the right questions to be asking, because if you make them ten foot tall on everything, then you're kind of psyching yourself out. So how do you get a more nuanced assessment?

And there's some sources that have been helpful from our shop have been looking at how they describe different military exercises in the different service newspapers. There is an emphasis on -- there was an emphasis on making things less scripted and more real, and they really emphasize realistic in those scenarios.

And it's watching people, it's watching film. It's like red was allowed to lose and allowed to learn. Those are the kind of transitions that we would monitor on how they think about their own vulnerabilities.

And then on Joint Ops, I think that yeah, they're still in the formative phases. When you look at something like the SSF, that's going to be a real testing ground, to see how these different things come together and how they bring it through the system.

But a lot of those things are things that I'll be looking at for the next five years, and I think you'll have a lot more hearings on that, on those same topics.

MR. POLLPETER: If I could just add one thing, I think the Chinese assessment of the PLA's weaknesses is also good news for us in the sense that, you know, the sky is not falling right now, and we have a window of opportunity, however long, 10, 15 years, 20 years, I don't know, that you know, as the U.S. military transitions from fighting counterinsurgencies over to great power competition, you know, we don't have to do this tomorrow but we can't wait.

The clock is ticking. We've got to continue moving on. So this does give us an opportunity, but you know, we have to be quick about it.

SENATOR TALENT: So just to confirm, you all would agree with the assessment that

the top-level Chinese political leadership is deeply concerned about what they see as the operational incapabilities of the PLA?

MR. POLLPETER: I would agree with that.

MR. STOKES: I would add political concerns as well.

SENATOR TALENT: About the loyalty and then sort of -- okay. Those are two different things, and I really wanted to make, because we had that testimony earlier. I was skeptical. But you all agree that this is a major factor in their thinking and planning and strategizing, particularly vis-a-vis the United States.

CHAIRMAN BARTHOLOMEW: Commissioner Cleveland.

VICE CHAIRMAN CLEVELAND: I'm interested in a fairly narrow issue, which it was prompted by, Mr. Ray, your testimony in which you talk about generative adversarial networks, which is an emerging artificial intelligence method for tricking computer programs into seeing objects and imagery that are not there.

I'm interested if you could talk a little bit more about what that actually means. But I'm interested in the question of how commercial or civilian applications are supporting any asymmetric advantage the Chinese may have, and I don't know if this artificial intelligence was developed commercially or in the civilian sector.

But what prompts this is the fact that there was an article in January about how BeiDou's navigation satellite system may be providing an advantage to Chinese missile accuracy and lethality.

So what I'm trying to understand is the role of civilian and commercial capabilities and how that's supporting this Chinese advantage or lack thereof, and then in particular this example you offered, Mr. Ray, of GANs. Does that make sense?

MR. RAY: Well, I'm glad it makes sense to you. On GANs, I'll get to the big-picture items because I am not a technical expert. I washed out of calculus and studied squiggly lines and military doctrine.

VICE CHAIRMAN CLEVELAND: Okay.

MR. RAY: But the fundamental point there is that all of these data collection platforms are great, but if the data itself is being poisoned and you can't trust it, then what good are they? That is to me -- that's what causes me concern about GANs, is that if they can trick AI-based methods of recognizing patterns into seeing something they don't, then all of a sudden you can't necessarily trust your data.

So I think the example in the article that they gave is if a GAN method understands how to trick a sensor or, sorry, an algorithm into thinking that there are bridges where there aren't actually bridges, well, all of a sudden a planner has additional targets to consider.

I think that's a simplistic example, but the bottom line is that you have to have data fidelity in order for all of this to make any sort of difference. If you can poison the well per se of what the AI is using, then that becomes a big problem.

To me, based on my understanding of GANs, that's what they're fundamentally designed to do, is to be adversarial and continually trick the algorithms that you use in your own AI capabilities. Because see on AI, that is a textbook example of how military-civilian fusion supports an emerging technology like AI, that can support both military and civilian applications.

AI is something that we looked at in our 2016 report on robotics for the Commission. A couple of takeaways there are just that when you look at the research being conducted, it's often in -- when you look at the authors and their affiliations and the different institutes that are involved, you see a lot of funding that supports military and civilian applications.

You see institutes with very deep military ties and they're very deeply integrated into the military industrial complex. They're participating in those exercises, and then finally one of the big disadvantages that we have is that in our system, Google can say we don't want to support DoD efforts on something.

In their system, I would love to see BeiDou refuse that, because they can't, and that to me is a fundamental difference in the way that our systems are structured. I think that our system is correct, and I don't think that their system is the right way to do business or a lot of things for that matter.

But it does provide them with some advantages, like advanced technology companies being unable to say no and having to cooperate and turn over whatever technological breakthroughs they work on.

VICE CHAIRMAN CLEVELAND: Thank you. Are there other -- go ahead, Mr. Stokes.

MR. STOKES: You said in other words, whether or not commercial or civilian applications, if they could be applied to, for military purposes. I would say the short answer would be sure, yes. There may be some exceptions, but say for example that lunar, that lunar program. Lunar program, if I'm not mistaken, at least at one point it was managed by the China space, National Space Administration, CNSA.

The director of CNSA is dual-hatted as one of the deputy directors of this -- the State Administration for Science, Technology and National Industry for National Defense. The word national defense should be important here.

There's a reason, SASTIND national defense. Anything in which you have a SASTIND oversight role or some degree of policy guidance, there's going, certainly going to be a PLA aspect to it.

CHAIRMAN BARTHOLOMEW: All right. The more we learn, the more troubling it all is. I have what is probably going to sound like an ignorant question. In cyber attacks, one of the difficulties of course is attribution. As China is expanding its global footprint in telecommunications and satellites, working with other countries, would we necessarily know if one of our --

We would know if one of our C4ISR-critical satellites was taken down. Would we know who took it down? For all of you, any of you. Because if we don't, we're crippled in responding, aren't we?

MR. POLLPETER: I don't know, but I would suspect that it may be difficult to determine that, since the forensics, some sort of forensic analysis would have to be done, and I'm not sure how long that would take.

I know that General Hyten has said that in the past, when a satellite had a problem, it was always assumed that it was some sort of mechanical issue and they just have to work through it, and there wasn't a sense of urgency.

And so you know, his mantra was we've got to get into the mindset of there could be -- this could be a threat, this could be an attack, not just a malfunction. So a changing of the mindsets also is probably key to this issue as well, which I think is happening in the U.S. Air Force right now. But it all depends, I think, on that forensics analysis and how well that can be done, you know, with a satellite in space.

CHAIRMAN BARTHOLOMEW: Anybody else?

MR. RAY: The same issues that Kevin highlighted, and you can imagine why that's such an appealing aspect of conducting cyberattacks, is that your adversary won't know if it's a

malfunction or if it's an actual attack, or if it's a prelude to an attack.

That's why when we talk about the information domain writ large, I think one of the topics that needs to be included is how do you -- how do you -- what are the strategic signals you want to send an adversary? What is a red line? What is the last straw when it comes to soft-kill methods?

If all of your birds are experiencing interference at the same time, then you need to -- I think it would be good to be clear on how, what the plan is for a response, and getting to what Kevin had as a forensics problem, yeah that's a big problem because you don't always -- it's hard to determine not just who's doing it, but also what's causing it.

Is it a cyber attack on a computer at a ground station? Is it interference and jamming from other means? Those are really hard questions. So whenever I read smarter people than me talking about how to build resilience into the system, a big part of that is understanding the threats that you experience, how to diagnose them and how to respond to them.

That's what -- those are the questions I would be asking anybody from DoD, because there is an -- there is an obsession, or not obsession. There's a tendency to think offensively, but not always defensively, and attribution is a big part of defense, in my opinion.

CHAIRMAN BARTHOLOMEW: Thanks. Mark.

MR. STOKES: I was just going to add, just to reinforce the notion that it's not just cyber in terms of an attribution problem, but when you do have satellite jamming, sometimes it can be difficult to attribute that as well. There have been cases I think in the past, maybe ten years ago, of jamming of a -- I forgot if it was a Voice of America or one, it was one particular transponder that was receiving interference transmitting into China. I don't think they were able to determine exactly where that came from.

CHAIRMAN BARTHOLOMEW: It makes it all very difficult to respond, doesn't it?

MR. STOKES: Right.

CHAIRMAN BARTHOLOMEW: Yeah.

VICE CHAIRMAN CLEVELAND: I just wanted a clarification on your point. When you talk about jamming, is it a sustained like day-long thing, or is it -- is it something that's disruptive and compromises the system in a way that it can't get back up and operational?

MR. STOKES: It could be any of the above. Normally, it would be for a relatively short period. It helps if you are monitoring what's coming off a particular transponder in the satellite. But just to be able to inject noise or some sort of interference, or you could even -- I mean there's other even more exotic things one can do.

But normally it would be a short, somewhat shorter duration, but it could be extended.

CHAIRMAN BARTHOLOMEW: Kevin.

MR. POLLPETER: Yeah. I just wanted to make a point. On the other side of the coin for attribution is something like a kinetic kill vehicle test, which I think people ask why are they developing these weapons? They create debris.

One reason may be that it's easy to try and deter or coerce your opponent, you know, blow up a satellite. It creates debris. The other side knows exactly what you did and that you're serious about it. Also, in a time when China's probably space situational awareness capabilities may be limited, it also gives them confidence that they have actually achieved their objective.

CHAIRMAN BARTHOLOMEW: That's true, but Kevin, debris is not selective. I mean to me, if they are destroying a satellite, don't they run the risk that it will affect their satellites too or pull in third parties?

MR. POLLPETER: Absolutely. But this is -- these are some of the concerns that I have

over China's counterspace program, that they're developing these capabilities yet, you know, most likely for a reason. So I have to assume that they for some reason are taking that into account and going ahead anyway.

CHAIRMAN BARTHOLOMEW: And I'm going to -- since we have some time, I want to introduce quantum into all of this. They seem to be making some strides in quantum that I'm not sure that we are making, and how is that going to affect sort of the vulnerability of their C4ISR systems? Do we know that? Maybe it doesn't?

MR. POLLPETER: Well, the promise of quantum communications is that you have an unbreakable communication system. So the extent that that is an accurate statement, it would really complicate issues for us I think, and you know, in collecting intelligence on China, you know. An unbreakable system would be, you know, would be you know, an extreme hurdle to get over.

CHAIRMAN BARTHOLOMEW: All right. Anybody else? Jonathan?

MR. RAY: Banking off of that, for intelligence collection, I think it does pose a problem. So in steady state, I think you'll see greater impact. But if anything, if there's a crisis or conflict and people start taking more actions against space-based assets, like they write in different books, antennas are still exposed. They're still open and they're still frail.

So I think that if you point a very high-powered laser at just about any kind of antenna on a satellite, it's going to be disruptive. So that's just -- that's the only solace that I take, that just because the satellite is quantum-enabled does not necessarily mean that it's --

CHAIRMAN BARTHOLOMEW: That it's safe.

MR. RAY: Yeah, that it's safe, right.

CHAIRMAN BARTHOLOMEW: Okay, thanks. Commissioner Lewis.

COMMISSIONER LEWIS: Thank you very much. You've given us a lot to think about. Kevin, I'd like to ask you a question. You said before that China does not want to go to war with us, because in relation to his question, maybe they're not really confident that they could win such a war.

You said they will go to war if they have to. As you see it and each of you, what is it that they would have to do? What kind of events would occur, in which you would see that they would say we have to go to war? The second part of that is can a war be limited to only cyberwar? I mean wouldn't the whole concept of mass destruction, mutual mass destruction be something that they would think about before they would start any kind of a war with us, either over Taiwan or destroying our satellites?

MR. POLLPETER: So I think for China to go to war with the U.S. would be a difficult, very difficult decision for them, and I think they are well aware of the risk that that would entail. But --

COMMISSIONER LEWIS: Or the escalation of it?

MR. POLLPETER: Correct, yes. I think, I think if they -- I think though that there are circumstances where they would feel compelled to go to war.

COMMISSIONER LEWIS: Give us examples.

MR. POLLPETER: I think if over some sort of Taiwan independence issue. I think if there was some conflict on the Korean peninsula, they could possibly get involved with that. If there was some escalation, let's say a South China Sea issue, that somehow there was some accident and there was a crisis that escalated, certainly we could see a conflict over that.

But I think what they would also -- you know, they faced the same decision, Mao faced the same decision with getting into or going against the United States during the Korean War,

and many of his advisors actually cautioned him against going up against the United States. But Mao decided it would be better, you know, to fight that battle.

So you know, these are difficult decisions that they've made in the past, and if they believe their legitimacy as a party is on the line, I think they would probably make do with what they had and they would go to war. But I'm not, I'm not saying that they're itching for a fight right now.

COMMISSIONER LEWIS: What are your views on that?

MR. STOKES: So the first point I'd make is the Chinese Communist Party is at war with us every minute of every day. So war should be viewed as sort of a continuum, and not necessarily sort of black and white or in binary terms.

What would trigger an extreme use of force? For example, an amphibious invasion of Taiwan or some sort of annihilative scenario, probably a confluence of events. If they're at immediate trigger in a Taiwan scenario, I'm not sure.

It's kind of hard to conceive of anything that would trigger a full-scale amphibious invasion of Taiwan, simply because of the cost that the Communist Party would bring upon itself. I'm not sure if they would survive such a venture.

In terms of more limited scenarios, North Korea certainly. Border and coastal defense scenarios to include South China Sea. Let's say if there's an incursion across one of their borders, whether it's in Xinjiang or whether it's pretty much in any location. I think you could see use of force in that scenario.

But there's a whole range of factors that would go in. What else is going on in the world? What's the domestic situation inside China? Or the projecting of political instability inside China and projecting that outwards. There's a whole range of things that could actually trigger a major conflict.

MR. RAY: They've already highlighted the issues --

COMMISSIONER LEWIS: Excuse me?

MR. RAY: So Kevin and Mark have already highlighted the issues that would trigger a forceful response, in my mind, and one thing to point out or that I want to emphasize too is that CCP is actively at war with us at any given point.

I agree with that assessment, because they are constantly trying to undermine U.S. interests and that is one reason why in my testimony I used the term steady state and not peace, because steady state, sub-kinetic, but you're still competing with each other and we're in a competitive state.

Or as Dr. Erickson, Andrew Erickson recently coined, competitive co-existence. That could be a useful way of thinking about it. One point to note is that when you talk about regime survival of the CCP and those stakes being involved, I think that's what makes them both reluctant and aggressive in their strategy.

They're reluctant to put all the chips on the table on any given situation, and if they do, they're going to have to be really aggressive because if they lose something like a Taiwan scenario, then they fear for their own survival. That's why the stakes to me are so high, and that's why that leads to reluctance to engage, but also an aggressive military strategy.

On the cyber question in particular, I think they would love to -- I think traditionally they would have loved to keep it in the cyber domain because the traditional assumption has been that the United States is more dependent on the network domain and on cyber writ large.

But that's changing. When you look at how at e-commerce in China, there's a lot of civilians are skipping credit cards. Those aren't really a thing. People pay with their phones. So

if all of a sudden you don't have a stack of cash and you're relying on a smartphone to pay for basic services, that's a vulnerability.

So far, I have not seen military sources describe that kind of vulnerability, and I have not seen them really think seriously about how modernization is great, but there are some costs that come with it, such as dependency on space and dependency on the cyber or network domain.

So bottom line, traditional assumption is yes, they would like to keep it contained, but in the future I think that they're going to be -- maybe they'll be a little more self-aware of their own dependencies.

COMMISSIONER LEWIS: Thank you.

CHAIRMAN BARTHOLOMEW: Commissioner McDevitt.

COMMISSIONER McDEVITT: Kevin, I want to return to you on a question I had earlier. You if I copied my notes correct, you indicated that you didn't think China understood space deterrence. And so what don't they understand I guess is my question, or how could they understand it, which could be more difficult?

And then for all of you, this may be something that is at a very high level of classification if anybody in the country knows, is how good are their satellite systems?

In other words, their surveillance satellites and what have you? Is their quality terrific? In other words, are these really good or are they average, below average? In other words, we know they have a lot of stuff on orbit, but is it doing the job?

MR. POLLPETER: So I think that China has a basic understanding of deterrence and space deterrence.

My comment was that it could be evolving. They could be, as they hash these things out, think more about it, that what they were assessing before, coming to a conclusion before, may not -- may change in the future. So therefore, we shouldn't say hey, this is the end-all, be-all of what China's thinking about deterrence, and I think some of those assumptions or sort of mischaracterizations of space warfare or that they're making now, maybe they'll put more effort into understanding those.

Maybe they're discussing those in closed doors in Beijing somewhere and we're just not seeing it in Chinese writings. So my caution there was simply hey, this could be a moving target. We shouldn't, you know, we shouldn't base all our conclusions on what they're writing right now.

Because a lot of Chinese writings on deterrence, and including space deterrence, is really from -- it really parallels what we see in western writings on deterrence.

Getting to your question about how good Chinese satellites are, I would say if you look at what's, sort of what they're publishing, is they are catching up but still maybe not as good as we are. So I think they've publicized their most accurate remote sensing satellite, I think has like half a meter resolution. Commercial space imagery is better than that.

They have a military system called the Yaogan, which they never really talk about that could have better resolutions. The BeiDou system is similar to GPS is catching up, but so far it does not have as good as accuracy as GPS and usually it can only get really good accuracy if it's backed up by a ground augmentation system.

One thing it does have that GPS doesn't is a communication system. So a Twitter-like account, 120 characters that they can communicate with other people on the system. So I think they're catching up, but they're not quite there yet. And even in regards to -- you know, we've commented about the number of satellites that China is launching.

But part of that, at least in the past, was because their satellites did not have the service

life that U.S. satellites had. So our satellites routinely have a service life of up to 15 years, and a few years back their satellites were going for three to five years.

So if you had those satellites, you know, ending their service life, you have to replace them. To turn a frown upside down, for the Chinese at least what that did give them was the ability to continually send up increasingly capable satellites.

Now they do have the DFH-4 satellite bus is now advertised as having a 15-year service life. So maybe they've sort of rectified that situation. I think a lot of that maybe had to do with battery life. They simply didn't have as good batteries, and also radiation-hardened chips that could survive the space environment.

Because if you do read some, I believe some export control cases where China, you know, illegally imported some radiation-hardened chips, which may indicate that that was also one of the vulnerabilities.

MR. STOKES: And in terms of specifics, how good they are, I'm not exactly sure. But I would point out that they're certainly getting better and have been getting better. Their first communications satellite launch, I think, was 1984 if I'm not mistaken, and then I think 1980s, maybe early 1990s, the first electro-optical. I think in the 80's the first recoverable electro-optical satellite.

They've had successive generations of synthetic aperture radar satellites. They have a space tracking system, again since their first space launch in the 1980s certainly is getting better. I think, I recall one in terms of being able -- their space debris monitoring. I mean when I hear the word space debris, automatically I think it's pretty interesting for counterspace capabilities.

But down to I think five, I think a five centimeter radar cross-section or something like that in terms of being able to track stuff. They've had, long had a program on developing a space-based space debris tracking capability. So they're getting better. I mean as an American, I'd like to think that we're still pretty far ahead. But I think they're getting better.

MR. RAY: I agree with that, and the only two takeaways I would like to add are -- one is that we underestimate quality at our peril. I think leading up to World War II, the underestimates of Japanese aviation is an instructive example of what could happen if you do that.

And then the second point is that, in my opinion, looking at these issues, there is a certain quality to quantity. So I'd be tracking numbers of satellites, because I'll take a resilient 80 percent solution than a vulnerable 110 percent solution just about any day.

So those are -- so I'm not going to wait until the technical debate. Again, a Chinese linguist, not a technical guy. But I think that -- I think that numbers of satellites and capability-based assessments are more instructive than how good the technical parameters are, the resolution.

CHAIRMAN BARTHOLOMEW: All right. Commissioner Wessel. Oh sorry. Yeah.

MR. POLLPETER: I would also just, you know, my ossified brain is really slow on the uptake here. So but this also may not be a question of are they on par with the United States, but just, is it good enough to get what they need to get done, and you know if that's the case, then they don't automatically need to, you know, to keep on par with us.

COMMISSIONER McDEVITT: To me, the good-enough issue would be can they target a moving ship?

MR. POLLPETER: Right.

COMMISSIONER McDEVITT: And keep a track on it, so that in fact they have a chance to hit it with a missile that flies 1500 miles.

MR. POLLPETER: And they're developing a satellite constellation that by 2030 will

have a revisit rate of every ten minutes. So they're developing those capabilities now.

CHAIRMAN BARTHOLOMEW: Mark.

MR. STOKES: Just one quick comment, on being able to track, provide QE quality and tracking quality data for it to be able to put fire on a ship, I would also point out that it's not just space, outer space assets, but it's also what's called near-space assets.

COMMISSIONER McDEVITT: Right.

MR. STOKES: Which I'm not even sure if we're in the game. It's those assets that provide near-quality capabilities that are similar to, for example, remote sensing satellites in low earth orbit, but remain under, you know, within 100 kilometers, investing significant resources in this area.

CHAIRMAN BARTHOLOMEW: All right. I think for the final question, Commissioner Wessel.

COMMISSIONER WESSEL: And since I'm keeping people from an -- after a long day, let me -- hopefully some quick answers. China has a ground station operating in Argentina. What should we think about that? Are they looking at other ground stations? How does that magnify their capabilities and what should we be doing?

COMMISSIONER LEWIS: And Norway.

COMMISSIONER WESSEL: I'm sorry?

COMMISSIONER LEWIS: And Norway too.

COMMISSIONER WESSEL: Norway is where they took one of ours down. I don't think it was a Chinese station, but please.

MR. POLLPETER: Yeah. I think the main concern about the station in Argentina is that we don't know exactly what they're doing there, because it's, you know, there's virtually no transparency.

I think its links to the Strategic Support Force, you know, would give us cause to worry that that will be used, that that station will be used in a military conflict, especially since there seems to be little oversight on the part of the Argentinian government over this.

I think it gives them a window into looking at satellites in the Western and Southern hemispheres, which they did not have potentially I guess, since it's been used to -- in support of the lunar exploration program when they landed a rover on the far side of the Moon.

It gives them that capability to go out to geosynchronous orbit to monitor spacecraft, out to geosynchronous orbit and even further out to the Moon. So it may give them an expanded surveillance capability in an area of space which maybe they didn't have great coverage before.

So it's all part of a, you know, a step by step program to, you know, to increase their capabilities.

COMMISSIONER WESSEL: Any other comments?

MR. STOKES: They've had parts of their space tracking and control system over other countries since the 1990s. I think Kiribati's one of them. I think it's Sweden may be the one where they have some kind of a ground station. I think Kiruna up in the very north, very north part seems to be affiliated with remote sensing.

COMMISSIONER WESSEL: And potentially a polar station, too.

MR. STOKES: Yes.

COMMISSIONER WESSEL: Okay, thank you.

CHAIRMAN BARTHOLOMEW: All right. Thank you, everybody. You've been terrific witnesses. It's been a long but really excellent day of testimony. Again, I want to thank our staff Alex for the terrific job that he did, and we look forward to further contact with you all. Thanks.

(Whereupon, the above-entitled matter went off the record at 4:30 p.m.)

Back to Table of Contents

26 April 2016
General (ret) James Cartwright, CSIS
Testimony before the US-China Economic and Security Review Commission
Strategic Competition with China in Space

Follow Up Question for the Record from Vice Chairman Cleveland
3 May 2019

Describe the most effective architecture to incorporate space [into the military]. Where does it fit in? Within combatant commands? Services? How should we resource it?

Problem statement: Recommended organizational construct for USC Title 10 National Security Missions in Space

Principal roles and missions in support of National Security Space Missions

- Man, train, equip & resource the force
- Provide mission and personnel supporting functions, e.g.,
  - Administrative
  - Logistical
  - Research & Development
  - Acquisition
  - Medical
- Operational employment in support of national security missions, under the direction of the National Command Authority force management and accountability constructs:
  - Allocation
  - Apportionment
  - Assignment

Desired attributes of the National Security Space Mission

- Provide direct and indirect support to national security objectives
- Provide offensive and defensive capabilities in support of national security space objectives
- Deter, deny, and when directed, defeat adversary intentions and capabilities counter to national security objectives
- Detect, characterize, & attribute intentions and capabilities counter to national security objectives both in space and globally

Recommended organizational construct for USC Title 10 National Security Missions in Space

- Space "Service" separate from the United States Air Force Service, under the United States Air Force Secretary, similar to the Navy/Marine Corps organizational relationships under the Secretary of the Navy
- Space "Service" responsible for the following space unique mission and personnel supporting functions integrated with the Air Force, where possible
  - Administrative
  - Logistical
  - Research & Development
  - Acquisition
  - Medical

- Operational employment in support of national security missions under the National Command Authority force management constructs:
  - Allocation
  - Apportionment
  - Assignment
- Resource authorities and accountability would also be patterned similar to the Navy/Marine Corps model
  - Space "Service" would have a separate budget, under the Secretary of the Air Force, for space-unique roles and missions
  - Space "Service" would have a co-mingled budget category for shared roles and missions with USAF, e.g., similar to Navy/Marine Corps blue in support of green, and green in support of blue
  - Secretary of the Air Force accountable for:
    - Resource advocacy and accountability
    - Service roles and missions integration, across all functions, that transition air and space

Question: Multiple Chinese academic/research institutions were mentioned [in your testimony]. Are any partnered with U.S. institutions?

Namrata Goswami, Ph.D.
Independent Senior Analyst

Academic Institutions: Beihang University and Chongqing University, an integral part of *Project 985* established by Chinese premier, Jiang Zemin in 1998,[1] are amongst the top publicly funded universities in China for research in science and technology. Both universities are taking the lead in developing the technology to realize future Chinese space goals like a research base on the Moon by 2036 and a Space-Based Solar Power (SBSP) satellite to be functional in Geo-Synchronous Orbit (GEO) by 2050.

Beihang University (previously called the Beijing University of Aeronautics and Astronautics)[2] experimented with a simulated Moon lab on Earth in 2018. The main focus of Beihang University is to develop aeronautical and astronautical research and education with the specific purpose of *prioritizing* China's national strategic needs.[3] In a report, carried by the *People's Daily*, on November 30, 2012, Beihang University was praised for its contributions to China's national defense.

> The report of the 18th National Congress of the Communist Party of China (hereinafter referred to as "NCCPC") pointed out that we should "speed up the modernization of national defense and military ", "implement innovation-driven development strategy, deepen the reform of scientific and technological system and promote the integration of science, technology and economy. We should accelerate the construction of national innovation system, which focuses on building a technological innovation system with enterprises as the main body, market as the orientation and industry-university-research collaboration as its characteristics…Beihang University (hereinafter referred to as "BUAA") as China's first aerospace institution of higher learning, has been providing an important intellectual and technological support to the *modernization of our country's national defense and military for many years* [emphasis added].[4]

Beihang University has partnered with the Arizona State University for students exchange programs within its Global Innovators program.[5] Beihang University has a student exchange initiative with Ohio State University, College of Engineering.[6] As per the *Times Higher Education Supplement*, "The university has established links with 152 universities and institutions from 40 countries including Canada, UK, France,

---

[1] "What is a 985 University?", at https://help.cucas.edu.cn/index/detail?id=2236 (Accessed on May 2, 2019).
[2] Beijing University of Aeronautics and Astronautics", at http://www.at0086.com/BUAA/ (Accessed on May 6, 2019).
[3] "Beihang at a Glance", at https://ev.buaa.edu.cn/About/Beihang_at_a_Glance.htm (Accessed on May 2, 2019).
[4] "People's Daily: Beihang University Cultivating Top-Notch, Innovative and Broad-Minded Talent", *People's Daily*, November 30, 2012 at http://hc.buaa.edu.cn/info/1015/1086.htm (Accessed on May 2, 2019).
[5] "ASU Forging Partnerships with China to Speed up Global Innovation", *ASU Now*, November 28, 2017 at https://asunow.asu.edu/20171128-global-engagement-asu-forging-partnerships-china-speed-global-innovation (Accessed on May 2, 2019).
[6] The Ohio State University, Office of International Affairs, "International Partnerships" at https://oia.osu.edu/international-partnerships/142-sea/3537-beihang-university.html (Accessed on May 2, 2019).

Germany, Russia, the United States and Sri Lanka".[7]As per its website, Beihang University specifies that it has partnered with "a foreign member of the US National Academy of Engineering", within its program of International Scientific and Technological Cooperation Base of Aerospace Physics.[8]

Chongqing University has international partnerships with University of Cincinnati,[9] and others. As per its international partnership page,

> Chongqing University has established cooperation with 115 institutions of higher education in over 20 countries, such as the USA, UK, France, Germany, Italy, Netherland, Canada, Australia, Japan, South Korea etc. The university has also established partnership with many prestigious international corporations or institutions, such as Siemens, Rockwell Automation, IBM, Microsoft, Lipo Group, New York Life Insurance, Omron, ABB, Ford, etc...[10]

Other U.S. academic institutions that Chongqing University has partnered with include the University of North Carolina at Wilmington, Tulane, Michigan Technological University and University of Arkansas, Fayetteville.[11] All U.S. universities were vetted and approved by the Chinese Ministry of Education to establish dual degree programs with Chongqing University.[12] It appears that there is a controlled level of collaboration between two of China's most successful universities on science and technology and U.S. universities.

Significantly, the People's Liberation Army Strategic Support Force (PLASSF) signed a 'Cooperation Framework Agreement" in 2017 with the China University of Science and Technology, Shanghai Jiaotong University, Xi'an Jiaotong University, Beijing Institute of Technology, Nanjing University, Harbin Institute of Technology and other six universities, as well as Aerospace Science and Technology Corporation, Aerospace Science and Industry Corporation, Electronic Technology Group Corporation.[13] As per the agreement,

> the military will focus on high-end talent training, innovation team building and cutting-edge science and technology research of new combat forces, focusing on receiving and receiving

---

[7] "Best Universities in Beijing", *Times Higher Education World University Rankings*, January 11, 2019 at https://www.timeshighereducation.com/student/best-universities/best-universities-beijing (Accessed on May 2, 2019).
[8] "International Scientific and Technological Cooperation Base of Aerospace Physics", Beihang University, November 30, 2017 at https://ev.buaa.edu.cn/info/1065/1410.htm (Accessed on May 2, 2019).
[9] University of Cincinnati, "Chongqing University", at https://www.uc.edu/international/strategic-partnerships/key-partners/cqu.html (Accessed on May 2, 2019); Michael Miller, "Celebrating a Milestone," UC Magazine, April 25, 2018 at https://magazine.uc.edu/editors_picks/recent_features/CQU.html (Accessed on May 2, 2019).
[10] "Study in Chongqing University", at http://study.cqu.edu.cn/HOME/ABOUT_US/University_Profile.htm (Accessed on May 2, 2019).
[11] "UNCW Among Select U.S. Universities Approved by the Chinese Ministry of Education for Dual Degree Partnership", University of North Carolina, Wilmington, March 21, 2018 at https://uncw.edu/news/2018/03/uncw-among-select-u.s.-universities-approved-by-the-chinese-ministry-of-education-for-dual-degree-partnership.html (Accessed on May 2, 2019).
[12] Ibid.
[13] "Strategic Support Force Cooperates with 9 Local Units to Train High End Talents of New Combat Forces", *Xinhua*, July 13, 2017 at http://military.people.com.cn/n1/2017/0713/c1011-29402123.html (Accessed on April 14, 2019).

> outstanding talents, carrying out special training, building practical training bases, promoting exchanges between experts and scholars, and deepening teaching and research.[14]

Amongst the universities mentioned in the agreement, the China University of Science and Technology has established academic partnership with the Florida State University for future research collaboration and student exchanges.[15] The Shanghai Jiaotong University has partnerships with the University of Maryland.[16] The University of Maryland and the Torch Program of the PRC's Ministry of Science and Technology are co-developing a U.S-China Science and Technology Park, aimed at promoting civilian technological partnership and innovation.[17] The Shanghai Jiaotong University has also established partnership with the Massachusetts Institute of Technology (MIT),[18] Drexel University,[19] while Xi'an Jiaotong University has academic partnerships with the Ohio State University's College of Engineering,[20] and the Washington University in St. Louis.[21] The Beijing Institute of Technology has partnerships with the University of Western Illinois;[22] Nanjing University has partnerships with the John Hopkins University,[23] and Syracuse University. The Harbin Institute of Technology has partnership with the Ohio State University, Department of Mathematics.[24] Significantly, all these university partnerships involve dual degree programs as well as student exchanges for purposes of science, technology and innovation. Innovation in science and

---

[14] Ibid.
[15] Kara Irby, "FSU Forges Partnership with East China University of Science and Technology", Florida State University News, February 19, 2018 at https://news.fsu.edu/news/2018/02/19/fsu-forges-partnership-east-china-university-science-technology/ (Accessed on May 2, 2019).
[16] "Partnerships with Chinese Institutions", University of Maryland, at https://globalmaryland.umd.edu/offices/partnerships-chinese-institutions (Accessed on May 2, 2019).
[17] Ibid.
[18] "SJTU Signed a Cooperation Agreement with MIT", Shanghai Jiaotong University, April 14, 2011 at http://en.sjtu.edu.cn/news/sjtu-signed-a-cooperation-agreement-with-mit (Accessed on May 2, 2019). "MIT to Support Creation of International Program at Shanghai Jiao tong University", *MIT News*, August 29, 2006 at http://news.mit.edu/2006/lfm-announcement (Accessed on May 2, 2019).
[19] Drexel University, "International Partnerships and Exchanges", at https://drexel.edu/global/partnerships-exchanges/current/ (Accessed on May 2, 2019). Also "Drexel Furthers its Academic Alliance with Shanghai Jiao Tong University", Drexel Now, April 14, 2016 at https://drexel.edu/now/archive/2016/April/Biomedical-China-Masters/ (Accessed on May 6, 2019).
[20] The Ohio State University, Office of International Affairs, "Xi'an Jiao Tong University", at https://oia.osu.edu/internationalagreements/4244-xi-an-jiaotong-university.html (Accessed on May 2, 2019). "International Partnerships Annual Report Reporting Period January 1-December 31, 2018 at https://oia.osu.edu/pdf/InternationalPartnerships2018.pdf (Accessed on May 6, 2019).
[21] "Xi'an Jiaotong University Named new McDonnell Academy Partner", Washington University in St Louis, April 12, 2016 at https://global.wustl.edu/xian-jiaotong-university-named-new-mcdonnell-academy-partner/ (Accessed on May 2, 2019).
[22] Western Illinois University, "International Partnerships", at http://www.wiu.edu/global_education/agents/partnerships.php (Accessed on May 2, 2019).
[23] John Hopkins School of Advanced International Studies, "Hopkins-Nanjing Center", at https://www.sais-jhu.edu/graduate-studies/campuses/nanjing-china#about-hopkins-nanjing-center (Accessed on May 2, 2019).
[24] The Ohio State University, Office of International Affairs, "Harbin Institute of Technology", at https://oia.osu.edu/internationalagreements/142-sea/1819-harbin-institute-of-technology-dual-degree.html (Accessed on May 2, 2019).

technology has been a continual focus of President Xi Jinping, with aspirations to turn China into a world leader in independent innovation, science and technology.[25]

U.S Private Space Sector: With regard to U.S. private space industry, Global IP, a Los Angeles based company had signed a $200 million investment deal with a Chinese company, when revealed, resulted in Boeing cancelling a satellite order from that company.[26] There are reports that China's TEN CENTS Holdings Ltd., invested in *Planetary Resources* and *Moon Express*.[27] *Moon Express*, a former Google Lunar X Prize competitor, has been selected by NASA's Commercial Lunar Payload Services (CLPS) to compete for contracts to deliver NASA's science and technology payloads on the lunar surface.[28] In 2017, NanoRacks, a Houston based space company, flew a space radiation environment experiment developed by Deng Yulin, a professor at the Beijing Institute of Technology on a Dragon cargo spacecraft to the International Space Station (ISS). Given the agreement was with NanoRacks, and not NASA,[29] the legal obstacles based on the 2011 Congressional ban on space cooperation between NASA and Chinese space institutions, were viewed as overcome since this was a civilian experiment that stayed on the Nanoracks platform.[30]

U.S-China Government Space Partnership: There is no evidence of partnership between state funded Chinese space institutions like the China National Space Administration (CNSA), the China Academy of Space Technology (CAST), the China Aerospace Science and Technology Corporation (CASC) or the China Academy of Launch Vehicle Technology (CALVT) and U.S.

---

[25] "China Focus: Xi calls for developing China into World Science and Technology Leader", Xinhuanet, May 29, 2018 at http://www.xinhuanet.com/english/2018-05/29/c_137213175.htm (Accessed on May 6, 2019).

[26] Brian Spegele and Kate 0' Keeffe, "Boeing Backs Out of Global IP Satellite Order Financed by China", *The Wall Street Journal*, December 6, 2018 at https://www.wsj.com/articles/boeing-backs-out-of-global-ip-satellite-project-financed-by-china-1544142484 (Accessed on May 2, 2019).

[27] Zen Soo, "China's Largest Tech Companies have Spent Billions on Investments, But Are They Smart Shoppers?", *South China Morning Post*, May 21, 2018 at https://www.scmp.com/tech/china-tech/article/2146500/chinas-largest-tech-companies-have-spent-billions-investments-are (Accessed on May 2, 2019). Also see Sean Kelly, "China is Infiltrating US Space Industry with Investments", *Hudson Institute*, December 26, 2018 at https://www.hudson.org/research/14773-china-is-infiltrating-us-space-industry-with-investments (Accessed on May 2, 2019).

[28] "NASA Announces New Partnerships for Commercial Lunar Payload Delivery Services", NASA, November 29, 2018 at https://solarsystem.nasa.gov/news/774/nasa-announces-new-partnerships-for-commercial-lunar-payload-delivery-services/ (Accessed on May 2, 2019).

[29] "NanoRacks Prepares Activation of Historic Chinese Research 25+Experiments Onboard International Space Station", NanoRacks, June 6, 2017 at http://nanoracks.com/nanoracks-launches-historic-chinese-research-25-experiments-to-international-space-station/ (Accessed on May 2, 2019). Jeff Foust, "One Small Step for U.S-China Space Cooperation", *SpaceNews*, July 10, 2017 at https://spacenews.com/one-small-step-for-u-s-china-space-cooperation/ (Accessed on May 2, 2019).

[30] William Pentland, "Congress Bans Scientific Collaboration with China, Cites High Espionage Risks", *Forbes*, May 7, 2011 at https://www.forbes.com/sites/williampentland/2011/05/07/congress-bans-scientific-collaboration-with-china-cites-high-espionage-risks/#264504964562 (Accessed on May 2, 2019). Marcia Smith, "Culberson Optimistic Restrictions on U.S-China Space Cooperation Will Remain", Spacepolicy.online, December 7, 2018 at https://spacepolicyonline.com/news/culberson-optimistic-restrictions-on-us-china-space-cooperation-will-remain/ (Accessed on May 2, 2019).

government space agencies like NASA and the White House Office of Science and Technology Policy (OSTP) due to the 2011 Congressional ban.

The Department of Defense and Full-Year Continuing Appropriations Act, 2011, enacted into law on April 15, 2011, specified in section 1340 (a):

> None of the funds made available by this division may be used for the National Aeronautics and Space Administration or the Office of Science and Technology Policy to develop, design, plan, promulgate, implement, or execute a bilateral policy, program, order, or contract of any kind to participate, collaborate, or coordinate bilaterally in any way with China or any Chinese-owned company unless such activities are specifically authorized by a law enacted after the date of enactment of this division.[31]

Interestingly, the Chinese white paper of 2016 claimed that

> China and the United States, within the framework of the China-US Strategic and Economic Dialogue, carried out a civil space dialogue, stating that the two countries would strengthen cooperation in space debris, space weather, response to global climate change, and related areas.[32]

In May 2011, Representative Frank R. Wolf requested the opinion of the United States Government Accountability Office (GAO) on "the propriety of activities undertaken in May 2011 by the Office of Science and Technology Policy (OSTP) with representatives of the government of the People's Republic of China… during the U.S.-China Dialogue on Innovation Policy (Innovation Dialogue) and the U.S.-China Strategic and Economic Dialogue (S&ED) held in Washington, D.C., in May 2011".[33] Wolf enquired as to whether "OSTP violated section 1340 of the Department of Defense and Full-Year Continuing Appropriations Act, 2011".

On October 11, 2011, GAO responded stating that:

> We conclude that OSTP's use of appropriations to fund its participation in the Innovation Dialogue and the S&ED violated the prohibition in section 1340. In addition, because section 1340 prohibited the use of OSTP's appropriations for this purpose, OSTP's involvement in the Innovation Dialogue and the S&ED resulted in obligations in excess of appropriated funds available to OSTP; as such, OSTP violated the Antideficiency Act, 31 U.S.C. § 1341(a)(1)(A).[34]

There is open source reporting that NASA aims to collaborate with CNSA, for purposes of lunar exploration especially after the landing of the *Chang'e 4* on the far side of the Moon. President Donald Trump has urged a return to the Moon as per his Space

---

[31] The Department of Defense and Full-Year Continuing Appropriations Act, 2011, at https://www.congress.gov/bill/112th-congress/house-bill/1473/text (Accessed on May 6, 2019).
[32] "Full text of White Paper on China's Space Activities in 2016", The State Council, The People's Republic of China, December 28, 2016 at http://english.gov.cn/archive/white_paper/2016/12/28/content_281475527159496.htm (Accessed on April 17, 2019). "The First Meeting of the U.S-China Space Dialogue", *Space Daily*, October 1, 2015 at http://www.spacedaily.com/reports/The_First_Meeting_of_the_U_S__China_Space_Dialogue_999.html (Accessed on May 3, 2019).
[33]For a full reading of GAO's response, please see United States Government Accountability Office, at https://www.gao.gov/assets/590/585718.pdf (Accessed on May 6, 2019).
[34] Ibid, p.1.

Policy Directive 1.[35] Any such future partnership is envisioned to involve sharing of data for lunar space science missions and explorations. In 2015, both NASA and CNSA attended the International Space Exploration Coordination Group (ISECG) organized at the European Space Agency (ESA) European Space Operations Center in Darmstadt where representatives from 14 space agencies discussed missions to Cis-Lunar space and Mars.[36]

During my field trip to China, I enquired of Chinese space thinkers and security analysts what they thought of the U.S. 2011 ban on any partnership between U.S. and Chinese space institutions. Their answer was that once China achieves technological sophistication with regard to space launches and missions, NASA and other U.S. space institutions will partner by default. They asserted that China's demonstration of its own indigenous advanced space technologies will address U.S. concerns over technology theft. Both the NASA administrator, Jim Bridenstine and CNSA administrator, Zhang Kejian, expressed interest in working together to share space science data during the 2018 69th International Astronautical Conference held in Bremen, Germany.[37] Nevertheless, any bilateral U.S-China government space partnership/cooperation will have to be approved by the U.S. Congress.[38]

[35] Presidential Memorandum on Reinvigorating America's Human Space Exploration Program", The White House, December 11, 2017 at https://www.whitehouse.gov/presidential-actions/presidential-memorandum-reinvigorating-americas-human-space-exploration-program/ (Accessed on May 1, 2019).

[36] Those represented were Italian Space Agency, the French Centre National d'Etudes Spatiales, China National Space Administration, Canadian Space Agency, German Aerospace Center, ESA, Indian Space Research Organisation, Japan Aerospace Exploration Agency, Korea Aerospace Research Institute, National Aeronautics and Space Administration, State Space Agency of Ukraine, Russian Federal Space Agency, the U.K. Space Agency and the United Arab Emirates Space Agency. See NASA, "International Space Agencies Meet to Advance Space Exploration", October 8, 2015 at https://www.nasa.gov/press-release/international-space-agencies-meet-to-advance-space-exploration (Accessed on May 2, 2019).

[37] Jeff Foust, "NASA Opens Door to Additional Cooperation with China", *SpaceNews*, October 1, 2018 at https://spacenews.com/nasa-opens-door-to-additional-cooperation-with-china/ (Accessed on May 1, 2019).

[38] U.S. Department of Commerce, "U.S. Space Industry "Deep Dive" Assessment: Impact of U.S. Export Controls on the Space Industrial Base", February 2014 at https://www.bis.doc.gov/index.php/documents/technology-evaluation/898-space-export-control-report/file (Accessed on May 1, 2019).