CHINA'S SPACE AND COUNTERSPACE PROGRAMS

HEARING

BEFORE THE

U.S.-CHINA ECONOMIC AND SECURITY REVIEW COMMISSION

ONE HUNDRED FOURTEENTH CONGRESS
FIRST SESSION

WEDNESDAY, FEBRUARY 18, 2015

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UNITED STATES-CHINA ECONOMIC AND SECURITY REVIEW COMMISSION

WASHINGTON: 2015

U.S.-CHINA ECONOMIC AND SECURITY REVIEW COMMISSION

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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.

March 26, 2015

The Honorable Orrin Hatch
President Pro Tempore of the Senate, Washington, D.C. 20510
The Honorable John A. Boehner
Speaker of the House of Representatives, Washington, D.C. 20515

DEAR SENATOR HATCH AND SPEAKER BOEHNER:

We are pleased to notify you of the Commission's February 18, 2015 public hearing on "China's Space and Counterspace Programs." The Floyd D. Spence National Defense Authorization Act (amended by Pub. L. No. 109-108, section 635(a) and amended by Pub. L. No. 113-291, Section 1259 B) provides the basis for this hearing.

At the hearing, the Commissioners received testimony from the following witnesses: Mr. Kevin Pollpeter, Deputy Director, Study of Innovation and Technology in China, Institute on Global Conflict and Cooperation, University of California-San Diego; Dr. Joan Johnson-Freese, Professor, National Security Studies, U.S. Naval War College; Mr. Dean Cheng, Senior Research Fellow, Asian Studies Center, The Heritage Foundation; Dr. Alanna Krolikowski, Princeton-Harvard China and the World Fellow, Fairbank Center for Chinese Studies, Harvard University; Mr. Tate Nurkin, Managing Director of Research and Thought Leadership, Jane's IHS Aerospace, Defense and Security; Mr. Mark Stokes, Executive Director, Project 2049 Institute; Mr. Richard D. Fisher, Jr., Senior Fellow, Asian Military Affairs, International Assessment and Strategy Center; Dr. Roger Handberg, Professor, Department of Political Science, University of Central Florida; and Dr. Phillip Saunders, Distinguished Research Fellow and Director, Center for the Study of Chinese Military Affairs, Institute for National Strategic Studies, National Defense University. The hearing examined the capabilities, scope, and objectives of China's space and counterspace programs. It explored the research and development efforts behind these programs and the factors that have contributed to China's recent space technology advances. The hearing also addressed the implications of China's dual-use and military space programs for the United States.

We note that prepared statements for the hearing, the hearing transcript, and supporting documents submitted by the witnesses are available on the Commission's website at 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 other issues enumerated in its statutory mandate, in its 2015 Annual Report that will be submitted to Congress in November 2015. Should you have any questions regarding this hearing or any other issue related to China, please do not hesitate to have your staff contact our Congressional Liaison, Reed Eckhold, at (202) 624-1496 or via email at reckhold@uscc.gov.

Sincerely yours,

Hon. William A. Reinsch
Chairman

Hon. Dennis C. Shea
Vice Chairman

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CHINA'S SPACE AND COUNTERSPACE PROGRAMS

WEDNESDAY, FEBRUARY 18, 2015

U.S.-CHINA ECONOMIC AND SECURITY REVIEW COMMISSION

Washington, D.C.

The Commission met in Room SD – 608 Dirksen Senate Office Building Washington, DC at 8:30 a.m., Commissioner Jeffrey L. Fiedler and Senator James M. Talent (Hearing Co-Chairs), presiding.

OPENING STATEMENT OF COMMISSIONER JEFFREY L. FIEDLER HEARING CO-CHAIR

HEARING CO-CHAIR FIEDLER: Good morning and welcome to the second hearing of the U.S.-China Economic and Security Review Commission's 2015 Annual Report cycle. I would mention that this is being Webcast so those who are weather-averse are sitting at home watching.

I want to thank our witnesses for being here today and for the time they have put in to their excellent written testimonies. Each of their written statements will be submitted for the record and will be available online at the Commission's Web site, www.uscc.gov.

Before we begin, let me take a moment to thank the Senate Budget Committee, Chairman Mike Enzi, and the Committee staff for providing this room for us today.

Today's hearing will examine the capabilities, scope and objectives of China's civilian and military space programs. It will also explore the research and development efforts behind these programs and the factors that have contributed to China's recent space technology advances. Finally, it will look at the economic and security implications of China's space and counterspace programs for the United States.

Over the last decade, China has rapidly scaled up and improved its civilian and military space platforms, including satellites, ground infrastructure and rockets. These inherently dual-use platforms help China achieve economic and scientific missions, while supporting expanded PLA operations and military modernization goals.

Although China is mostly playing catch-up to the United States in space capabilities, China poses a number of challenges to U.S. activities in space. First and foremost is China's development of new counterspace technologies that could disable or destroy U.S. satellites and their support architecture.

In a decade, China may lead the only international space station, fully deploy its own dual-use satellite navigation system, and serve as the primary space launch partner for many international customers.

We look forward to hearing a wide range of views today on how the United States can best address these challenges.

I will now turn to my hearing co-chair Senator Jim Talent for his opening remarks.

PREPARED STATEMENT OF COMMISSIONER JEFFREY L. FIEDLER
HEARING CO-CHAIR

U.S.-China Economic and Security Review Commission

Hearing on China's Space and Counterspace Programs

Opening Statement of
Commissioner Jeffrey L. Fiedler
February 18, 2014
Washington, DC

Good morning and welcome to the second hearing of the U.S.-China Economic and Security Review Commission's 2015 Annual Report cycle. I want to thank our witnesses for being here today, and for the time they have put into their excellent written testimonies. Each of their written statements will be submitted for the record and will be available online at the Commission's website (www.uscc.gov). Before we begin, let me take a moment to thank the Senate Budget Committee, Chairman Mike Enzi, and the Committee staff for securing this room for us today.

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Although China is mostly catching up to the United States in space capabilities, China poses a number of challenges to U.S. activities in space. First and foremost is China's development of new counterspace technologies that could disable or destroy U.S. satellites and their support architecture. In addition, China's space exploration and satellite launch plans could erode U.S. dominance in space. In a decade, China may lead the only international space station, fully deploy its own dual-use satellite navigation system, and serve as the primary space launch partner for many international customers.

We look forward to hearing a wide range of views today on how the United States can best address these challenges.

I now turn to my hearing co-chair Senator Talent for his opening remarks.

OPENING STATEMENT OF COMMISSIONER JAMES M. TALENT
HEARING CO-CHAIR

HEARING CO-CHAIR TALENT: Thank you, Commissioner Fiedler and thanks to our witnesses for being here today to help us examine China's space programs and their implications for the United States.

America's space architecture is vital to its civilian life as well as to the operation of its armed forces, and until recently, Americans could take that architecture for granted. However, alongside China's ostensibly civilian space programs, the PLA is pursuing a multifaceted counterspace program with the ability to disrupt or destroy U.S. space architecture.

In 2007, China successfully tested its first kinetic antisatellite weapon, destroying an aging weather satellite and creating over 2,000 pieces of debris. This event shocked the international community, and the debris remains a threat to all satellites in orbit.

Since then, China has only increased its counterspace capabilities and has developed and tested more sophisticated technologies designed to disable or destroy satellites. These include missile intercept tests, robotic arm technology, ground-based lasers, and cyber attacks.

In July of last year, China conducted its third non-destructive anti-missile test in space.

Congress brought much-needed attention to China's counterspace program in a joint House subcommittee hearing last year. In the coming days, the Commission will publish a report by the University of California-San Diego that documents the full scope of China's counterspace capabilities, along with China's space programs. The lead author of that report, Kevin Pollpeter, is here with us today.

PREPARED STATEMENT OF COMMISSIONER JAMES M. TALENT
HEARING CO-CHAIR

U.S.-China Economic and Security Review Commission

Hearing on China's Space and Counterspace Programs

Opening Statement of
Senator James M. Talent
February 18, 2014

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With that in mind, I would like to introduce our first panel on China's civilian, dual-use, and military space programs. Mr. Kevin Pollpeter is deputy director of the University of California Institute on Global Conflict and Cooperation project on the Study of Innovation and Technology in China. He is widely published on China national security issues, focused on China's space program and information warfare.

Dr. Joan Johnson-Freese is a professor of National Security Studies at the U.S. Naval War College. Her space-related publications include: Heavenly Ambitions: America's Quest to Dominate Space, Space as a Strategic Asset, The Chinese Space Program: A Mystery within the Maze, and over 100 journal articles.

Mr. Dean Cheng is a senior research fellow in the Asian Studies Center at the Heritage Foundation. He has written extensively on China's military doctrine, technological implications of its space program, and dual-use issues associated with China's industrial and scientific infrastructure.

Thank you all for joining us. Before we begin, we ask that you please keep your opening remarks to seven minutes. Mr. Pollpeter, let's start with you.

PANEL I INTRODUCTION BY COMMISSIONER JAMES M. TALENT

HEARING CO-CHAIR TALENT: With that in mind, I'd like to introduce our first panel on China's civilian, dual-use and military space programs. Mr. Kevin Pollpeter is Deputy Director of the University of California Institute on Global Conflict and Cooperation Project on the Study of Innovation and Technology in China. He is widely published on China national security issues, focused on China's space program and information warfare.

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Mr. Dean Cheng is a Senior Research Fellow in the Asian Studies Center at the Heritage Foundation. He has written extensively on China's military doctrine, technological implications of its space program, and dual-use issues associated with China's industrial and scientific infrastructure.

Thank you all for joining us on this cold day. Before we begin, we do want to ask that you please keep your opening remarks to seven minutes to leave plenty of time for questions. And Mr. Pollpeter, let's start with you.

OPENING STATEMENT OF MR. KEVIN POLLPETER
DEPUTY DIRECTOR, STUDY OF INNOVATION AND TECHNOLOGY IN CHINA, INSTITUTE ON GLOBAL CONFLICT AND COOPERATION, UNIVERSITY OF CALIFORNIA-SAN DIEGO

MR. POLLPETER: Okay. Very good. Thank you, Senator Talent.

Good morning, Commissioners. I'm happy to be here. As you well know, there has been a dramatic increase in China's space capability since the year 2000, and although China conducts a space program for both political and economic reasons, what I want to focus on mainly here today is on the national security implications and progress that China has made in its space program.

Indeed, I would argue that China's space program plays a central role in China's anti-access/area denial plans.

China views space as critical to its development of what they call an "informationized force." And, in fact, almost every Chinese source that you do read states that whoever controls space controls the earth. As a result, Chinese military writers conclude that China must achieve space supremacy, which is to control space, to be able to freely use space, and to be able to deny the ability to use space to adversaries.

And so what we see here is almost a full spectrum development of its space capabilities, both on the C4ISR realm and on the counterspace realm. We have the Beidou satellite navigation system, which by 2020 will have a constellation of 35 satellites. It will be similar to our GPS system, and with the aid of a differential supplementary system, it will be able to achieve accuracies of up to one meter.

They have introduced a wide range of remote-sensing satellites since 2000. These include electro-optical, both color, multispectral, black and white, synthetic aperture radar, electronic intelligence satellites, and by 2020, China wants to form a global 24-hour all-weather remote-sensing system.

And connecting all these is a system of communication satellites called the Tianlian satellites, which will be able to connect and provide near real-time information gathering and processing for China's ISR capabilities.

And what this is supposed to do is to enable China to be able to detect and locate and target U.S. Navy ships' bases that are beyond visual range and to be able to keep those ships out beyond an effective range.

We also see China is invested heavily in counterspace capabilities during this time. We've mentioned the 2007 ASAT test. There have been missile defense tests in 2010, 2013, and 2014, and these missile defense tests have obvious counterspace implications, and these are mainly to threaten satellites in low earth orbit.

In 2013, we have seen what China has called a high altitude scientific mission. This also has obvious counterspace implications in that it could threaten U.S. satellites in medium earth orbit and geosynchronous orbit.

China has also been engaged in a far-ranging directed-energy weapon campaign, developing lasers, high-powered microwave weapons and particle beam weapons.

In 2006, China used a laser against a U.S. satellite though it's unclear what the purpose of that was, whether it was actually to interfere with the satellite or whether it was to actually just range the satellite.

We've also seen a host of co-orbital satellite technologies being developed by China.

These are primarily dual-use. All of them have a legitimate peaceful use. With the Shenzhou-7 in 2009, China used the Banxing-1, or the BX-1, to orbit the Shenzhou-7 to take images of the Shenzhou-7. In 2010, China bumped two satellites together in what was ostensibly a practice for their future docking missions.

And in 2013, China has tested a robotic arm, space robotic arm system, where one satellite met close with another and grappled with it.

Cyber is also a continuing sort of pernicious threat to our space capabilities. There have been reported hacks against our Landsat systems, against our jet propulsion laboratory, most recently against our National Weather Service. It's uncertain who did these so we can't say that China did these, but it does point to a vulnerability within our satellite computer systems, and it also points that China views cyber as a new method of warfare that will change, what they say will change the future of warfare as we know it and places a lot of emphasis on this in their writings.

There's also such things as electronic warfare, specifically against GPS. GPS has a very weak signal and it's easy to jam.

Lastly, what I want to point out is what is unique about China's space program is its emphasis on manned platforms. We well know that they have a vibrant manned space program, but they also see military uses for their manned space program that includes reconnaissance as well as counterspace implications, whether such fanciful notions of putting weapons on space stations or having astronauts fly around in spacecraft attacking other satellites.

But buttressing this is a new series of launch vehicles that China plans to introduce. The first one will probably be launched this year, the Long March 7, and a much heavier version with the Long March 5, which will be able to put up larger reconnaissance satellites as well as aid China's efforts to the moon.

What I want to point to here is development of solid rocket launch vehicles, one, the Kuaizhou, and the other is the Long March-11. These can be launched on mobile rocket launchers. They carry relatively small satellites but will enable China to have an operational responsive space capability where if they lose satellites or if they lose their launch centers, they'll be able to rapidly replace satellites with these launchers.

So, by 2013, we will see that China will have a new variety of launch vehicles. They will have a comprehensive robust space-based C4ISR network. They will have a satellite navigation system that will have accuracies as good as GPS, and they will be able to launch on a much more responsive basis than either the U.S. or they can do right now.

You've asked us to take a look at the implications. What should be some of the responses by the U.S. for this? First of all, I would say that we need to continue to invest in spaceYou know, there are a lot of reasons why we are good at doing space, but money is a buttressing factor, is the fundamental factor, and we need to keep investing in space both on the military and civilian side.

And we also need to invest in our people. If you look at the workforce demographics for China's space industry, their big bubble in demographics is people aged from 25 to 35. If you look at our workforce, it's aging. The largest percentage is 55 to 65, and we need to be able to keep those people going into our pipeline.

And, finally, we need to invest in things like space surveillance network and invest in smaller, more nimble satellites so we can develop our own operational response capability.

And with that, I will end and thank you, Commissioners.

PREPARED STATEMENT OF MR. KEVIN POLLPETER
DEPUTY DIRECTOR, STUDY OF INNOVATION AND TECHNOLOGY IN CHINA, INSTITUTE ON GLOBAL CONFLICT AND COOPERATION, UNIVERSITY OF CALIFORNIA-SAN DIEGO

Testimony before the U.S.-China Economic and Security Review Commission for the hearing on "China's Space and Counterspace Programs"

February 18, 2015

Kevin Pollpeter
University of California Institute on Global Conflict and Cooperation

China is a nation on a quest for wealth and power. It seeks increased influence and independence from foreign powers with the ultimate goal of preserving China's sovereignty, independence, territorial integrity, and political system. Over the long term, China seeks to transform the international system to better suit its interests, but seeks to integrate itself into the existing international system over the short term with the goal of reshaping the Asia-Pacific political environment into one in which it is dominant.

China's pursuit of space power is intended to carry out this strategy. China views the development of space power as a necessary move for a country that wants to strengthen its national power. Indeed, China's goal is to become a space power on par with the United States and to foster a space industry that is the equal of those in the United States, Europe, and Russia. China takes a comprehensive, long-term approach to its space program that emphasizes the accrual of the military, economic, and political benefits space can provide. By placing much of its space program in a 15-year development program and providing ample funding, the Chinese government provides a stable environment in which its space program can prosper. Although China is probably truthful when it says that it is not in a space race, such statements mask the true intent of its space program: to become militarily, diplomatically, commercially, and economically as competitive as the United States is in space.

China's efforts to use its space program to transform itself into a military, economic, and technological power may come at the expense of U.S. leadership. Even if U.S. space power continues to improve in absolute terms, China's rapid advance in space technologies will result in relative gains that challenge the U.S. position in space. At its current trajectory, China's space program, even if not the equal of the U.S. space program, will at some point be good enough to adequately support modern military operations, compete commercially, and deliver political gains that will serve its broader strategic interest of again being a major power more in control of its own destiny.

Military Benefits

China's space program assists the People's Liberation Army (PLA) in its efforts to achieve information superiority, defined as the ability to freely use information and the ability to deny the use of information to an adversary. Based on their analysis of U.S. military operations, Chinese military researchers view space as a critical component in making the PLA into a force capable

of winning "informatized" wars and recognize the role space plays in the collection and transmittal of information and the need to deny those capabilities to an adversary.

Indeed, nearly every Chinese source describes space as the "ultimate high ground," leading many Chinese analysts to assess that space warfare is inevitable. Because of the preeminence of the space battlefield, analysts writing on space argue that it will become the center of gravity in future wars and one that must be seized and controlled. In fact, these analysts argue that the first condition for seizing the initiative is to achieve space supremacy.

Space Technologies

China has made impressive progress in space technologies since 2000. China now has nearly a full range of satellites to accomplish a variety of missions. These include remote sensing satellites with various resolutions and covering various spectrums, a satellite navigation system, communication satellites, and robust human spaceflight and lunar exploration programs.

Space-based C4ISR Technologies

A robust, space-based C4ISR system is often described as a critical component of a future networked PLA. The necessity to develop space-based C4ISR systems is based on the requirement to develop power-projection and precision-strike capabilities. The development of long-range cruise missiles and ballistic missiles requires the ability to locate and target enemy ships and bases hundreds of kilometers away from China's shores, as well as the ability to coordinate these operations with units from multiple services. In doing so, remote sensing satellites can provide intelligence on the disposition of enemy forces and provide strategic intelligence before a conflict begins. Communication satellites can provide global connectivity and can facilitate communications between far-flung forces. Navigation and positioning satellites can provide critical information on location and can improve the accuracy of strikes.

Satellite Navigation

China's Beidou satellite navigation system is planned to provide a global service by 2020. Designed to be similar to the U.S. Global Positioning System (GPS), Beidou will consist of 35 satellites in medium Earth and geosynchronous orbits that will provide positioning accuracies of less than 10 meters. With the use of a nation-wide system of differential Beidou, accuracy will be improved to one meter. Unlike GPS, Beidou has a short messaging service in which messages as long as 120 characters can be sent to other Beidou receivers. Beidou is increasingly used by the Chinese military at the regiment level and above and is reportedly being integrated into weapon guidance systems.

Remote Sensing

The stated purpose of China's satellite remote sensing project is to build an all-weather, 24-hour, global Earth remote sensing system by 2020 capable of monitoring the ground, atmosphere, and oceans. China has a variety of remote sensing satellites, including four new series introduced since 2000: the Gaofen, Yaogan, Huanjing, and Tianhui satellites. This is in addition to legacy satellite series such as the Ziyuan Earth remote sensing satellite and the Fengyun meteorological satellite.

With these satellites, China can serve a variety of remote sensing needs. Chinese imagers have

stated resolutions of one to thirty meters and can image in the visible, infrared, and multispectral ranges. The Yaogan and Huanjing satellites also use synthetic aperture radar (SAR) to be able to image through cloud cover or at night. Certain Yaogan satellites are also rumored to have electronic intelligence capabilities.
Accessing information from these satellites is facilitated by a network of three satellites, designated Tianlian, that relay communications and data between satellites and ground stations anywhere on the Earth regardless of the position of the satellite in orbit or the location of the unit on the ground.

Counterspace Technologies
The PLA also recognizes that it must deny the use of information to its opponents. Chinese analysts assess that the employment of space-based C4ISR capabilities by potential adversaries, especially the United States, requires the PLA to develop capabilities to attack space systems. According to the U.S. Defense Department, China has a broad-based development program for counterspace technology that consists of jammers, direct-ascent kinetic-kill vehicles, directed-energy weapons, and co-orbital spacecraft.[1] China's development of counterspace weapons appears to be aimed at developing an all-around capability to threaten satellites with a variety of weapons at all orbits.

Direct Ascent Counterspace Technologies
The most prominent demonstration of China's counterspace technologies was the 2007 destruction of a defunct FY-1C meteorological satellite with a direct-ascent kinetic-kill vehicle. In 2010, 2013, and 2014, China conducted mid-course tests of a missile defense system that are believed to be de facto ASAT tests.

In addition to missile defense tests, China conducted a "high altitude science mission" in 2013 using a sounding rocket. According to the Chinese Academy of Sciences, the rocket reached an altitude of more than 10,000 kilometers and released a barium cloud to study the dynamic characteristics of the Earth's magnetosphere.[2] This claim appeared to be contradicted by a U.S. government assessment that the rocket "appeared to be on a ballistic trajectory nearly to geosynchronous Earth orbit (GEO)," which could refer to a distance of 30,000 kilometers.[3] If so, the test would represent an expansion of China's ASAT capabilities and could help enable China to threaten satellites such as GPS and communication satellites in medium and high Earth orbits.

Directed Energy Counterspace Technologies
China is also developing directed-energy weapons such as lasers, high-powered microwave, and particle beam weapons for ASAT missions.[4] The Defense Department concluded in 2006 that

[1] Office of the U.S. Secretary of Defense, Annual Report to Congress: Military and Security Developments Involving the People's Republic of China (2012), 9.
[2] "中国再次高空科学探测试验：高度更高数据更多" [China Again Conducts a High Altitude Science Mission: Higher Altitude and More Data], 中国新闻网 [China News], May 14, 2013, accessed September 2, 2014, http://www.chinanews.com/gn/2013/05-14/4817925.shtml.
[3] Brian Weeden, "Through a Glass, Darkly: Chinese, American, and Russian Anti-Satellite Testing in Space," Space Review, March 17, 2014, accessed September 2, 2014, http://www.thespacereview.com/article/2473/1.
[4] Office of the U.S. Secretary of Defense, Annual Report to Congress: Military and Security Developments Involving the People's Republic of China (2012), 9.

China had "at least one…ground-based laser designed to damage or blind imaging satellites."[5] Lasers at higher power levels can permanently damage satellites and at lower power levels can temporarily blind the imagers of a remote sensing satellite. In 2006 it was reported that China had fired a laser at a U.S. satellite. According to U.S. officials, the intent of the lasing is unknown and did not damage the satellite, suggesting that China could have been determining the range of the satellite rather than trying to interfere with its function.[6]

China is also researching radio frequency (RF) weapons that could be used against satellites. Radio frequency weapons using high power microwaves can be ground-based, space-based, or employed on missiles to temporarily or permanently disable electronic components through overheating or short-circuiting. RF weapons are thus useful in achieving a wide spectrum of effects against satellites in all orbits.[7] Because RF weapons affect the electronics of satellites, evaluating the success of an attack may be difficult since no debris would be produced.[8]

Co-orbital Counterspace Technologies

Chinese researchers also discuss the use of co-orbital counterspace technologies. As one researcher states, the "ample use of the superiority and characteristics of modern small satellites, ingeniously applied to space attack and defense, will cause small satellites to become a space weapon assassin's mace."[9] Co-orbital satellites are those satellites that come within a close distance to another satellite to interfere with, disable, or destroy the target satellite. Co-orbital satellites do not have to be dedicated to the counterspace role and can also serve legitimate peacetime functions.[10]

According to the U.S. Defense Department, China has "conducted increasingly complex close proximity operations between satellites."[11] During the Shenzhou-7 mission the Banxing-1 flew around Shenzhou-7 at a distance of several tens of meters to several hundred meters. After the astronauts departed for Earth, BX-1 orbited Shenzhou-7 at a distance of one to two hundred kilometers. BX-1 was equipped with two cameras that took images of Shenzhou-7. The stated reason for the BX-1 was to test the orbiting of a spacecraft with the Shenzhou 7 to prepare for an

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[5] Office of the U.S. Secretary of Defense, Annual Report to Congress: Military and Security Developments Involving the People's Republic of China (2006), 35.

[6] Elaine M. Grossman, "Top Commander: Chinese Interference With U.S. Satellites Uncertain," World Politics Review, October 18, 2006, accessed September 2, 2014,

[7] Office of the U.S. Secretary of Defense, Annual Report to Congress: Military and Security Developments Involving the People's Republic of China (2006), 34; and Office of Technology Assessment, Anti-Satellite Weapons, Countermeasures, and Arms Control, September 1985, 66–67.

[8] David Wright, Laura Grego, and Lisbeth Gronlund, The Physics of Space Security: A Reference Manual (Cambridge, MA: American Academy of Arts and Sciences, 2005), 133.

[9] Lin Laixing, "Study on the Overseas Microsatellite Application in Space Attack-Defense (国外微小卫星在空间攻防中的应用研究)," Journal of the Academy of Equipment Command and Technology (装备指挥技术学院学报), 2006/6, 49.

[10] See, for example, Huang Siyong and Xu Peide, "空间武器平台潜伏轨道分布模型研究" [Study of Distributed Model of Hidden Orbits for Space Weapons Platforms], 航天控制 [Aerospace Control], June 2007; and Ma Wendi, 小卫星编队与反卫星卫星 ["Small Satellite Formations and ASAT Satellites"], 中国航天 [Aerospace China], April 2006.

[11] Office of the U.S. Secretary of Defense, Annual Report to Congress: Military and Security Developments Involving the People's Republic of China (2012), 9.

eventual docking mission with a space station.[12]
The BX-1 mission was involved in some controversy when it passed within 45 kilometers of the International Space Station, leading some to conclude that the mission was also a test of a co-orbital ASAT capability[13] or that it was testing satellite inspection capabilities.[14] The proximity of the BX-1 did not present a hazard to the International Space Station.[15]

In August 2010 it was reported that after conducting a series of maneuvers the Shijian-12 (SJ-12) satellite had most likely bumped into the Shijian 6F (SJ-6F), causing it to drift slightly from its original orbit. The maneuvering could have been practice for docking the Shenzhou space capsule with the Tiangong-1 space station, but Chinese silence on the intention of the test fueled concern that it was a cover for testing ASAT capabilities.[16]

In August 2013 China conducted a test of robotic arm technologies involving the Chuangxin-3, Shiyan-7, and Shijian-15 satellites where one of the satellites acted as a target satellite and another satellite, most likely equipped with a robotic arm, grappled the target satellite. As with the August 2010 test involving the SJ-12 and SJ-6F, the test could have been for a legitimate peaceful purpose: the testing of robotic arm technologies to be used on future Chinese space stations. As with the August 2010 tests, however, the dual-use nature and silence by the Chinese on the matter have only fueled speculation that China was also testing counterspace technologies.[17]

Cyber Operations
Many Chinese writings describe cyber operations as a new type of warfare which holds the potential to change the face of war as we know it by being able to greatly affect an adversary's political, economic, and military capabilities.[18] China may have been involved in computer hacks against satellite computer systems. In October 2007 and July 2008, a computer attack against the command and control system of Landsat-7, a remote sensing satellite operated by the USGS and NASA, resulted in 12 or more minutes of interference on each occasion. The attacks did not

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[12] "伴飞小卫星将"追赶"分离后的神七轨道舱" [Small Companion Satellite Will Chase After the Shenzhou 7 Orbital Capsule After Separation], Xinhuanet, September 24, 2008, accessed March 26, 15, http://news.xinhuanet.com/newscenter/2008-09/24/content_10104787.htm; "Shenzhou-7 Launches Small Monitoring Satellite," Xinhuanet, September 27, 2008, accessed March 26, 15, http://news.xinhuanet.com/english/2008-09/27/content_10123015.htm; "伴飞小卫星将给神七'照相'" [Small Companion Satellite Will Take Photographs of Shenzhou 7], Xinhuanet, September 24, 2008, accessed March 26, 15, http://news.xinhuanet.com/newscenter/2008-09/24/content_10104656.htm.
[13] "Closer Look: Shenzhou-7's Close Pass by the International Space Station," International Assessment and Strategy Center, October 9, 2008, accessed March 26, 15, http://www.strategycenter.net/research/pubID.191/pub_detail.asp.
[14] "China's BX-1 Microsatellite: A Litmus Test for Space Weaponization," Space Review, October 20, 2008, accessed March 26, 15, http://www.thespacereview.com/article/1235/1.
[15] Tianlian satellites are discussed in further detail later in the paper.
[16] Brian Weeden, "Dancing in the Dark: The Orbital Rendezvous of SJ-12 and SJ-06F," Space Review, August 30, 2010, accessed September 2, 2014, http://www.thespacereview.com/article/1689/1.
[17] See Kevin Pollpeter, "China's Space Robotic Arm Programs," SITC News Analysis, October 2013, accessed September 2, 2014, http://igcc.ucsd.edu/assets/001/505021.pdf.
[18] Lu Yunsheng and Liu Haifeng, "Jisuanji wangluo gongji tixi gouxiang" (A Vision for Computer Network Attack), Wangluo anquan jishu yu yingyong (Network Security Technology and Application), No. 108 (December 2009), p. 43.

result in the perpetrator achieving the ability to take command of the satellite. In June and October 2008, the command and control system for the Terra EOS (Earth Observation System) was hacked into, resulting in two or more minutes and nine or more minutes of interference, respectively. In both cases, the perpetrator had the ability to command the satellite, but refrained from doing so.[19] The attacks have not been attributed and China has denied responsibility for the attacks.[20]

Electronic Warfare

China has acquired foreign and indigenous jammers that give it "the capability to jam common satellite communications bands and GPS receivers."[21] GPS, in particular, can be easily jammed due to the attenuation of the signal over the 12,500-mile distance between the satellites and Earth.[22] As a result, even low-power jammers can achieve effects over long distances. According to the Defense Science Board, "modest (few watt) jammers can deny acquisition [of the GPS signal]" at ranges up to hundreds of kilometers.[23]

Nuclear Weapons

China could detonate a nuclear weapon in space to destroy and disable satellites through both the blast and the electromagnetic pulse generated by the explosion. The use of a nuclear weapon in space, however, would also affect China's satellites, as well as those of third parties.[24]

Manned Platforms

Chinese analysts also see a role for manned platforms in space warfare. Manned platforms are described as more responsive than unmanned platforms and able to employ a variety of weapons.[25] Other authors write that manned platforms are "the best space weapon for attacking satellites in low earth orbit, synchronous orbit, and high orbit."[26]

Manned space platforms include space capsules, space stations, and space planes. Space capsules and space planes can transport goods and people between ground and space, carry out space rescue missions, and conduct reconnaissance and surveillance against targets.[27] According to an

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[19] U.S.-China Economic and Security Review Commission, 2011 Report to Congress of the U.S.-China Security and Economic Review Commission, November 2011, 216.

[20] Sui-lee Wei, "China Denies It Is Behind Hacking of U.S. Satellites," Reuters, October 31, 2011, accessed September 9, 2014, http://www.reuters.com/article/2011/10/31/us-china-us-hacking-idUSTRE79U1YI20111031?feedType=RSS&feedName=scienceNews&utm_source=dlvr.it&utm_medium=twitter&dlvrit=309301.

[21] Office of the U.S. Secretary of Defense, Annual Report to Congress: Military and Security Developments Involving the People's Republic of China (2011), 37.

[22] Congressional Budget Office, "The Global Positioning System for Military Users: Current Modernization Plans and Alternatives," October 2011, 4.

[23] Defense Science Board, "Report of the Defense Science Board Task Force on Tactical Air Warfare," November 1993, 12.

[24] Office of the U.S. Secretary of Defense, Annual Report to Congress: Military and Security Developments Involving the People's Republic of China (2011), 37.

[25] Li Yiyong, Li Zhi, and Shen Huairong, "临近空间飞行器发展与应用分析" [Analysis on Development and Application of Near Space Vehicle]," 装备指挥技术学院学报 [Journal of the Academy of Equipment Command and Technology], 2008/2, 64 and Chang, Military Astronautics, 118–19.

[26] Li, Cheng, and Zheng, Integrated Aerospace Information Operations, 218.

[27] Chang, Military Astronautics, 123, 145.

article written by the current director of the China Manned Space Agency, space stations can service military satellites in orbit, including repair, maintenance, fueling, and replenishment of ammunition, as well as serve as platforms for kinetic and directed energy weapons.[28]

Launch Vehicles

China is developing a new generation of launch vehicles capable of launching China's large space station and larger satellites. The new rockets are designed to meet China's launch needs for the next 30–50 years and offer increased reliability and adaptability and will be powered by "nonpoisonous" and "nonpolluting" engines that will provide more thrust than the current generation of launch vehicles. [29] The new generation of rockets will be divided into light, medium, and heavy-lift versions that will be able to send 1 to 25 metric ton payloads into low Earth orbit and 1 to 14 metric ton payloads into geosynchronous Earth orbit.[30] This presents a significant increase in payload capacity. China's current heaviest launch vehicle, the LM-2F, can lift eight metric tons into low Earth orbit.

This new generation of Long March vehicles has been designated the Long March 5, 6, and 7. The Long March 5 will be used to launch the heaviest payloads into orbit, such as China's planned large space station, and larger communication and remote sensing satellites. The Long March 7 will be a medium-lift rocket that will be used to ferry supplies to the space station. The Long March 6 is a light launch vehicle intended to launch payloads of up to one metric ton into orbit.

Additionally, China is developing operationally responsive space capabilities that will allow it to replace depleted or destroyed satellites quickly. Its development of the Kuaizhou and Long March-11 launch vehicles, both solid-fueled rockets, provide China with the capability to launch relatively small satellites rapidly if other satellites were to be destroyed or degraded. Although not as capable as larger satellites, these smaller satellites would be "good enough" to meet the needs of the Chinese warfighter. Moreover, the ability to launch these rockets from road-mobile launchers will also provide the Chinese military with the capability to replenish or augment its satellite architecture when its launch centers have been damaged or destroyed and would be less susceptible to U.S. prompt global strike capabilities.

Ground-based Infrastructure

China has four launch centers, including its newest launch center in Wenchang, Hainan Province and a network of telemetry, tracking, and control (TT&C) stations.

Launch Centers

Jiuquan Satellite Launch Center (中国酒泉卫星发射中心)

The Jiuquan Satellite Launch Center is China's oldest and largest, and conducts launches of

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[28] Wang Zhaoyao, "军事航天技术及其发展" [Military Space Technology and Its Development], 航天器工程 [Spacecraft Engineering] 1 (2008): 17.

[29] Zhang Feng, "中国的长征五号运载火箭" [China's Long March 5 Launch Vehicle], 卫星应用 [Satellite Application], 2012/5, 29.

[30] Sun Zifa, "中国未来5年实现"长征"五号六号七号火箭首飞" [In 5 Years China Will Realize the First Flights of the 'Long March' 5, 6, and 7], sohu.com, accessed September 2, 2014, http://news.sohu.com/20130301/n367552968.shtml.

spacecraft into low, medium, and high Earth orbits. It is the only launch center that has conducted human space flight launches.[31] The launch center is composed of a northern launch pad and a southern launch pad. The northern launch pad launches LM-2C and 2D rockets while the southern launch pad launches LM-2E and 2F rockets. In addition to the launch pads, the launch center has a command and control center, a rocket fuel storage area, a tracking station, a satellite and launch vehicle assembly station, a solid fuel rocket assembly station, and other support facilities.[32]

Taiyuan Satellite Launch Center **(**中国太原卫星发射中心*)*
The Taiyuan Satellite Launch Center is located near Taiyuan, Shanxi Province. Construction of the Taiyuan Satellite Launch Center began in 1967. The launch center conducts launches of satellites into sun synchronous and low Earth orbits, including meteorological, remote sensing, and communications satellites. The center consists of a launch site, a command and control center, and a technology testing area. The launch site consists of a single launch pad.[33]

Xichang Satellite Launch Center (中国西昌卫星发射中心)
The Xichang Satellite Launch Center is located 60 kilometers north of Xichang, Sichuan Province. Construction on the launch center began in 1970. This launch center launches satellites into geosynchronous orbits, including communication, broadcast, and meteorological satellites. The launch center is composed of a headquarters department, a launch site, a communication station, a command and control center, a technology testing station, and three tracking stations. The technology testing station has a launch vehicle testing facility, a satellite assembly and testing facility, and a rocket engine assembly, testing, and flaw detection facility.[34]

Wenchang Satellite Launch Center (文昌卫星发射中心)
The Wenchang Satellite Launch Center on Hainan Island was approved in 2007 and was reportedly completed in October 2014. The launch center's closer proximity to the equator than China's three other launch centers can increase launch payloads by 10–15 percent and satellite life by 2–3 years, a factor important for developing the commercial launch market. Launches will also be directed over the ocean, which will permit debris from launches to land safely out to sea. Wenchang will be the new launch center for China's manned space flights.

TT&C Network
China's improving TT&C network allows it to support China's human spaceflight and lunar exploration programs and enables China to better control its own satellites and to monitor the satellites of potential adversaries. China operates two satellite control centers at Xi'an and Beijing, and a network of 20 domestic TT&C stations based in China and three stations in Pakistan, Namibia, and Kenya, as well as three operational tracking ships. China built two dish antennas: a 50-meter diameter antenna near Beijing and a 40-meter diameter antenna near Kunming, Yunnan Province. The European Space Agency has also assisted China in its tracking

[31]解放军总装备部:中国军工系统核心 ["PLA General Armament Department: China Defense Industry System Core"], accessed Feb. 5, 2012, www.360doc.com/content/11/1214/11/5575132_172141966.shtml; and http://www.cgwic.com/LaunchServices/LaunchSite/JSLC.html.
[32] Zhang, China Military Encyclopedia (Second Edition): Introduction to Military Equipment, 434–36.
[33] Ibid., 438–39.
[34] Ibid., 436–38.

efforts by allowing it to track a European lunar spacecraft launched in 2003.[35] In addition, ESA also provided TT&C support for China's lunar missions at its stations in Maspalomas, Canary Islands, and Kourou, French Guiana.[36]

The TT&C requirements for the Chang'e missions, for example, are described as the most difficult challenge. The Chang'e-1 controllers, for example, had to follow a careful balancing act in which the spacecraft's sensors had to face the moon to collect data, its antennas had to face the Earth to communicate with ground control, and its solar panels had to face the sun.[37] In August 2011, Chang'e 2 traveled to the L2 La Grange point to test China's deep space TT&C network. China is just the third country behind the United States and Europe to have sent a satellite to L2.[38] After completing its mission at L2, in April 2012 Chang'e-2 went to image an asteroid, Toutatis, passing within two miles of the object. [39]

China's Space Program to 2030

If the current trajectory of China's space program continues, by 2030 China will have a new line of advanced launch vehicles, a robust, space-based C4ISR network made up of imagery satellites with resolutions well below one meter, and more capable electronic intelligence communication satellites all linked together by data-relay satellites, in addition to a global satellite-navigation system that may gradually approach current GPS standards. At this point, China could also likely have made operational a number of advanced counterspace capabilities, including kinetic-kill, directed-energy, and co-orbital ASAT capabilities as well as some form of missile defense system.

Although China is probably truthful when it says that it is not in a space race, such statements mask the true intent of its space program: to become militarily, diplomatically, commercially, and economically as competitive as the United States is in space. Despite Chinese statements that it is not in a space race, China's space program has generated concern both in the United States and in Asia. As Clay Moltz writes, "There is a space race going on in Asia, but its outcome—peaceful competition or military confrontation—is still uncertain." He concludes that although "there are still reasonable prospects for avoiding negative outcomes in space…Asia is at risk of moving backward, motivated by historical mistrust and animosities and hindered by poor communications on security matters."[40] As a result, China's progress in space technologies, whether in relative or absolute terms, has implications for the United States and its neighbors. As China's space program increases in capability, it can be expected to wield this power in ways that, according to Bonnie Glaser, not only "persuade its neighbors that there is more to gain from accommodating Chinese interests" but also "deter countries from pursuing policies that inflict

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[35] Ibid.

[36] "Chang'e-1 (Lunar-1 Mission of China)," eoPortal Directory, accessed March 26, 15, https://directory.eoportal.org/web/eoportal/satellite-missions/c-missions/chang-e-1.

[37] Bradley Perrett, Frank Morring, Jr., and Craig Covault, "Spacefarers," 26–28.

[38] "Chang'e-2 Moon Orbiter Travels Around L2 in Outer Space."

[39] Liu Jianun, Ren Xin, Mou Lingli, Zhang Liyan, Feng Jianqing, Wang Xiaoqian, and Li Chunlai, "嫦娥二号卫星有效载荷与科学探测"[Chang'e-2's Payload and Scientific Surveying], 生命科学仪器 [Life Science Instruments], January 2013, 37; Chinese Spacecraft Flies by Asteroid Toutatis," Space.com, December 17, 2012, accessed March 26, 15, http://www.space.com/18933-chinese-probe-asteroid-toutatis-flyby.html.

[40] James Clay Moltz, Asia's Space Race: National Motivations, Regional Rivalries, and International Risks (New York: Columbia University Press, 2012), 191.

damage on Chinese interests."

There are several actions the United States can take to ameliorate the effects of China's rise as a space power.

First, if the United States is to remain the leading space power then it must continue to invest in both its civilian and military space programs. Although innovation is affected by many factors, nothing can get done without adequate funding. This fact has not been lost on the Chinese government, which is taking a broad-based, well-funded approach to its space program.

Second, the most valuable resource of any industry is its people. The United States must continue to invest in its space workforce and in science, technology, engineering, and math (STEM) education. China's space industry workforce is young, with 55 percent the industry's employees aged 35 years or younger. The U.S. space industry workforce, on the other hand, is older, with nearly 60 percent of its workforce 45 years of age or older. Over the long-term, China's relatively young workforce will gain valuable experience that could provide an edge in innovating while the U.S. workforce loses high quality workers through retirement.

Third, the United States should enhance its space situational awareness capabilities to better able to better monitor the space and counterspace activities of other countries. Adequately defending the U.S. space-based architecture requires having a good picture of the operational environment and the threat it may pose.

Fourth, the United States could invest in smaller and more distributed satellite capabilities. Although smaller satellites would not be as capable and robust as larger satellites, the distribution of greater numbers of satellites would make the loss of any one satellite less catastrophic to the architecture as a whole. Owing to their lower cost, these satellites would provide a "good enough" capability that could be more quickly replenished.

OPENING STATEMENT OF DR. JOAN JOHNSON-FREESE
PROFESSOR, NATIONAL SECURITY STUDIES, U.S. NAVAL WAR COLLEGE

DR. JOHNSON-FREESE: Thank you. Good morning. Thank you for the opportunity to speak with you today regarding the implications of China's actions and emerging capabilities in space for the United States.

The views I offer are solely mine and do not represent the views of the U.S. Navy or the Naval War College.

I don't speak or read Chinese so I can't present any newly discovered, potentially shocking evidence of Chinese actions or intent regarding space. Nor am I an engineer so I can't decipher or speculate about the capabilities of hardware or suggest new hardware for the United States. And I don't work with classified information so that limits my analysis to being based on what is publicly available.

Nevertheless, as a political scientist who has followed and studied both the U.S. and Chinese space program for over 20 years, what I can offer is a perspective regarding what the U.S. can and cannot control regarding Chinese space activities, necessary avenues for maintaining U.S. space superiority, approaches essential to maintain the sustainability of the space environment, and therefore requirements to achieve U.S. goals in space within the context of rapidly expanding Chinese space capabilities.

I suspect the perspectives regarding implications for the U.S. and consequent policy recommendations will vary more among the panel than assessments of what the Chinese are actually doing in space. That is the dilemma of dual-use technology.

Though policies, doctrines, and public statements can provide indications of intent, ultimately intent is revealed by actions. A co-orbital rendezvous and proximity operation satellite in space, for example, can be observed. Whether the satellite is intended for such benign operations as assessing damage to another satellite or whether for nefarious purposes, such as ramming into another satellite, or both, can rarely be determined based solely on the hardware.

Further, a multiplicity of views regarding underlying drivers for space activity in China, just as there are in the United States, further complicates assessments.

Consequently, analysis of intent through written statements inherently involves speculation and careful attention to sources backing that speculation. Unquestionably, though, the best available way to assess intentions is through dialogue and cooperation.

The space environment is characterized in U.S. policies as contested, congested and competitive, and a domain that no nation owns but on which all rely. Specifically, because the United States does not own or control space, partnering with responsible nations, international organizations, and commercial firms, as well as seeking common ground among all space-faring nations, becomes imperative.

Security, sustainability, free-access and stability in space are the stated goals of the U.S., through the National Security Strategy, the National Space Policy, and the National Security Space Policy.

Part of preventing and deterring aggression includes developing capabilities to deter, defend against, and defeat aggression, drawn from the 2010 QDR and cited in the National Security Space Strategy.

Language in the National Defense Authorization Act for fiscal year 2015 evidences considerable U.S. attention to that approach. In line with promoting peaceful and the safe use of space, other elements of stated U.S. policy require equally focused attention, including: increased

resilience for military space systems; transparency and confidence-building measures; increased and expanded space situational awareness; and a non-binding International Code of Conduct for Space Activities.

Those efforts must receive the same attention as counterspace efforts for U.S. policy goals to be achieved. Similar support, however, has not been seen as forthcoming from Congress. This creates the perception elsewhere that perhaps the U.S. isn't serious about norms or efforts beyond counterspace generally.

U.S. emphasis on counterspace is often presented as in response to actions and intentions of other countries, specifically China. Increasingly, however, it seems that speculation about Chinese intentions is based on material not publicly shared, making the feasibility of both the speculation and appropriate U.S. responses difficult to assess.

For example, to my knowledge, China has done nothing since the irresponsible 2007 ASAT test that goes beyond what the U.S. considers international norms of responsible behavior.

Beyond counterspace, strong international norms can also be a strong deterrent, further compelling pursuance. The interrelated nature of the strategic approaches laid out in the multiple U.S. policies requires implementation of all elements. Pursuing deter, defend and defeat through counterspace measures alone not only decreases the potential for strategic success, but can be counterproductive in much the same way export control laws consequent to the 1999 Cox Committee Report proved to be.

Further, due to the global commons nature of the space environment and the importance of sustainability of that environment, the U.S. must seek common ground with China in areas of common interest. Consideration of what China is doing in space and what we think we know about why is useful in identifying these common interests. I have provided my assessment of that information in my written testimony.

To summarize, the U.S. cannot control Chinese space ambitions. Even influence is limited due to imperfect knowledge of Chinese decision-making, operating procedures, and, perhaps most importantly, Chinese space stakeholders have no incentive to inhibit aggressive or reckless Chinese behavior because they are not tethered to any obligations, interests or benefits they might obtain through cooperation with the United States.

Nor can the U.S. control space in the same way that it controls airspace. Yet space is a global commons, the sustainability of which is critical to U.S. national security. Consequently, increased cooperation with China is in the best interest of U.S. national security.

Further, counterspace technology is not a panacea to achieve U.S. goals in space or to address terrestrial threats. At best, it is a capability to have on reserve as part of a comprehensive deterrence strategy. Alternatively, especially, when other components of the comprehensive strategy are neglected, it can be ineffective and destabilizing.

In order to protect U.S. assets and achieve stated U.S. goals, all approaches stated in the nested U.S. space strategies must be pursued with equal attention. These include resiliency, space situational awareness, increased transparency and confidence-building measures. Domestically, they include a continued rationalization of export control regulations to a globalized world, supporting STEM education, supporting R&D, and demonstrating the United States does have the political will to be the leader of all spacefaring nations. Further implementation of U.S. space strategy is the only prudent way forward.

Thank you.

PREPARED STATEMENT OF DR. JOAN JOHNSON-FREESE

PROFESSOR, NATIONAL SECURITY STUDIES, U.S. NAVAL WAR COLLEGE

The question before the Commission concerns how the United States (U.S.) can achieve stated U.S. goals regarding space security given a rapidly expanding and increasingly sophisticated Chinese space program.[41] The importance of protecting the space environment and U.S. space assets in orbit, assets which provide information critical to the U.S. civilian and military sectors and overall U.S. national security, has required that goals be considered and reconsidered at many levels and within multiple communities of the U.S. government. Therefore, it is appropriate to begin by referencing the multiple and nested U.S. strategies related to or referencing space, specifically the 2010 National Security Strategy (NSS), the 2010 National Space Policy (NSP), the 2010 Quadrennial Defense Review (QDR) and the 2011 National Security Space Strategy (NSSS)[42] for analytic parameters.

Guidance in the NSS is simply stated. "To promote security and stability in space, we will pursue activities consistent with the inherent right of self-defense, deepen cooperation with allies and friends, and work with all nations toward the responsible and peaceful use of space." (p. 31)[43] These general ideas are reiterated in the NSP as "the United States considers the sustainability, stability, and free access to, and use of, space vital to its national interests." (NSP p.3)

With security, sustainability, free-access and stability as overall goals, the NSSS recognizes the importance of working with all space-faring nations due to the nature of the space environment stated as both contested, congested and competitive (NSS p.i) and "… a domain that no nation owns, but on which all rely," (NSSS p.i). Specifically, because the United States does not own or control space, "partnering with responsible nations, international organizations, and commercial firms" (NSSS p.8) as well as seeking "common ground among all space faring nations" (NSSS p.5) becomes imperative. Both compels consideration of "how to deal with China." The contested, congested and competitive space environment presents both challenges and opportunities (NSSS p.1) if only through the self-interest of all space-faring nations in protecting the space environment.

Within those parameters, the security-specific NSSS goals are given as: strengthen safety, stability, and security in space; maintain and enhance the strategic national security advantages afforded to the United States by space; and energize the space industrial base that supports U.S. national security. The NSS approaches to achieving the policy goals, are clearly stated.

> The National Security Space Strategy draws upon *all elements of national power* and
> requires *active U.S. leadership* in space. The United States will pursue a set of *interrelated strategic approaches* to meet our national security space objectives:

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[41] The views expressed here are solely those of the author and do not represent the views of the U.S. government, the U.S. Navy, or the Naval War College.

[42] http://www.defense.gov/home/features/2011/0111_nsss/docs/NationalSecuritySpaceStrategyUnclassifiedSummary_Jan2011.pdf

[43] There is considerable complexity even within this guidance. Compared to ground, air, maritime and even cyber, there has been relatively little multilateral or public discussion on what the right of self-defense means in the context of space.

[italics added]

- Promote responsible, peaceful, and safe use of space;
- Provide improved U.S. space capabilities;
- Partner with responsible nations, international organizations, and commercial firms;
- Prevent and deter aggression against space infrastructure that supports U.S. national security and;
- Prepare to defeat attacks and to operate in a degraded environment. (p.5)

Part of preventing and deterring aggression includes developing capabilities to "deter, defend against, and defeat aggression," drawn from the 2010 Quadrennial Defense Review (QDR) and cited in the NSSS (p.10).

Language in the National Defense Authorization Act for FY 2015 evidences considerable U.S. attention to that approach. Secure World Foundation analyst Brian Weeden suggests attention may be focused on those elements to the exclusion or discounting of others.[44]

In line with promoting responsible, peaceful and the safe use of space other elements requiring focused attention include resilience for military systems, increased transparency and confidence building measures (TCBMs), increased space situational awareness (NSP, pp. 11-12) and a non-binding International Code of Conduct for Space Activities as supported by U.S. Secretary of State Hillary Clinton,[45] Air Force Space Command chief General William Shelton[46] and Strategic Command chief General Robert Kehler[47] in 2012. Strong international norms can also be a strong deterrent, further compelling pursuance. The interrelated nature of the strategic approaches requires implementation of all elements. Pursuing "deter, defend and defeat" through counterspace measures alone not only decreases the potential of strategic success, but can be counterproductive in much the same way export control laws consequent to the 1999 Cox Committee Report proved to be.[48] Further, due to the "global commons"[49] nature of the space environment and the importance of sustainability of that environment, the U.S. must seek common ground with China in areas of common interest. Consideration of what China is doing in space and why is useful in identifying these common interests.

Categorization of Chinese space activities as military or civilian is complicated by the fact that the vast majority of space technology (>90%) is dual use. Further, in order to maximize

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[44] Brian Weeden, "The End of Sanctuary in Space," War is Boring, January 7, 2015. https://medium.com/war-is-boring/the-end-of-sanctuary-in-space-2d58fba741a

[45] http://www.state.gov/secretary/20092013clinton/rm/2012/01/180969.htm

[46] http://breakingdefense.com/2012/03/safe-passage-why-the-pentagon-wants-an-international-code-of-c/

[47] http://www.cfr.org/united-states/conversation-c-robert-kehler/p28404

[48] http://www.bis.doc.gov/index.php/forms-documents/doc_view/898-space-export-control-report

[49] The importance of protecting "commons" environments is increasingly noted. The Defense Department has recently changed the name of the "AirSea Battle" concept to "Joint Concept for Access and Maneuver in the Global Commons." http://news.usni.org/2015/01/20/document-air-sea-battle-name-change-memo, http://news.usni.org/2015/01/20/pentagon-drops-air-sea-battle-name-concept-lives Application to the "commons" principles in space is difficult for definitional, legal and operational reasons. Joan Johnson-Freese and Brian Weeden, "Application of Ostrom's Principles for Sustainable Governance of Common-Pool Resources to the Near Earth Environment," Global Policy, Vol. 3, No. 1, 2012, pp. 72-81.

resources many countries, including China, France and Japan,[50] deliberately develop technology or establish organizations and operations for dual-use purposes. They have far less a dichotomy between military and civilian space activities and organizations than in the United States, though the lines between U.S. programs often blurred as well. For example, prior to the Space Shuttle, U.S. civilian launchers were born from missile programs, and the Space Shuttle cargo bay was specifically designed to be large enough to carry large U.S. reconnaissance satellites. Overall, the United States is more the exception than the rule in utilizing what can be a duplicative approach to space administration and technology development through its civilian and military space programs.

Because of the largely dual-use nature of space technology, virtually any space activity can be deemed as military. Therefore it is (relatively) easier to know *what* China is doing in terms of space activities than *why*. A co-orbital rendezvous and proximity operation satellite in space can, for example, be observed. Whether the satellite is intended for such benign operations as assessing damage to another satellite, or whether for nefarious purposes such as ramming into another satellite, or both, can rarely be determined based on hardware. A multiplicity of views regarding underlying drivers for space activity in China, just as there are in the United States, further complicates assessments. China is a country of such size, and with a rapidly increasing number of media and internet outlets for expressing views and dispersing information, that "evidence" can be found for almost any assessment, thereby accommodating the substantiation of preconceived assumptions as analysis. Consequently, analysis of intent through written statements inherently involves speculation and so careful scrutiny of sources backing such speculation becomes especially imperative.[51] Unquestionably though, the best way to assess intentions is through dialog and cooperation.

THE "WHAT" OF CHINESE SPACE ACTIVITIES

China has an expansive, ambitious space program intended to fulfill a variety of perceived needs, both civil and military. Whether or not it is aggressive, and how much and in what form a threat to the United States are more complex questions. Therefore a brief review of some key areas of Chinese space activity is in order, with reference to similar capabilities in the U.S. and other countries in some instances.

China is pursuing development of a full range of satellite capabilities and is making significant across-the-board progress in terms of both scope and sophistication. Of the approximately 1235 satellites currently in orbit, America, Russia, and China own the most: the U.S. has 512, Russia 135, and China 116.[52]

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[50] The French space agency Centre National E'tudes Spatiales (CNES) is the technical manager for most French military space programs. It receives a considerable portion of its annual budget from the French General Directorate for Armament (DGA). Regarding information regarding Japan's long reliance on being able to utilize dual-use space technology to circumvent Constitutional provisions regarding military space technology, see: Joan Johnson-Freese and Lance Gatling, "Security Implications of Japan's Information Gathering Satellite (IGS) System, Intelligence and National Security, Volume 19, Issue 3, 2004.

[51] Gregory Kulacki, "The 2014 USCC Report: Still Sloppy After All These Years," All Things Nuclear, November 24, 2014. http://allthingsnuclear.org/the-2014-uscc-report-still-sloppy-after-all-these-years/

[52] Union of Concerned Scientists database. Numbers valid as of July 31, 2014. http://www.ucsusa.org/nuclear_weapons_and_global_security/solutions/space-weapons/ucs-satellite-database.html#.VK_WsXu4F2A

The growing capacity of Chinese aerospace industry demonstrates the broad programmatic ambitions and China's pragmatic utilization of industrial facilities for building both military and non-military spacecraft. A massive new factory in the port city of Tianjin, not far from Beijing, was completed in 2013. Floor space of the facility is estimated at about 100,000 square meters, or 1.08 million square feet, big enough to allow for product construction and testing. According to a Tianjin city official, facilities there "will be able to build 6-8 outsize spacecraft a year, satisfying requirements for the space station, outsize [communications] satellites, large remote-sensing satellites, large unfolding precision structures and so on."[53] Some of those will likely be modules for the Chinese space station. Others will likely be for large, military reconnaissance satellites much the same size as the space station components. Representatives of the China's General Armaments Department responsible for military satellites were present at the factory groundbreaking, evidencing military involvement in the facility.

China's development of its own satellite navigation system, Beidou (also known as Compass), owned by the Defense Ministry, began operational testing in 2012, and is expected to provide global coverage by 2020 through a constellation of thirty-five satellites. Reluctant reliance on the U.S. owned and U.S. military operated Global Positioning System (GPS) satellites, given that it and the internet are considered global utilities, likely prompted China's desire for its own satellite navigation system, just as it did in Europe with the Galileo system and Russian restoration of the Glonass system capabilities.

China's earth observation capabilities are rapidly expanding. The Ziyuan-1 series is owned by the Chinese Center for Resource Data and Application and has been used in conjunction with the China-Brazil Earth Resources (CBERS) program with Brazil, while Ziyuan-2 and Ziyuan 3 satellites are owned and operated by the People's Liberation Army (PLA). Chinese media refers to China's Yaogan satellites as for disaster relief, earth observation and scientific experimentation. However, the high resolution optical or radar satellites are fully funded by the People's Liberation Army (PLA). Yaogan satellites were launched in 2007, 2008, 2009, 2010 and two in 2014. Additionally, China launched the high-definition Earth observation satellite, Gaofen 1 in May 2013, followed by Gaofen 2 in August 2014, as part of China's High-Resolution Earth Observation System (CHEOS) program approved in 2010.[54] Another three satellites are planned for launch by 2016. The stated purpose of the program is to bolster disaster relief capabilities, as well improving land resources surveying, environmental monitoring, geographical mapping and precision agriculture, though military applications are technologically feasible and likely.

The Chinese Meteorological Administration launched its third Fengyun polar-orbiting weather satellite in 2014. The Fengyun-3 satellite, along with Fengyun-2, forms a monitoring network capable of persistent three-D, multiple-spectrum and remote-sensing observation of the earth. It also represents China's second generation of polar-orbiting satellites.[55]

China is developing smallsats and microsatellites, most to be developed solely by Chinese manufacturers, as are other countries including the United States, England, Japan, and Russia. Smallsats and microsats are considered useful for a wide range of purposes, ranging from student

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[53] Bradley Parrett, "Chinese Factory to Build Outsize Spacecraft," Aviation Week & Space Technology, January 28, 2013. http://aviationweek.com/awin/chinese-factory-build-outsize-spacecraft

[54] http://www.unoosa.org/pdf/pres/stsc2014/tech-47E.pdf

[55] "China's Polar Orbiting Meteorological Satellite Now Operational," Space Daily, May 8, 2014. http://www.spacedaily.com/reports/Chinas_polar_orbiting_meteorological_satellite_now_operational_999.html

projects to military and intelligence missions, even as antisatellite weapons if maneuverable. China's BX-1, also known as CompanionSat, was launched in 2008 as part of the Shenzhou-7 (SH-7) human spaceflight mission. Weighing approximately 90 pounds, it was maneuverable and provided images of the Shenzhou-7 (SH-7) capsule, demonstrated the ability to inspect the orbital module (close proximity operations), and conducted some limited proximity operations. Additionally, it carried out a data relay experiment.

Lin Mingsen, deputy director with the Chinese National Satellite Ocean Application Service announced in October 2014 that China would build and launch a new "constellation" of HaiYang maritime monitoring satellites in 2019, employing synthetic aperture radar.[56] Instruments carried onboard previous HY satellites included a microwave imager, a dual-band radar altimeter– used to measure sea levels and wind speeds – and Ku-band radar scatterometer for measuring the sea surface wind field.[57] The new system will allow maritime surveillance day or night in any weather conditions, including of the U.S. Pacific fleet.

China enjoys use of a number of communication satellites, many indigenous satellites evolved from the Dong Fang Hong (DFH) design first launched in 1970. Communications satellites have also been purchased from other countries, including the United States, and are operated by such organizations as Apstar, Asiasat, and Chinasat, all officially for civilian use. The Zhongzing version of Chinasat owned and operated by the PLA.

China also has also launched a number of experimental satellites in recent years, specifically the Shiyuan, Chuangxin (Innovation) and Shijian (Practice) satellites. Their stated missions have included earth observation, space weather experimentation, space debris observation, mechanical arm observations and testing space maintenance technologies,[58] through capabilities including close proximity operations. Chinese media refers to China's Yaogan satellites as also for disaster relief, earth observation and scientific experimentation. However, the high resolution optical or radar satellites are fully funded by the People's Liberation Army (PLA). Launches of these satellites have been accompanied by a considerable amount of speculation regarding their intended use. Speculation regarding these missions might be compared to the international curiosity concerning the intended use of the U.S. X-37B Orbital Test Vehicle.

China is also expanding its launch capabilities. The Chinese Long March 3B is currently its most powerful rocket in use, capable of lifting approximately eight tons to Low Earth Orbit (LEO). The first LM-5 in its final stages of assembly in a Tianjian factory will more than triple that capability to carry 25 tons to LEO. While development has been plagued by repeated delays, a LM-5 first launch will likely occur in 2015 from China's Wenchang launch site on Hainan Island. Wenchang is China's newest launch site, in addition to the three remote launch sites at Xichang (geosynchronous satellites, lunar probes), Jiquan (human spaceflight) and Taiyuan (polar orbiting satellites). China selected the Wenchang launch site on Hainan Island, formerly used only for sub-orbital launches, for upgrading specifically due to its low latitude location of

[56] "China to Launch New Maritime Surveillance Satellites," October 8, 2014. http://www.business-standard.com/article/pti-stories/china-to-launch-new-marine-surveillance-satellites-114100800618_1.html
[57] Rui C. Barbosa, "China's surge continues with HaiYang 2-A launch via Long March 2B," NASA Spaceflight.com, August 15, 2011. http://www.nasaspaceflight.com/2011/08/chinas-surge-haiyang-21a-launch-long-march-4b/
[58] See comments by Gregory Kulacki in, Leonard David, "Mysterious Actions of Chinese Satellites Have Experts Guessing," Space Insider, September 9, 2013. http://www.space.com/22707-china-satellite-activities-perplex-experts.html

19 degrees north. The equatorial boost from that location will support a significant increase in payload weight that Chinese rockets can carry, a factor important when launching space station components, large satellites, and exploration beyond Low Earth Orbit (LEO). Additionally, rather than having to rely on narrow rail transport of launch vehicles to the remote launch sites, rockets, including the much larger LM-5, can be transported to Wenchang by sea.

China's most publicized space activities are those related to the Shenzhou human spaceflight and the robotic Chang'e lunar programs. Originally known simply as Project 921, the Shenzhou program was approved as a three-step plan for human spaceflight in 1992. China has been relatively open about programmatic goals, and has stuck to its announced plan: send humans into orbit, demonstrate advanced capabilities through a small laboratory (the Tiangong program), and finally, build a large space station. The Tiangong spacecrafts are not space stations intended for long-term use, or to be permanently manned, but form the basis for a small laboratory to test technologies similar to those tested by the United States during the Gemini program, including rendezvous, docking, and life support. Tiangong is likely to host manned missions later in its evolution. At 8.5 tons, Tiangong is smaller than both Skylab (about 80 tons), and the 30-ton space station China has always planned as the culmination of its 1992 three-step plan.

The prototype Tiangong-1(Heavenly Palace) was used to conduct experiments in conjunction with the Shenzhou 8-10 spacecrafts. Taingong-2 was to be a marginally improved version of Tiangong-1 and was originally scheduled to be launched in 2014. That date got delayed until 2015 at the earliest, when it became clear that more than marginal changes needed to be made in order to achieve the intended mission goals, including docking with a cargo vehicle. Consequently, though originally there was also to be a Tiangong-3 spacecraft with expanded capabilities, it appears those all may be incorporated into Tiangong 2.

China is executing the robust Shenzhou human spaceflight program at a pace simultaneously incremental and accelerated: incremental in following almost the same timeline milestones as the U.S. did during Mercury, Gemini and Apollo, and accelerated in that it accomplished these milestones with fewer flights.[59] For example, between Yang Liwei's first-ever manned flight in 2003 and Zhai Zhigang's spacewalk in 2008 there was only one other Shenzhou program flight. Compare that to the number of flights that occurred during the Mercury (6 crewed flights) and Gemini (10 crewed flights) programs, and one finds a much higher number of U.S. launches, with smaller steps taken by each. Shenzhou 9, launched in June 2012, included China's first female taikonaut, Liu Yang.

Although sometimes presented by the media as fact, China does not have an approved human lunar spaceflight program. Such a program is under discussion, but China currently has an approved human spaceflight program and an approved robotic lunar program. Together, however, these two programs are developing and testing the component parts for a lunar human spaceflight program. It is unlikely that China would take that step until completing its large space station, leaving a lunar focus until the 2025/2030 timeframe.

Chang'e is the mythical Chinese moon goddess for whom the robotic Chinese Lunar Exploration Program vehicle is named. Chang'e 1 was launched in 2007 and operated until 2009, and demonstrated China's capability both to put satellites into lunar orbit and to return imagery. Chang'e 2 was launched in 2010. After flying in a closer-to-the-surface lunar orbit and providing

[59] http://swfound.org/media/90819/swf_human_space_programs_fact_sheet.pdf

imagery with a high resolution camera—pictures essential for an anticipated soft-landing Chang'e 3 mission in 2013—Chang'e 2 left lunar orbit for the Earth-Sun L2 Lagrangian Point, to test Chinese tracking and control capabilities, capabilities also valuable to the military. Using a non-military program to test technology of potential value to the military is not exclusive to China. The U.S. Clementine spacecraft in the 1990's was a joint program between the Ballistic Missile Defense Organization (BMDO) and the National Aeronautic and Space Administration (NASA) to test BMDO technology by mapping the Moon.

Prior to China, only the United States and the European Space Agency had visited L2. Chang'e 2 then set out for an extended mission to asteroid 4179 Toutatis. Chang'e 3 was launched in December 2013 and became the first lunar soft lander since the Soviet Luna 24 spacecraft in 1974. Chang'e 3 carried with it the lunar rover Yutu, or Jade Rabbit. In February 2014 the Chinese and international press followed the success, demise and revival of the anthropomorphized rover with great interest. Chang'e 5-T1 (formerly Chang'e 4, as a back up to Chang'e 3) was launched and returned to Earth in October 2014 as a precursor to a planned Chang'e 5 sample return mission by conducting atmospheric re-entry tests. The Chang'e 5 sample return is scheduled for 2017.

China is expanding its military space capabilities in all areas of command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) that have proved critical in enhancing terrestrial force effectiveness, and in space weapons. While there are still significant gaps in China's capabilities in areas such as surveillance, Beijing has supplemented its needs through purchases from such providers as Spot Image (Europe), Infoterra (Europe), MDA (Canada), Antrix (India), GeoEye (United States), and Digital Globe (United States).[60] It is not just a globalized world but a globalized space industry. Commercial access to space technology and space-based information is widely available to China while it develops its own capabilities.

China is also developing counterspace capabilities including at least 1 ground-based kinetic-kill anti-satellite (ASAT) system, the DN-1,[61] and potentially a second ground based system, DN-2[62]. In 2007, China conducted an ASAT weapons test, destroying one of its own defunct weather satellites using a direct ascent, kinetic-kill vehicle. Impact resulted in more than 3,000 pieces of space debris being created, significantly adding to the congestion of the space environment. The debris will take decades to dissipate and in the meantime threatens potentially catastrophic damage if it collides with active spacecraft, including the ISS.

In 2008 the United States conducting Operation Burnt Frost, destroying one of its own malfunctioning satellites using missile defense technology. Given the nearly symbiotic nature of missile defense/ASAT technology, China has seemed to learn that missile defense testing was politically acceptable, while ASAT testing was not (even without debris creation). Consequently, the Chinese have conducted what it deemed (non-destructive) "missile defense" tests in 2010, 2013 and 2014. India is also developing a two-tiered missile defense system with technology potentially useful to the development of ASAT capability, including its first exoatmospheric

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[60] http://www.defense.gov/pubs/pdfs/2010_CMPR_Final.pdf

[61] Also referred to as the SC-19, referencing it as the 19th type of rocket launched from Shuangchengzi Space and Missile Center, also known as Jiquan. http://www.nti.org/facilities/71/

[62] Brian Weeden, "Anti-Satellite Tests In Orbit – The Case of China," Fact Sheet, Secure World Foundation, August 2013. http://swfound.org/media/115643/china_asat_testing_fact_sheet_aug_2013.pdf

intercept test in 2014. Russia is threatening to revitalize its once active counterspace program as well.[63]

THE "WHY" OF CHINESE SPACE ACTIVITIES

The motivations behind initial Chinese space efforts and the more recent decision to pursue human spaceflight within the context of China's internal history is examined by Gregory Kulacki and Jeffrey Lewis in the 2009 publication *A Place for One's Mat: China's Space Program from 1956-2003*.[64] Using Chinese-language sources, the authors' central observation is that China understood efforts in three major areas -- launching satellites, launching communications satellites specifically and human spaceflight -- each as "efforts to be a measure of national accomplishment necessary to qualify for inclusion among the major spacefaring countries that set the rules. Equity appears to have been the principal concern of China's political leadership."[65] In that respect, China was and continues to seek recognition as a regional and global power. As a space-faring nation, China seeks to be a stakeholder in setting the rules for space. Whether as an equal – a place for their mat among other powers – or the dominant regional power or as a usurper of U.S. power is a question about which analysts often disagree. China's most recent Space White Paper from 2011 again places Chinese space activities in the context of overall national development strategy.[66]

Domestic pride and international prestige, economic development (including skilled jobs and expanded science and engineering educational programs), and dual-use technology development are all proven reasons for pursuing human spaceflight programs, as demonstrated in the United States with the Apollo Program. China is well aware that the United States enjoyed multiple benefits in all of these areas through the Apollo Program, and all today motivate China's commitment to long-term space exploration programs, including human spaceflight. An ambitious, multi-faceted space program continues China's traditional heritage of undertaking big projects, like the Great Wall and the Three Gorges Dam, to demonstrate national prowess. Space activity continues that tradition, now with a techno-nationalist bent.[67]

Although human spaceflight and exploration are primarily political acts, both generic and specific capabilities developed in conjunction with these activities are in many cases transferrable to the military. Improvement in computational analysis and composites developed for space capsules are of value to the military. Tracking ships required for human spaceflight missions are also be useful in missile tracking. It is reasonable to assume that dual-use satellites will be fully utilized for both civilian and military purposes.

The 1990-91 Iraq War has been termed "the first space war" based on some high profile examples of the use of space-based force enhancement capabilities, such as satellite imagery, by the U.S. military. That war convinced China that it would be no match for U.S. conventional forces for many years. Further, China observed the increased advantages received by conventional forces from space assets, and recognized that a significant space capabilities gap

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[63] "Russia, China aim to close military technology gap with US: Hagel," Reuters, September 3, 2014. http://allthingsnuclear.org/the-2014-uscc-report-still-sloppy-after-all-these-years/

[64] American Academy of Arts & Sciences. http://carnegie.org/fileadmin/Media/Publications/PDF/spaceChina.pdf

[65] Kulacki & Lewis, p. 9.

[66] http://images.spaceref.com/china/ChinaSpaceActivitiesin2011.pdf

[67] David Barboza, "In China, Projects to Make the Great Wall Feel Small," The New York Times, January 12, 2015. http://mobile.nytimes.com/2015/01/13/business/international/in-china-projects-to-make-great-wall-feel-small-.html?referrer=&_r=0

existed between the U.S. and China. Consequently, toward protecting their self-interests, specifically Taiwan, China began attempting to close that gap.[68] That interpretation, offered by Union of Concerned Scientists China Program Director Gregory Kulacki in 2014 based on a Second Artillery operations textbook, is a considerably different "intent" assessment than the preparation for "asymmetric warfare" assessment often made based on 1999 book *Unrestricted Warfare* written by two PLA colonels, a book written for public release.

From a Chinese perspective, a number of U.S. actions could be and were interpreted as challenging to their interests at best, more often threatening, and not just actions regarding space. During the 1996 Taiwan Strait crisis when Beijing conducted a series on missile tests in the waters surrounding Taiwan, U.S. President Bill Clinton sent two aircraft carrier battle groups to the Taiwan Straits. The ability of the U.S. fleet to arrive of China's shores relatively undetected by China and to potentially interfere with what China considers the imperative of China-Taiwan unity resulted in a strong call for expanded military capabilities in China, specifically in the maritime domain. The HY-3 satellites are among the Chinese technologies that will serve China in this regard, providing capabilities to monitor not just activity in and around Taiwan, but also the contested Senkaku Islands and in the South China Sea.

It is important to note, however, that China would likely be developing space capabilities regardless of any specific set of historical events, and probably at the same rate. Jonathan Ray at National Defense University suggests Chinese use of a "technology reserve" model of matching capabilities but deferring deployment applicable in conjunction with a neutron bomb, ballistic missile defense, anti-satellite weapons and hypersonic glide vehicle systems.[69] In that model, "strategic environment" is a key factor, making consideration of Beijing perception of the strategic environment essential.

The 1999 Cox Committee Report and consequent State Department interpretations of export licensing regulations were intended to impede Chinese space activities by denying China technology, in effect, to isolate Chinese space activities. Instead, China has worked with other countries that have been more than willing to expand and increase their own aerospace business sector market share, or China developed indigenous capabilities. Parts of U.S. regulations that categorized such items as communications satellites as weapons systems and pointedly handicapped the U.S. satellite industry rather than stunting Chinese space activities held until 2013.[70]

The first Shreiver space wargame was held in 2001. The scenario in that wargame was of a large country threatening its small off-shore neighbor. It wasn't a leap for the Chinese to envision themselves as the adversary in the wargame, designed to explore U.S. requirements for space control, countering advanced adversary space capabilities, and evaluate the enemy's ability to deny U.S. and allied space capabilities.

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[68] Gregory Kulacki, "An Authoritative Source on China's Military Space Strategy," March 2014. http://www.ucsusa.org/nuclear_weapons_and_global_security/solutions/us-china-cooperation/china-anti-satellite.html#.VMb9EcaKjhk

[69] Jonathan Ray, Red China's "Capitalist Bomb": Inside the Chinese Neutron Bomb Program, National Defense University press, January 2015. http://ndupress.ndu.edu/Portals/68/Documents/stratperspective/china/ChinaPerspectives-8.pdf

[70] William J. Broad, "Communications Satellite Made legal for Export," The New York Times, January 3, 2013. http://www.nytimes.com/2013/01/04/science/communications-satellites-banned-as-weapons-now-legal-for-export.html

China is not a partner in the International Space Station (ISS), although for a long time it eagerly sought inclusion. Arguments against Chinese inclusion initially focused on China having little to contribute, in terms of financial support, hardware or knowhow. When that situation began to change, considerations of ideology and technology transfer issues were raised. Opponents considered the U.S. working with an authoritarian communist government as inappropriate, although the U.S. has pragmatically worked with unsavory governments in other areas of the world when it serves U.S. realist interests. When all else failed, potential technology transfer issues were raised to block Chinese inclusion. Not being included has supported arguments within China to build their own space station. China's planned space station will de facto replace the ISS when ISS reaches the end of its operational lifetime, conferring both techno-nationalist and leadership connotations to China. China is already courting other countries along those lines.[71]

The primacist strategy adopted by the U.S. after 9/11 and embedded in the 2002 National Security Strategy was not limited to terrestrial policies, but space policies as well. The 2003 Air Force Transformational Flight Plan, including plans for orbiting weapons, and the 2004 follow-up Air Force Doctrine Document 2-2.1, *Counterspace Operations*, indicated that space was seen as the fourth battlespace. The United States vigorously pursued small satellite technology similar to the BX satellites China is developing and the U.S. sees as threatening. An Air Force official was quoted in the trade publication *Inside the Pentagon* about the Air Force XSS program that "XSS-11 can be used as an ASAT weapon."[72] Actions and rhetoric supported the idea that the United States was moving beyond seeking "space superiority," an advantage over other countries by some potentially minimum amount, to "space dominance," the unchallengeable ability to control the space environment.[73] That potential was of concern to a number of countries, including allies, not just China.

An editorial ran after the release of the 2006 U.S. National Space Policy in *The Times* (London), titled "America Wants it All - Life, the Universe, and Everything,"[11] stating that apparently space was no longer the final frontier, but the 51st state of the United States. The editorial went on to say that, "The new National Space Policy that President Bush has signed is comically proprietary in tone about the U.S.'s right to control access to the rest of the solar system."[74] That same newspaper ran an article entitled "Son of Star Wars takes out toxic satellite with $30m space attack" after the destruction of US-193 in February 2008. While not challenging U.S. motives explicitly, the article cynically stated the satellite's destruction had been "broadcast" by President Bush "as a safety measure" and "the Pentagon celebrated its $30 million Star Wars-style interception in space."[75]

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[71] Andy Pasztor, "China and Europe in Talks on Space Exploration Program," Wall Street Journal, July 17, 2014. http://www.wsj.com/articles/china-europe-in-talks-on-space-cooperation-1405592579?mod=_newsreel_3

[72] Elaine M. Grossman and Keith Costa, "Small, Experimental Satellite May Offer More Than Meets the Eye," Inside the Pentagon, December 4, 2003.

[73] Joan Johnson-Freese, "Strategic Communication with China: What message about space?" China Security, Volume 2, Number 1, Winter 2006.

[74] Bronwen Maddox, "America Wants it All - Life, the Universe, and Everything," http://www.timesonline.co.uk/article/0,,30809-2410592,00.html

[75] Michael Evans and Jane McCartney, "Son of Star Wars takes out toxic satellite with $30m space attack," The Times (London) 22 February 2008, p. 39.

The U.S. rhetoric – and policies -- that prompted that assessment seemed to dissipate with the realization that while air dominance, control of a limited space for a limited time, was technically achievable, space dominance, control of all of space all of the time, was not.

At the highest levels of government, President Barack Obama met with then-Chinese President Hu Jintao in January 2011. Part of their joint statement addressed the desire for deepened dialogue and interaction in space, which many people interpreted as a new willingness on the part of the United States to work with China. But cooperation was not to be. As of April 2011, NASA funding legislation prohibits any joint scientific activity between the United States and China that involves NASA or is coordinated by the White House Office of Science and Technology Policy (OSTP). That legislation has endured. NASA and OSTP remain banned from bilateral activity with China. The publicly stated rationale behind the legislation was stated by Congressman Frank Wolf in a 2011 interview. "We don't want to give them the opportunity to take advantage of our technology, and we have nothing to gain from dealing with them," Wolf said. "And frankly, it boils down to a moral issue. … Would you have a bilateral program with Stalin?"[76] Congressman Wolf's 2013 letter to NASA Administrator Charles Bolden provides another perspective on rationale, having to do with potentially using the promise of space cooperation as a means to seek meaningful progress in China on freedom of religion and human rights.[77] Nonetheless, the potential for technology transfer, nothing to gain and ideology have been consistent threads of rational for U.S. policies toward China regarding space.

A WAY FORWARD FOR THE UNITED STATES

Regardless of whether Chinese intentions are merely ambitions or more nefariously aggressive, the United States must use all tools of national power – not just those related to deter, defend and defeat – to achieve the space-related goals set out in the NSS, the NSP and the NSSS. Congressman Wolf's statement largely restates the reasons most often used for why the United States should not working with China on space issues - technology transfer concerns, values, and nothing to gain – thus limiting U.S. policy options necessary for achieving stated policy goals. Additionally, especially among those who grew up during the Cold War, there is a tendency to equate China with the Soviet Union, despite the vast difference between them and in the context of today's globalized world versus the post-World War II world. Limiting U.S. options has never been in U.S. national interest and isn't on this issue either. Those options enhance deter, defend and defeat efforts. First, however, the counterarguments to each of Congressman Wolf's arguments deserve note.

Congressman's Wolf's perspective assumes that working with the United States would give China opportunities in terms of surreptitiously obtaining U.S. technology otherwise unavailable to it. But we live in a globalized world. Attempting to isolate Chinese space activities has proved futile, and in fact pushed China and other countries into developing indigenous space industries — totally beyond any U.S. control — than they might not have done otherwise, and arguably reap more political and prestige benefits from doing so that if they had gotten the same technology from partnering with the U.S. The only outcome of the past two decades of strict export control there is hard data on is the damage to the U.S. commercial space sector.[78]

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[76] Jeffrey Mervis, "Spending Bill Prohibits U.S.-China Collaborations, ScienceInsider, April 21, 2011, http://news.sciencemag.org/technology/2011/04/spending-bill-prohibits-u.s.-china-collaborations

[77] http://news.sciencemag.org/sites/default/files/media/Wolf%20Letter%20PDF_0_0.pdf

[78] http://www.bis.doc.gov/index.php/forms-documents/doc_view/898-space-export-control-report

Second, Wolf's rationale assumes the United States has nothing to gain by working with the Chinese. On the contrary, the United States could learn about how they work — their decision-making processes, institutional policies and standard operating procedures. This is valuable information in accurately deciphering the intended use of dual-use space technology, long a weakness and so a vulnerability in U.S. analysis. Working together on an actual project where people confront and solve problems together, perhaps, a space science or space debris project where both parties can contribute something of value, builds trust on both sides, trust that is currently severely lacking. It also allows each side to understand the other's cultural proclivities, reasoning and institutional constraints with minimal risk of technology sharing. Perhaps most importantly, cooperation would politically empower Chinese individuals and institutions who are stakeholders in Chinese space policy to be more favorably inclined toward the United States. A cooperative civil and commercial relationship creates interests that could inhibit aggressive or reckless behavior, as opposed to Chinese space policy being untethered to any obligations, interest or benefits it might obtain through cooperation with the United States.

The National Academies of Science (NAS) 2014 report titled *Pathways to Exploration: Rationales and Approaches for A U.S. Program of Space Exploration,* includes a specific recommendation that it is in U.S. interests to work with China.[79] NAS has also successfully completed the first Forum for New Leaders in Space Science with the Chinese Academy of Science in 2014. It brought together 16 early career space scientists from China and the US to meet over two workshops where they shared research results and discussed future research opportunities. A second forum is being planned.

Wolf further stated that the United States should not work with China based on moral grounds. While clearly the United States would prefer not to work with authoritarian and/or communist regimes, it has done so in war and in peacetime when it has served American interests, and continues to do so today. That is the basis of realism: Serve American interests first. While the United States would prefer not to work with Stalin, we continue to work with Putin when it benefits us to do so. Were the U.S. not to work with authoritarian regimes, it would have few regimes to work with at all in the Middle East. The U.S. provided supported Saddam Hussain's regime in the Iran-Iraq War.[80]

Chinese politicians are interested in the ISS for symbolic reasons, specifically, being accepted as part of the international family of spacefaring nations as a sign of regime legitimacy. But it is unrealistic to expect withholding U.S. cooperation on space issues can influence regime change in China. A similar approach was considered with the Soviet Union, and it failed. Further, in terms of the U.S. doing China a favor by working with it, perhaps ironically many Chinese space professionals fear that cooperation with the United States would just slow them down. American politics are viewed as fickle and without the will to see programs to completion. This view is reflected in changing European views regarding space leadership. A 2013 piece in Germany's

[79] http://www.nap.edu/catalog/18801/pathways-to-exploration-rationales-and-approaches-for-a-us-program

[80] Ted Koppel reported in 1992 that the "Reagan/Bush administrations permitted—and frequently encouraged—the flow of money, agricultural credits, dual-use technology, chemicals, and weapons to Iraq." ABC Nightline. July 1, 1992.

Der Spiegel suggested that Europe is thinking of redirecting its primary space alliance from the United States to China, due to China's "rising power" status in space.[81]

The question of whether China is challenging U.S. leadership in space has received considerable media attention in the form of a U.S. – China "space race," prompted largely by perceptions of declining U.S. space leadership. The U.S. civil space program is not dying, military space activities continue to expand, and no country is doing anything in space that has not already been done by the United States. But having started with such a spectacular accomplishment as the Apollo Program, it has been difficult to maintain the public enthusiasm required to fund further space spectaculars, such as a human spaceflight mission to Mars. Although not completely unsupportive, the U.S. public treats the space program as expendable to other government programs. The reality is that space, as with other areas of international relations, will likely be a multipolar environment in the future.[82] America's unipolar moment is over, and as long as it is reluctant to work with rising partners such as China, the perception of its space leadership will continue to decline as well. That is not to say that the United States will not continue to lead in some areas of space activity. If only by virtue of a heftier budget, the United States will be able to lead in select areas. But the days of total leadership are over. It will be a tough pill to swallow for those who crave exceptionalism—but if we are unwilling to pay the price tag, then swallow it, we must.[83] In that respect, China has not "usurped" the perception of U.S. space leadership, it is being ceded to them.

This rebuttal to Congressman Wolf's views assumes that the United States has a choice regarding whether or not to work with China. If, however, sustainability of the space environment upon which the U.S. generally and the U.S. military specifically relies upon for advantages is to be maintained, the space debris issue alone requires that the U.S. not exclude diplomacy as a policy option.

While missile defense/ASAT testing has been conducted in ways to minimize debris issues since 2007, the potential threat to the space environment in non-test circumstances has become clear. If there was any upside to the 2007 Chinese test, it was the frightening realization by all countries of the fragility of the space environment. With regard to China specifically, since this 2007 test China has done nothing further in space that can be considered irresponsible or outside the norms set by the United States. Mankind's dependence on space assets thereby makes it in the best interests of all spacefaring nations to cooperate to maintain that environment.

China was scheduled to host an international meeting of the Inter-Agency Space Debris Coordinating Committee (IADC) only days after its 2007 ASAT test that significantly worsened space debris, resulting in China cancelling the meeting out of embarrassment. There is a certain (understandable) glee in the U.S. military, which has the most sophisticated government space tracking abilities, at being able to warn China of potential collisions between its own space junk

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[81] Kevin Holden Platt, "ESA Mulls New Alliance as China Becomes Space Leader," Der Spiegel, February 8, 2013, <http://www.spiegel.de/international/europe/esa-mulls-new-alliance-as-china-becomes-space-leader-a-882212.html>.

[82] Global Trends 2030: Alternative Worlds, National Intelligence Council NCI 2012-001, December 2012. <http://www.dni.gov/index.php/about/organization/national-intelligence-council-global-trends>

[83] Joan Johnson-Freese, "Exceptionalism, Conflicting Public Mandates and Ceding American Leadership in Space," Fletcher Forum, forthcoming, Winter 2015.

and its own satellites.[84] More recent constructive Chinese involvement with the IADC indicates recognition of need to sustain the space environment and cooperated on relevant issues, particularly the space debris issue.[85] These are the type of "common ground" issues that provide opportunities to work with all spacefaring nations to protect the "congested, contested and competitive" space environment.

U.S. emphasis on counterspace is often presented as in response to actions and intentions of other countries, specifically China, presumably recent. Increasingly, however, it seems speculation about Chinese intentions is based on material not publically shared, making the feasibility of both the speculation and appropriate U.S. responses difficult to assess. For example, to my knowledge China has done nothing since its admittedly irresponsible 2007 ASAT test that goes beyond what the U.S. considers international norms of responsible behavior.

Pursuing efforts to enhance transparency, confidence-building measures, toward identifying "common ground among all space-faring nations," and resiliency for military systems (NSSS, p.8) all must be pursued with the same energy and commitment as counterspace operations. Otherwise, just as efforts to isolate Chinese space activities have backfired on the U.S. in areas such as export control, the unintended consequences of a principally "deter, defend, defeat" strategy could trigger an arms race that puts the sustainability of the space environment at significant risk, to the detriment of U.S. national security.

With regard to the resilience, specifically the purview of the Department of Defense (DOD) and Office of the Director of National Intelligence (ODNI), resilience has faced resistance from elements within as being too expensive or, as with space arms control, just too difficult.[86] The Air Force appears to be taking the time honored approach of studying the problem rather than acting on it. Center for Strategic and Budgetary Assessments analyst Todd Harrison characterized part of the problem as a lack of interest on the part of Pentagon leaders. He stated, "While everyone recognizes space as a critical enabler for the war fighter at all levels of conflict, from low to high end, it is not the sexy weapon system that puts hot metal on a target. So it doesn't attract much interest from senior leaders."[87] Counterspace, however, offers that sexy option.

Regarding transparency, the need to share information about satellite locations was recognized by the private satellite owners and operators, promoting the formation of the Space Data Association. At the government level, Space Situational Awareness (SSA) efforts have largely been to "formalize the existing model of one-way data flow from the American military to other

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[84] Warren Ferster, "U.S., Japan Sign Pact on Space Situational Awareness," Space News, March 12, 2013. http://spacenews.com/us-japan-sign-pact-on-space-situational-awareness/

[85] Joan Johnson-Freese, "Taking Out the Space Trash; A Model for Space Cooperation," BreakingDefense.com, May 2, 2014. http://breakingdefense.com/2014/05/taking-out-the-space-trash-a-model-for-space-cooperation/

[86] Brian Weeden, "U.S. Satellite Needs More Than Swords and Shields," Defense News, January 20, 2015. http://www.defensenews.com/story/defense/commentary/2015/01/19/commentary-us-satellites-need-swords-shield

[87] Stew Magnuson, "Air Force Space Programs on Hold as New Architecture Studied, National Defense, January 2015.
http://www.nationaldefensemagazine.org/archive/2015/January/Pages/AirForceSpaceProgramsonHoldasNewArchitectureStudied.aspx
s/22017839/

countries and satellite operators"[88] and the U.S. signing bi-lateral agreements with France[89] and Japan, and the U.S., United Kingdom (U.K.), Canada and Australia signing a limited agreement in 2014.[90] While U.S. efforts to provide collision-avoidance information to other countries – including China – are admirable, as an increasing number of countries place an increasing number of satellites in orbit, improving current techniques and increasing collaboration and cooperation on exchanges of information must be aggressively pursued.

And while the U.S. has rhetorically supported the European led efforts toward an International Code of Conduct, continued Congressional restrictions regarding bilateral U.S.-China space cooperation sends a powerful signal regarding U.S. seriousness regarding its intent to work with all space faring nations for the good of the space environment. Anything less than a comprehensive effort to constructively deal with issues related to the "space commons" can yield limited success at best.

Regardless of various interpretations of Chinese intent, the United States must pursue all policy goals of the NSS, NSP and NSSS. That will inherently involve working with China in some areas, and pursuing a full range of approaches to policy goals. The sustainability of the space environment is as key to protecting assets as is protecting assets from hostile actions. They are inherently intertwined.

Policies attempting to constrain, contain and control Chinese space activities have been repeatedly demonstrated of limited value. The most viable way for the U.S. to stay ahead of China in space capabilities is to focus on what it does have control over; its own programs. Funding, acquisition processes, strengthening the industrial base, cultivating and supporting science, technology, engineering and math (STEM) education programs and opportunities, resilience and broad based research and development will yield as much or more gain toward achieving U.S. space policy goals are key in the regard.

To summarize, the U.S. cannot "control" Chinese space ambitions; even influence is limited. Nor can the U.S. "control" space in the same way that it can control airspace. Yet space is a global commons the sustainability of which is critical to U.S. national security. Consequently, cooperation with China in areas of shared interests is in the best interests of U.S. national security. In order to protect U.S. assets and achieve stated U.S. goals, all approaches stated in the nested U.S. space strategies must be pursued with equal attention. Full implementation of U.S. space strategies is the prudent way forward.

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[88] Weeden, January 20, 2015.

[89] Daniel Wasserbly, "U.S. France sign Space Situational Awareness Agreement," Janes, January 26, 2014. http://www.janes.com/article/33081/us-france-sign-space-situational-awareness-agreement

[90] Mike Gruss, "News From 30th Space Symposium," SpaceNews, May 22, 2014. http://spacenews.com/40651news-from-the-30th-space-symposium-us-three-allies-sign-space/

OPENING STATEMENT OF MR. DEAN CHENG
SENIOR RESEARCH FELLOW ASIAN STUDIES CENTER, THE HERITAGE FOUNDATION

MR. CHENG: Good morning, members of the Commission. Thank you very much for the opportunity to be here.

My comments today are about China's potential military space doctrine and, in particular, China's interest in what we term "counterspace."

Chinese views on the importance of space, including counterspace operations, do not occur within a vacuum. Rather, they are part of the larger view of the nature of modern and future warfare. Although the Chinese People's Liberation Army has not fought a war since 1979, they have been assiduous students of other people's wars, and especially those of the United States.

Having closely observed our conflicts from the first Gulf War, Operation Desert Shield/Desert Storm, through our operations in the Balkans, the war in Afghanistan, the war with Iraq, the PLA has reached several conclusions:

First, future wars will involve joint operations. This is a conclusion dating back to the first Gulf War. Future wars will involve not only land, sea and air domains, but also outer space and cyberspace, and all the services that operate in those domains will have to operate together. But to conduct joint operations spanning millions of cubic kilometers reaching from outer space to the ocean depths and spanning continents requires common situational awareness, extensive communications network, and arrays of precision munitions.

Thus, future wars will therefore be based not on individual weapons or even weapon systems but systems-of-systems bound together through information. The ability to fight and win what they term "local wars under informationized conditions" then rests upon the ability to establish information dominance, or information superiority, depending on how you want to translate the Chinese term.

This is the ability to collect, transmit, and exploit information in times and places of one's own choosing while denying an opponent that same ability. And because space systems play such a key role in the collection, transmission and exploitation of information, space superiority or space dominance is viewed by the PLA as essential for seizing and maintaining information dominance.

This interest in space dominance is, in turn, reflected in the assessments of American intelligence agencies. Most recently General Vincent Stewart of the Defense Intelligence Agency noted that several nations, specifically including China, are developing counterspace capabilities.

General Vincent notes, quote: "Chinese military writings specifically highlight the need to interfere, damage and destroy reconnaissance, navigation and communication satellites."

General Vincent mentions various Chinese writings. While he doesn't specify what he's referring to, he might be including the 2013 volume The Science of Military Strategy, published by the Chinese Academy of Military Sciences, available through finer Chinese book shops everywhere.

He might also have been referring to the PLA Encyclopedia published in 2007. In that volume on military strategy, the definition of the term "space dominance" is provided. This is a volume that the entire PLA uses. Space dominance will be a vital factor in securing air dominance, maritime dominance and electromagnetic dominance, and it will directly affect the

course and outcome of wars.

Or he might have been referring to the most recent series of Chinese military teaching materials published, again, by the Academy of Military Sciences Publishing House. This new series provides Chinese military officers and students within their PME system with extensive discussions about Chinese thinking on a variety of military subjects, and intriguingly in this new series of 65 volumes, there is one specifically dedicated to the issue of military space operations.

In this regard, it has significant similarities to, but also significant differences from, a previous 2005 PLA textbook entitled Military Astronautics, which again was used by the PLA to teach its own officers about how to think about military space operations.

Let me note here that Chinese military doctrine does not map directly onto our own concepts, much less our own terminology. For the United States, military space operations are comprised of space situational awareness, space force enhancement, space support, space control and space force application.

According to the Science of Space Operations Teaching Materials, space superiority requires the ability to undertake space deterrence, space blockades, space offensive operations, space defensive operations, and the provision of space information and support. Again, these terms don't quite map onto each other.

The conduct of space operations, however, according to PLA analyses, is marked by certain characteristics. Space warfare is high-intensity conflict, with limited available forces due to the high costs associated. It is offense dominant as it is hard to preserve or defend orbital assets and the overall space architecture.

The guiding thought, according to these writings on space operations, is “active defense; all aspects unified; the key point is space dominance.”

"Active defense" refers back to Chinese military strategy. The emphasis here is on the ability to secure the initiative, not to simply be passive.

"All aspects unified" refers to several things. First, that all space assets, civil, commercial, as well as military, will be employed under a unified command and control structure that is run by the military in time of war. This has distinct implications for national defense mobilization, including of university and commercial assets.

It also refers to the integration of space operations with land, sea, air, cyber and electronic warfare operations.

Finally, "key point is space dominance" refers to the importance of establishing space dominance for oneself, but that also one must strive to deny an opponent those same capabilities.

Space operations consistent with the guiding thought of "active defense, all aspects unified, key point is space dominance" includes space deterrence, space blockades, space offensive and defensive operations.

In the interest of time, let me just briefly talk about how the Chinese think about space deterrence. The Chinese do have an escalatory ladder in this regard or conceive of one. It begins by displaying weapons effects, such as we saw in 2007. It escalates from there to the conduct of space exercises. In time of crisis, it would involve the redeployment of space assets, and most intriguingly in this new edition, the Chinese talk about space "shock and awe." Admittedly, that's a translation of their term, but I think “shock and awe” is probably the best way to translate that here.

This is the highest level of space deterrence. It involves both soft and hard kill operations, and it specifically includes attacking networks in information warfare.

Let me conclude by noting that at this time, it is still not known whether the PLA has

issued a formal doctrine governing military space operations, including counterspace activities.

However, the issuance of so many key Chinese military documents, a new encyclopedia in 2007, a new volume on terminology, the series of teaching materials, a new Science of Military Strategy in 2013, raises the distinct likelihood that there has, in fact, been an updating of the PLA's doctrine, which was last officially issued in 1999. If so, it is quite likely that it has included, in fact, a doctrine governing space operations, including the importance of establishing space dominance.

Thank you very much for your time.

PREPARED STATEMENT OF MR. DEAN CHENG
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CONGRESSIONAL TESTIMONY

The PLA's Interest in Space Dominance
Testimony before
US-China Economic and Security Review Commission

February 18, 2015
Dean Cheng
Senior Research Fellow
The Heritage Foundation

My name is Dean Cheng. I am the Senior Research Fellow for Chinese Political and Security Affairs at The Heritage Foundation. The views I express in this testimony are my own, and should not be construed as representing any official position of The Heritage Foundation.

The Chinese People's Liberation Army (PLA) has been a close observer of other people's wars. Since the early 1990s, Chinese military analysts have carefully analyzed such conflicts as the first Gulf War (Operation Desert Shield/Desert Storm), the NATO intervention in the Balkans, the American invasion of Afghanistan, the 2003 Iraq War, as well as Russian wars and counterinsurgencies along its periphery.[1] Chinese analysts have also examined earlier conflicts such as the 1973 Arab–Israeli War and the 1982 Falklands conflict.

From their analysis, the Chinese have concluded that the key to fighting and winning modern wars lies in the ability to establish "*zhi xinxi quan*; 制信息权" (information dominance). Because of the evolution in human society and economics towards the Information Age, Chinese analysts expect most future wars will be "*xinxihua tiaojian xia jubu zhanzheng*; 信息化条件下局部战争" (local wars under informationized conditions). Winning such wars depends upon the ability to better exploit information just as during the Industrial Age success in war depended upon the ability to better mobilize the full panoply of national economic resources and industry. The key is establishing "information dominance," i.e., the ability to gather, transmit, manage, analyze, and exploit information, and preventing an opponent from doing the same.

To this end, space plays an essential role. Based on PLA assessment of recent "local wars" (which encompasses most wars since at least the Vietnam War and the 1973 Arab–Israeli war), space has played a growing role. More and more essential data, from meteorological information to weapons guidance and communications, is gathered from or transits through satellites. As one PLA assessment noted, in the course of the NATO intervention in Kosovo, the US military deployed some 50 satellites, and integrated them with unmanned aerial vehicles and aircraft to create a comprehensive surveillance system. Space systems are judged to have provided 70 percent of battlefield communications, 80 percent of battlefield surveillance and reconnaissance, and 100 percent of meteorological data, and did so through all weather conditions, 24 hours a day. Moreover, 98 percent of precision-guided weapons were guided with space-based information.[2] Consequently, establishing "*zhi tian quan*; 制天权" (space dominance) has become an essential element of achieving "information dominance."

PLA analyses suggest that it views space in a very holistic fashion. Chinese writings note that the overall space system encompasses not only satellites in orbit, but also terrestrial launch, mission control, tracking, and telemetry and control (TT&C) facilities, as well as the data links that tie the space and earth-bound portions together. Consequently, efforts aimed at establishing space dominance must incorporate offensive and defensive measures covering this full range of targets (orbiting systems, ground-based systems, data).

Chinese Space Doctrine

At this point in time, it is not yet clear whether the PLA has promulgated a formal doctrine for military space operations. As important, it is essential to recognize that, in PLA writings, there is no single concept that corresponds directly to that of "counter-space." Rather, within the context of establishing "space dominance," or "space control," there are a range of tasks and missions that would correspond to aspects of counter-space activities. Thus, the ability to establish space

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[1]For a fuller discussion of Chinese lessons learned from these various conflicts, see Andrew Scobell, David Lai, and Roy Kamphausen, Chinese Lessons from Other People's Wars (Carlisle, PA: Strategic Studies Institute, 2011).

[2]Jiang Lianju, Space Operations Teaching Materials (Beijing: AMS Press, 2013), p. 65.

dominance requires the ability to conduct space offensive operations, space defense operations, and space blockades.

More important to understanding PLA thinking about space than a specific counter-space term or concept is the "*zhidao sixiang*; 指导思想" (guiding thought) for space operations. For the PLA, the guiding thought establishes certain principles that are expected to inform doctrine, activities, and acquisition. In the case of the PLA, the guiding thought for space operations appears to be "active defense, all-aspects unified, key point is dominating space."[3] Each of these elements, in turn, has important significance.

Active Defense. "Active defense" is integral to all Chinese military strategy, and is not limited to space-related operations. While assuming the strategic defensive, the PLA concept of active defense emphasizes the importance of seizing the initiative at the tactical and operational level. In the context of space operations, active defense again assumes a more strategically defensive stance, although one which nonetheless seeks to deter aggression and maintain national security and interests, while at the same time, undertaking space combat preparations so as to be able to seize the initiative in space-related operations. In particular, it presumes "offensive actions at the campaign and tactical level to secure strategically defensive goals."[4]

All Aspects Unified. "All aspects unified" refers to the need to unify thinking about a number of different aspects of space operations. It requires viewing the various domains of military activity, including not only outer space, but land, sea, air, and the electromagnetic spectrum (e.g., cyber and electronic warfare operations), in a joint fashion, with operations in each domain contributing to, and requiring support from, the other domains. Similarly, it requires seeing all the various wartime activities, including offensive and defensive operations, provision of information support and fire support, and hard-kill and soft-kill methods, in an integrated or unified fashion, rather than as discrete phases, tasks, or methods.

Thus, proper conduct of space operations should involve the application of soft-kill methods, such as dazzling or jamming, in coordination with hard-kill methods, such as direct-ascent-kinetic kill vehicles. Space operations should be coordinated with terrestrial operations, not only for the provision of meteorological, positioning and navigation, or communications data from space systems, but also for air, land, and sea attacks on an enemy's space launch and mission-support facilities. As with cross-domain operations, the various methods and activities should be seen holistically, all contributing to the goal of establishing space dominance while serving the larger, strategic ends of the overall campaign.

To this end, command and control of space operations plays a central role. Not only must the various space activities, including offensive and defensive operations, be closely controlled, but competing demands for reconnaissance and early warning, communications, navigation, and various other space information support assets must also be managed. This encompasses not only military space assets, but civilian and commercial systems as well. Space operations must also be integrated into larger, joint campaign plans to help achieve terrestrial objectives; command and control of space operations must therefore reconcile space-related requirements, timing, and structure with those of the overarching joint campaign.[5]

Key Point Is Establishing Space Dominance. "Key point is establishing space dominance"

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[3]Ibid., p. 40.

[4]Ibid.

[5]Ibid., p. 43.

emphasizes the importance of securing space dominance, through the comprehensive application of various types of tactics and forces, in a variety of ways, including interference, obstruction, disruption, and destruction of enemy space-related systems (including terrestrial facilities and data links). The objective is both to prevent the enemy from operating their space systems for as much of the course of the conflict as possible, while also ensuring that one's own space systems can operate effectively. To this latter end, establishing space dominance also encompasses the exploitation of space, whether in the provision of information support to terrestrial operations, undertaking space deterrence, or engaging in operations against remaining enemy space assets.[6]

Chinese Assessment of Required Space Capabilities for Space Dominance

In order to meet the demands of the guiding thought for space operations, PLA analysts conclude that a nation must be able to fulfill certain tasks. These include the ability to enter space, to exploit space, and to control space.

The Ability to Enter Space. This includes not only space launch capacity, but also the ability to monitor and maintain space vehicles after they have been launched. It therefore includes tracking, telemetry, and control (TT&C) capabilities. It also includes the establishment of overall space situational awareness (SSA), and maintaining it even in the face of enemy electronic countermeasures (ECM) and other interference.[7] In addition, satellite servicing capability and retrieval of certain types of space systems is also included in this task.

The Ability to Exploit Space. From the PLA's perspective, this primarily involves the provision of information support to terrestrial operations, including reconnaissance and surveillance, ballistic missile early warning, communications, navigation and positioning, meteorological data, and geodesy information (i.e., information about the globe, essential for determining missile trajectories). This support significantly enhances the effectiveness of land, sea, and air forces, and is what makes space a force multiplier in the Chinese perspective. Such information support is essential for successful joint operations.

The Ability to Control Space. This follows from the ability to launch systems into orbit and successfully exploit space. Fundamentally, it is the establishment of space dominance, the ability to dominate a certain area of space at given times and places of one's choosing, while denying an opponent the same ability.[8] Controlling space, in turn, requires fulfilling several distinct responsibilities. First, there must be the ability to preserve one's own space assets, including the ability to operate in the face of enemy interference or destructive attacks. Second, there must be the ability to interfere with, disrupt, or destroy other nations' space systems. Finally, there is the ability to conduct support to terrestrial operations, including the provision of space-to-ground attacks in the future.

To fulfill these tasks, a nation must field space forces that possess certain capabilities. These include:

- Space launch facilities;
- Space tracking, telemetry, and control facilities;
- Orbital space combat capabilities and units;
- Strategic missile forces;
- Ground-based space defense forces (which have the ability to establish SSA); and

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[6]Ibid., p. 44.

[7]Ibid., p. 65.

[8]Chinese Military Encyclopedia Editorial Committee, PLA Encyclopedia: Military Strategy (Beijing: NDU Press, 2007), p. 211.

- Space logistics and safeguarding capabilities and forces.

The PRC currently fields or is developing all of these forces. In the context of counter-space capabilities, of particular note is China's interest in orbital space combat capabilities and ground-based space defense forces.

Chinese Space Weapons Developments

Since the 1990s, Chinese writings have increasingly emphasized the importance of space. In that time, that interest has also been reflected in a number of weapons tests and other activities that suggest an ongoing array of weapons development efforts. These include a number of different anti-satellite vehicles, as well as possible directed-energy weapons (e.g., lasers). Chinese cyber capabilities may also have anti-satellite functions (among others); similarly, Chinese conventional modernization may allow them to hold some of the terrestrial elements of the American (and allied) space infrastructure at risk.

Ground-launched Anti-satellite Systems. In January 2007, China tested a direct-ascent kinetic-kill vehicle against a defunct FY-1C weather satellite, resulting in one of the worst debris-generating events in space history. This test, according to Paula DeSutter, then–Assistant Secretary of State for Verification, Compliance, and Implementation, was not the first test, however, but followed two earlier non-destructive tests of the same system.[9] This ongoing development program does not appear to have ended, although there have not been any comparable tests since 2007.

Since then, however, China ***has*** conducted three tests of a ballistic missile defense system that might also have anti-satellite applications. In 2010, the Chinese "conducted a test on ground-based midcourse missile interception technology within its territory."[10] As American defense officials noted, "We detected two geographically separated missile launch events with an exo-atmospheric collision also being observed by space-based sensors."[11] The Chinese conducted another missile defense test in January 2013, and used almost the exact same language to describe it (i.e., a midcourse missile interception). In July 2014, the Chinese conducted another test, which it has termed a missile defense test, but which the United States characterized as a non-destructive anti-satellite test.[12] It should be noted that these tests resemble the American interception of the satellite US193 with an Aegis missile.

While these earlier tests were engaging targets in low-earth orbit (160–2000 kilometers altitude), in 2013, China has also tested a ground-launched anti-satellite system that would appear to be able to threaten satellites in geosynchronous orbit (36000 kilometers altitude).[13] This constitutes a substantial expansion of the potential threat posed by Chinese anti-satellite capabilities. As important, it would hold at risk a range of key satellites, including communications and missile early warning systems.

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[9]Lon Rains and Colin Clark, "Profile: Keeping a Watch on U.S. Interests," Space News, March 1, 2007, http://spacenews.com/profile-keeping-watch-us-interests/ (accessed February 6, 2015).

[10]"China Reaffirms Its Missile Test Defensive," Xinhua, January 12, 2010, http://news.xinhuanet.com/english/2010-01/12/content_12797459.htm (accessed February 6, 2015).

[11]"China: Missile Defense System Test Successful," USAToday, January 11, 2010, http://usatoday30.usatoday.com/news/world/2010-01-11-china-missile-defense_N.htm (accessed February 6, 2015).

[12]Mike Gruss, "U.S. State Department: China Tested Anti-Satellite Weapon," Space News, July 28, 2014, http://spacenews.com/41413us-state-department-china-tested-anti-satellite-weapon/ (accessed February 6, 2015).

[13]Brian Weeden, "Through a Glass, Darkly," Secure World Foundation, March 17, 2014, http://swfound.org/media/167224/Through_a_Glass_Darkly_March2014.pdf (accessed February 6, 2015).

Co-orbital Anti-satellite Systems. The ability of satellites to maneuver together has both peaceful and military potential. Docking maneuvers are integral to such actions as resupply of the International Space Station and were fundamental to the American Moon landings. At the same time, however, any satellite, if it has sufficient fuel and can be finely controlled while guided by a sufficiently discerning tracking system, can serve as a co-orbital anti-satellite system; in effect, it would be a space kamikaze. Recent Chinese developments in small satellites and space robots, as well as manned space missions, have demonstrated an ability to maneuver satellites together.

In 2010, two Chinese small satellites, SJ-06F and SJ-12, engaged in a series of maneuvers that suggest a controlled conjunction, in which the two satellites "bumped."[14] The ability to undertake controlled approaches reflects a nascent ability to steer a satellite, and to bring it into contact with another space system. Similarly, China's controlled docking maneuvers by the Shenzhou-VIII, Shenzhou-IX, and Shenzhou-X space capsules with the Tiangong space lab demonstrate China's ability to closely monitor spacecraft operations, including approach and contact. That Shenzhou-VIII was remotely docked via ground control also reflects Chinese ability to bring spacecraft into carefully controlled contact with each other.

In August 2013, China again demonstrated an ability to maneuver satellites in close proximity, as several Chinese satellites apparently maneuvered in a manner that again suggests that they may have physically contacted each other. One of the satellites may have been equipped with a robotic arm, adding an additional capability for servicing satellites—or damaging them while in orbit.[15]

Directed-Energy Weapons. Chinese KKV tests have garnered significant commentary and discussion; less is known about Beijing's development of directed-energy weapons (DEW). In 2006, China apparently fired lasers at American satellites passing overhead. Contemporary reporting indicated that this was one of a series of events involving Chinese lasers and American military or intelligence satellites.[16] While the United States expressed concern over what was then described as an anti-satellite system, subsequent reporting suggested that it was not clear whether these were, in fact, weapons, or laser-ranging devices.[17] Other reports suggest an ongoing research effort into developing lasers for a variety of defense purposes, including anti-satellite functions.[18]

Cyber Capabilities. As noted earlier, the Chinese interest in counter-space is not limited to developing systems to attack orbiting satellites, but also extends to the ability to degrade or damage datalinks that connect satellites to ground stations. Space dominance can be achieved if a key satellite is shut down, its mission payload is pointed in the wrong direction, or it is unable to communicate at critical moments, as if it had been destroyed by an anti-satellite system. Indeed, this may be a preferable outcome, since attribution may be difficult and such approaches are

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[14]Brian Weeden, "Dancing in the Dark: The Orbital Rendezvous of SJ-06F and SJ-12," The Space Review (August 30, 2010), http://www.thespacereview.com/article/1689/1 (accessed February 6, 2015).

[15]Kevin Pollpeter, "China's Space Robotic Arms Programs," Study of Innovation and Technology in China Project (October 2013), http://igcc.ucsd.edu/assets/001/505021.pdf (accessed February 6, 2015).

[16]Vago Muradian, "China Attempted to Blind U.S. Satellites with Laser," Defense News, September 25, 2006.

[17]"NRO Confirms Chinese Laser Test Illuminated US Spacecraft," Space News, October 3, 2006, http://spacenews.com/nro-confirms-chinese-laser-test-illuminated-us-spacecraft/ (accessed February 6, 2015), and "China Jamming Test Sparks US Concern," USAToday, October 5, 2006, http://usatoday30.usatoday.com/tech/news/2006-10-05-satellite-laser_x.htm (accessed February 6, 2015).

[18]Wendell Minnick, "China Pursues Systems to Keep US Forces at Bay," Defense News, September 17, 2013, http://archive.defensenews.com/article/20130917/DEFREG03/309160021/China-Pursues-Systems-Keep-US-Forces-Bay (accessed February 6, 2015).

unlikely to generate space debris (and attendant political and diplomatic criticism). Consequently, Chinese cyber capabilities should be considered an integral part of China's counter-space capabilities.

Several recent cyber incidents involving space systems have been attributed to the PRC, suggesting that they are actively exploring vulnerability in space information systems. Hacking incidents in 2007 and 2008 against the LANDSAT-7 and Terra AM-1 EOS (Earth Observation System) satellites reportedly allowed cyber-intruders to gain control over all functions of these satellites for several minutes.[19] The attacks have been attributed to the PRC. Other reports suggest that China is responsible for hacking into the National Oceanic and Atmospheric Administration's weather satellite system.[20]

Potential Future Development Trends in PLA Space Capabilities

As the PLA continues its modernization program, it will likely continue to improve its ability to secure information dominance, including space dominance. At the same time, as technology improves, space operations themselves will shift from primarily oriented towards provision of information support towards combat capabilities to achieve space dominance.

PLA assessments on requirements for "army-building" (i.e., military modernization) include several areas for improving China's military space capabilities.

Rapid Space Launch Capability. In terms similar to how American analysts describe "operationally responsive space," Chinese analysts cite the need for rapid launch of satellites to augment current constellations in time of crisis, and to replace lost assets in time of conflict. Intriguingly, it is also suggested that it may not be necessary to deploy a complete constellation in peacetime; if one possesses a rapid-launch capacity, it would be possible to augment a minimal peacetime constellation in time of crisis or conflict.[21] In this regard, Chinese development of the Kuaizhou solid rocket space launch system would seem to suggest that the PLA has already prioritized improvements in this area.[22]

More Robust Space Situational Awareness. An important likely focus in the coming years will be improving China's *kongjian taishi ganzhi*; 空间态势感知 (space situational awareness) and strategic early warning capacity. This will include both ground-based and space-based sensors to provide PLA planners with better strategic early warning about changes in the space environment.[23] At the same time, there is recognition that China's growing investment in countering orbiting systems requires improved SSA to ensure that it can identify the right targets

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[19]Tony Capaccio and Jeff Bliss, "Chinese Military Suspected in Hacker Attacks on U.S. Satellites," Bloomberg News, October 27, 2011, http://www.bloomberg.com/news/2011-10-27/chinese-military-suspected-in-hacker-attacks-on-u-s-satellites.html (accessed February 6, 2015).

[20] Mary Pat Flaherty, Jason Samenow, and Lisa Rein, "Chinese Hack Weather Systems, Satellite Network," The Washington Post, November 12, 2014, http://www.washingtonpost.com/local/chinese-hack-us-weather-systems-satellite-network/2014/11/12/bef1206a-68e9-11e4-b053-65cea7903f2e_story.html (accessed February 6, 2015).

[21]Tan Rukun, Operational Strength Construction Teaching Materials (Beijing: AMS Publishing House, 2012), p. 157.

[22]Rui C. Barbosa, "China Launches Kuaizhou-2 in Second Launch Within 24 Hours," NASASpaceflight.com, November 21, 2014, http://www.nasaspaceflight.com/2014/11/china-launches-kuaizhou-2-second-launch-24-hours/ (accessed February 6, 2015), and Richard Fisher Jr., "China Launches Second Kuaizhou Mobile SLV," Jane's Defence Weekly, November 26, 2014, http://www.janes.com/article/46360/china-launches-second-kuaizhou-mobile-slv (accessed February 6, 2015).

[23]Tan, Operational Strength Construction Teaching Materials, pp. 158–159.

and then engage them successfully. Improved SSA will also benefit efforts at space defense, as adversary orbital anti-satellite weapons can be detected and characterized earlier, allowing Chinese space operators more time to move their own assets.[24] The PRC is therefore likely to develop space surveillance systems that will provide real-time tracking data on the tens of thousands of space objects currently in orbit.

Improved Offensive and Defensive Space Capabilities. China is clearly developing a number of anti-satellite systems, including a demonstrated capacity for direct-ascent kinetic-kill vehicles, co-orbital anti-satellite systems, and cyber tools that could interfere with space control systems. Future developments may include more soft-kill options that would lead to "mission kills" on satellites, preventing them from gathering or transmitting information, rather than physically destroying the system. The PLA suggests that these efforts might include co-orbital jammers and satellites that could eavesdrop on a target satellite's control and data transmission in peacetime, and perhaps hijacking or other interference with the satellite in time of crisis or conflict.[25]

Other areas that the PLA is likely to pursue include defensive measures that would counter adversary attempts at establishing space dominance by allowing Chinese space systems to either survive enemy space attacks or repair and otherwise ameliorate damage. These might include robots capable of on-orbit repairs, or a greater emphasis on small satellites that could allow rapid reconstitution of key space information support functions.[26]

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[24]Ibid., pp. 161–162.

[25]Ibid., p. 161.

[26]Ibid., p. 158.

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PANEL I QUESTION AND ANSWER

HEARING CO-CHAIR FIEDLER: Commissioner Wessel.

COMMISSIONER WESSEL: Thank you all for being here today and for those who are returning, and, Mr. Pollpeter, I have to say that your forthcoming study, is extremely thorough, and I think it will provide an important contribution to the analysis and discussion of these areas. So thank you.

Let me ask you, Dr. Johnson-Freese, I was a little surprised, I have to say, by your testimony, and you take some time to address former Congressman Wolf's activities in this area. And in some ways, your testimony seems to be swimming against the tide, shall we say, in terms of the view that while the fruits of engagement were expected to be robust after China's entry into the WTO, with rising cybersecurity concerns, with attribution sets that clearly link in indictments, now open indictments, et cetera--Mr. Cheng related a number of open source writings as to Chinese doctrinal approaches on space--that cooperation doesn't seem to be yielding many benefits for the United States, but the benefits seem to be tilted towards China.

So the cooperation seems to be fueling, assisting their movement along the spectrum of becoming a major space power. They now rank close to Russia in terms of the number of satellites that are deployed. They've clearly shown through actions and doctrine that space, to quote Star Trek, "is the final frontier," and they hope to dominate it.

And when one looks at their doctrinal writings relating to asymmetric warfare where the United States has assets that are robust--aircraft carriers, missiles, et cetera--that they realize that we are dependent on space, informationalized warfighters, and so this is an area, as is cyber, where they want to dominate and deny the U.S. the ability to advance its own interests.

Help me understand why you're such an optimist about cooperation, and what it should yield, and why those who are cautious, as Mr. Wolf is, has been, and many others, why we should be, I guess, in my view, ignoring some of their most recent activities? And I would like to hear from the other panelists as well. Why optimism when history seems to say that things are going in the opposite direction?

DR. JOHNSON-FREESE: Thank you for the opportunity to address that. As I said in my remarks, I'm sure there's going to be more variance about, about interpretations of what's going on than what's actually going on. I don't disagree with Kevin or Dean in any way in terms of what the Chinese are doing.

What I would characterize differently, I don't see myself as an optimist; I see myself as a realist and that we are not going to stop China from pursuing its activities. Therefore, I choose to look at it in terms of what is in the best interest of the United States in terms of responses.

And in that regard--

COMMISSIONER WESSEL: And I apologize. Do you take that from a commercial setting? You know, many who want to eliminate our export controls are doing so because they view sales rather than what it might do to fill the gaps in China's capabilities.

DR. JOHNSON-FREESE: In terms of export controls, I think we should build very high fences around those things which we actually control, but I think it has done the U.S. satellite industry no good to stop not only components but full products from being sold to China when they're easily available on the commercial market, the global commercial market.

These are things that the United States no longer has a monopoly on. If we have a monopoly on it and we can control it, absolutely, there should be the strict export controls. But I think we have, with our export controls after 1999, we did very little to stop China from getting

technology. What we did was allow the aerospace industries of other countries to make great leaps forward at the expense of our satellite industry.

COMMISSIONER WESSEL: And in the cooperation that Mr. Wolf was so concerned with with NASA, my understanding--and I'm not a rocket scientist--far from it as some of my colleagues may say--it appears that knowledge and experience in space has tremendous value. So what NASA may be providing them is the experience, the capabilities that will accelerate their ability to deny, deter, et cetera.

DR. JOHNSON-FREESE: Well, you know, this goes back to debates we had about the Soviet Union. When the Soviets visited the Johnson Space Center and went back and reconfigured Star City to be an exact duplicate of Johnson Space Center in terms of the organizational setup, was that technology transfer?

Technology transfer goes to not just hardware but know-how, and know-how can sometimes be harder to transfer than actual hardware. So I think, I'm not sure--and I've never really been able to find out what exactly Congressman Wolf was fearful that was going to be transferred--to just ban all bilateral cooperation with China basically says we don't have the opportunity to try and decipher intent.

As I said in my testimony, I think the best way to try and figure out someone's intent is sit down and ask them, and when we deny ourselves that opportunity, you know, if you take the perspective keep your enemies close and--

COMMISSIONER BARTHOLOMEW: Your friends close and your enemies--

DR. JOHNSON-FREESE: --your friends close and your enemies closer, I see no benefit from not working with the Chinese, and I would cite to you the recent experience of RIMPAC last year, inviting the Chinese for the first time to participate in RIMPAC, and they brought two ships, one to participate and one to spy on the exercise, but from everything I've been able to find out from people who were there, there was very productive dialogue with the Chinese, that the Americans that were there felt that they learned more about Chinese intent and even having, according to, I think it was Admiral Locklear was quoted as saying even having the ship there to spy on the activities perhaps acknowledged that the Chinese realized that these kind of observations should be kind of normal relations.

I'm not arguing cooperation is going to solve our problems. I'm arguing that with dual-use technology, dialogue is a good way to expand our understanding of intent, much better than pure speculation. And while, again, I totally admire Mr. Cheng's ability to go through all these Chinese information and doctrines, I don't think there is a Chinese view about. China has, like the United States, a multiplicity of views, and as was mentioned--Senator mentioned--I wrote a book a few years ago that talked about U.S. ambitions to dominate space. I can imagine a similar hearing going--not a hearing, but a meeting going on in China with citations to a number of different sources in the United States that talk about the U.S. wanting to dominate space and what should they do about it?

There are many different views in China, and those who might be more amenable to working with the U.S. on areas of common interest, which may be narrow, which may be broad, have really no vested interest to do so or are not stakeholders in trying to do that because we have no avenues of cooperation in space similar to those that are being heavily advocated by the U.S. military in maritime relations.

MR. CHENG: Joan makes an impassioned argument about what it means to be a realist. Evidently I have a very different view of what realism is.

Let me first note I don't think anyone is claiming that we can stop China's space program.

Although I do find it intriguing that Joan at the same time argues that no one can stop the Chinese space program from progressing, however they're going to progress, which is certainly true, but that somehow by offering cooperation, we can create stakeholders within the Chinese system if they aren't stakeholders already.

And let me note here that when we are talking about stakeholders, this goes to a fundamental question about cooperation, which is who exactly is it we are cooperating with? As of right now, here we are eight years after the Chinese ASAT test of 2007. I'm not sure anyone can tell us who actually made that decision. Walk us through. We know who ultimately fired these systems.

And let me note here that at the time there were some fascinating arguments being made, including by some "realists," that this may have been evidence of a "rogue PLA." The PLA just did it on its own. Maybe there weren't even, you know, the political authorities didn't know. Why? Because the Foreign Ministry didn't know except, of course, within the Chinese political structure, the Foreign Ministry is actually largely irrelevant, which makes them very different from our National Security Council foreign policymaking structure or even the old Soviet Politburo.

And that goes to the second point here, which is where do civilian space authorities, presumably these stakeholders who would like cooperation to facilitate understanding and join Pugwash and do all those other things, where do they sit within this system?

The reality is that they seem to have very little voice. Do we think that offering cooperation is going to somehow make them give them a seat at the table? Well, you would think that the foreign minister in their system already would have a seat at the table, and yet there is very, very good evidence, and I don't think there are too many China analysts out there who would argue that the foreign minister has anywhere near the kind of authority that we would want.

Let me also note here regarding RIMPAC, I find it again interesting that we would consider this to be a success, first, that we invite the Chinese and they show up actually with two ships to participate and a spare one to do spying. As for the idea that this has somehow led to a conclusion that, you know, spying or strategic reconnaissance operations are the norm, I would say that that's optimism, not realism, because we have the experience of our P-8 pilot who nearly got rammed by a Chinese fighter pilot doing a barrel roll around the aircraft when it was conducting SROs in Chinese territory after RIMPAC, and the Chinese attitude was very specific: "Thank you for inviting us to RIMPAC; now go away."

That, you know, this is not an acceptance of the rule of law any more than joining WTO has been. It is instead a rather longstanding Chinese attitude, which is "Thank you very much for incorporating me, as you should, but that does not give you rights in my sphere of influence."

It is an interesting question why we would assume that in the context of space where what is a major stakeholder--the military--says we need dominance, we need superiority, is somehow going to be diluted or ameliorated. I would agree with Joan, we do need dialogue.

Whether or not that dialogue--I would pose this final aspect to you, the members of this Commission. In 2010, I believe, NASA Administrator Bolden went to China. I do not believe that he has ever provided a report to the Congress, to the American people, or to any part of the public as to what was on the agenda and whom he met with. Perhaps before we have dialogue with the Chinese, we might want NASA to have dialogue with the United States.

HEARING CO-CHAIR TALENT: Two questions. Mr. Cheng and Mr. Pollpeter, although if you want to comment on this, Dr. Johnson-Freese, please do.

Have the Chinese done anything that other countries haven't done? I mean have they done anything that you think or that violates international norms regarding space, you know, and if so, what?

Dr. Johnson-Freese, one of my concerns about cooperation, this is done extremely carefully, is that if China does have goals in its region which are in conflict and which it recognizes are in conflict with America's interests, including a norm-based international system, and if they are purposefully pursuing the means to achieve that, and that's--I mean the Commission has pretty much concluded that--my concern is that offers of cooperation/dialogue in the face of that might be taken by the Chinese as naivete.

In other words, they might see us frankly as fools for that, which is the wrong impression that we want to send. What we want to send is that, indeed, we are realists, and we're--not in a doctrinal sense, but we're realistic about them. And this is my concern about how they ended up viewing RIMPAC and sending that intel--I'd appreciate your further comments. I'm not trying to argue with you. I'm trying to dialogue with you.

Them sending that intel ship under those circumstances to me was a statement, and it was not a statement that they want to cooperate with us, and I don't--I understand Admiral Locklear believes differently, but Captain Fallon didn't, and since he's only a captain, that's the reason he's not there anymore. I'm referring, of course, to the head of intelligence for PACOM.

Okay. So have at it.

MR. POLLPETER: I would say I think it's hard to find something that China has been doing differently. We conducted, you know, they conducted a kinetic, direct-ascent kinetic kill vehicle test in 2007. We did way back in '96. They have tested lasers. We have tested lasers with counterspace applications.

I think the issue here is more one of ambiguity and transparency and sort of overall intent, and I think, you know, it is very difficult. China has a much more opaque space program than what we do. They are less transparent, and I think it's a little bit more difficult to figure out exactly what they're trying to do and their overall intent.

And this raises suspicions and concerns that maybe they could alleviate by being a little bit more forthcoming about how, you know, how dual-use are these? Are these really military tests or are these really more tests for civilian applications?

And we've done some one-offs here and there, but I think there's an overall direction to the Chinese counterspace program and space program overall that really indicates a very assertive intent to be able to deny the U.S. access to its space capability, something more assertive and coordinated than what we have done, you know, since the '60s.

MR. CHENG: I don't think the Chinese have been demonstrated to have done anything that specifically violates norms, in part because norms are very sort of squishy at this point, without real treaties and the like, but I would note that Brian Weeden of the Secure World Foundation has concluded that the Chinese tested what would appear to have been an ASAT aimed at geosynchronous orbit systems.

This is unprecedented. It places the most valuable piece of orbital terrain under threat. It is something that neither we nor the Russians developed. And just to clarify. I come from the Heritage Foundation, a noted right wing conservative organization. Brian Weeden works with the Secure World Foundation, a much more liberal entity. So this is not the right citing the right.

[Laughter.]

DR. JOHNSON-FREESE: To address your question, I am arguing that the United States should pursue all avenues available to us. I am not arguing against counterspace capability

development. I am simply saying I see no case where dialogue would not help us decipher intent.

We talk about China wants to develop capabilities to allow them access and the ability to use space. I think that is exactly what the U.S. wants as well. Whether we see theirs as unreasonable and ours as reasonable, again, I just see it as a matter of we need to sit down and talk to China.

China in 2007 when they conducted their ASAT test, they learned from us. As we've all said, they study us. They studied the Apollo playbook. They studied the Iraq war in the '90s, and after the 2007 ASAT test, if there is any upside to that at all, they learned the vulnerability of the space environment. And I think that is something we all need to keep our eye on. How do we sustain the space environment so that we can all use it?

One of the ways we do that is through potential rules, but, of course, it has been the United States that has been adamantly against any kind of a formal agreement about space weaponization.

Interestingly enough, this is the point I wanted to make, we talk about whether or not we should cooperate with China. I would note at this point in time there is a very strong faction in China that doesn't want to cooperate with the United States because those people feel that the United States would just hold them back because we don't follow through on our space activities, that our space program is floundering.

Right not their space station, as was mentioned, will likely be the de facto international space station in the future when ours, when the International Space Station is no longer, is deorbited.

So my point is we shouldn't see cooperation with China as doing them a favor. It has to be something that is seen as a benefit to both sides. And my point is that we would get benefit from limited, directed cooperation as one tool in our tool kit.

Reliance purely on counterspace technology, technology to protect technology, limits us, and that in order to achieve the goals that we have set out in our multiple space strategies, which includes sustainability, and sustainability is threatened by space weapons, that we need to pursue all these avenues, and one of those should be dialogue potentially leading to some form of cooperation so that we can get a better idea of intent.

MR. POLLPETER: Yes. I just wanted to add what we don't see. I've looked at over 800, maybe 900 sources, on China's space program, Chinese sources. And we see a lot of writings on the offensive side, how China should be trying to seize control of space, but what we don't see is a recognition that as China becomes more invested in space, that they take on the same vulnerabilities as the U.S.

And so there is no recognition yet, at least on the part of Chinese military writers, that they may be taking on some of these vulnerabilities, and some of the things that they want to do in space may be actually bad for them as well, and whether they will maybe eventually come along to that understanding. Whether we can help them out, remains to be seen, but it's certainly something that we need to be concerned about, both from the offensive side because they are so offensive oriented, and these norms that Senator Talent has referred to, they seem to still be very much underdeveloped at least within the Chinese military community writing on space.

HEARING CO-CHAIR FIEDLER: Thank you.

I think we've dealt with cooperation. The place is pretty opaque on every level decision-making wise, and I don't particularly see why dialogue on space will give us any more insight into their decision-making process. As a matter of fact, before this Commission, or first the

White House announced that they didn't think that Hu Jintao knew. I mean it was very clear. And then the Pentagon came before us and say, yeah, yeah, he knew for sure.

Okay. So now you're telling us that they didn't know that they were going to create debris.

DR. JOHNSON-FREESE: Oh, no, I didn't say that.

HEARING CO-CHAIR FIEDLER: Well, I mean it came very close to like, oh, shooting down a satellite is going to be problematic. Right? So clearly, to me, whoever made that decision either didn't care or wasn't consulting with their scientists.

I want to get down to a more realistic or maybe cynical view of space and warfare. Given our dependence, and everyone else's increasing dependence, on space as a communication vehicle, a targeting vehicle and everything else, it seems to me that it is inevitable that one side or the other is going to attempt to deny people access to space.

Furthermore, I don't believe the United States dominates space now. Dominating space means to me not offensive capability but maintaining our capabilities, defending them. Right now I think there are a number of people that can deny us our space assets. Combine that with cyber, why would you not attack our space assets and a massive cyber attack to our infrastructure when you think that it's demanded?

The availability of weaponry has historically, you know, driven its use. So I'm not so sure--maybe I'm backing into a cooperation argument, but in the end I think I'm not. I think it doesn't matter if you talk to them. I think they're going to do what's in their interests and we're going to do what's in our interests when push comes to shove depending on what the issue is.

I don't think it's the Senkaku Islands, but it may be something else. Why would the Chinese want to let our aircraft carriers come closer to their shores in say a Taiwan conflict or Taiwan crisis when they decide to invade Taiwan rather than keep them over the horizon? Why wouldn't the United States want to disable that capability when it's sending its aircraft carriers close to China's shores?

I'm very pessimistic. Does anybody share my pessimism about the inevitability of space warfare?

MR. POLLPETER: I would share your pessimism. I don't know if it's inevitable, but I would certainly say that there are trend lines indicating that combat in space is something we definitely need to be worried about.

One of my main concerns is looking back into near history back at the 1999 accidental bombing of the embassy, Chinese embassy in Belgrade, and I think that was a formative experience for the PLA. And you see that its military budget after '99 has really grown by leaps and bounds after that, and what we've seen, if you look at the biography of General Zhang Wannian, he says that meetings were held that very night of the bombing, and Jiang Zemin ordered that the PLA should develop weapons that can shoot far, look far, and strike accurately, and this is where the idea of the shashoujian, or the assassin's mace weapon, came into play about how the PLA, according, what Zhang Wannian passed on was that what the enemy fears most, we should develop.

And I think, you know, there has been that trajectory by the PLA to develop asymmetric weapons, especially even though you just released a report last week pointing out the weaknesses of the Chinese military.

HEARING CO-CHAIR FIEDLER: That may be more reason to do it.

MR. POLLPETER: Right, right, exactly, sir. That's exactly what--

HEARING CO-CHAIR FIEDLER: Given other conventional weaknesses.

MR. POLLPETER: That as even though their military is coming along, China has been modernizing at a very rapid rate, they're still very much behind the U.S., and this gives them an incentive to attack things like our space infrastructure.

HEARING CO-CHAIR FIEDLER: Dean.

MR. CHENG: I too also am pessimistic, although I think that's more genetic in my case. But let me first build off of--

HEARING CO-CHAIR FIEDLER: It has to do with my age in my case.

[Laughter.]

MR. CHENG: Let me first build off of Kevin's comment regarding the report released last week. I think it should be very sobering when we consider that the weaknesses identified by the RAND team are things like logistics, expeditionary lift, things like that, the same kinds of weaknesses that actually mark our European allies.

It is sobering to consider that in 1995, the PLA fielded the world's best obsolete equipment, and less than 20 years later, now, their shortcomings are comparable to those of Western Europe. That should give us an idea of how quickly the gap has closed.

Another person who is a pessimist is then Senior Colonel, now Major General Yao Yunzhu, noted PLA foreign handler, sometimes referred to as a "barbarian handler," who at Davos several years back said space war is inevitable.

That being said, I think that it is important to consider, as you noted, that the Chinese look at space as a holistic entity. It is not just systems in orbit. It is the data links that tie space systems in orbit to the ground. It is terrestrial launch facilities, mission control centers, et cetera. So when the Chinese talk about space warfare, when the Chinese talk about denying an opponent space dominance, we have this image of laser battle stations and KKVs and co-orbitals, and the Chinese are thinking of much broader.

It can be as simple as the strategic backhoe cutting fiber-optic and power links to mission control centers. It could be inputting cyber malware, viruses, et cetera, into either satellite control systems or the data coming off of it. Simply ordering a satellite to turn away from its target in a time of crisis.

It is also worth noting here that, I think, the Chinese ASAT test was in 2007. The Chinese were writing about the importance of demonstrating space weapons capabilities in 2005. This is not ex post facto, “Oops, I didn't realize what I was doing; let me make up a reason for this.” They talked about the need to do this long before they actually fired off an ASAT that generated a lot of debris, and while some might argue that they haven't done so since, and this is evidence that they've learned, the flip side to that is how often do I have to show you that I have a gun and have demonstrated proficiency in it, and to what extent do I now just have to pull back, show you the butt, and leave it at that?

DR. JOHNSON-FREESE: Well, I'll join the pessimist ground, but I am pessimistic because of the categorization of inevitable. Declaring something inevitable will make it so. And I think that we certainly would be less than prudent not to consider it as a possibility and prepare for it, but I think that means we should do everything we can to not make it inevitable because, again, the battle that Dean described of lasers firing in space and satellites blowing up is not in the U.S. interest. Sustainability of the environment is in our interest, and we ought to do everything we can to work for that.

And I also do want to clarify, I did not say or I hope I didn't say or imply that the Chinese were not aware of the debris that they created, that they were going to create, in 2007. Actually their space debris community was pretty on point as to what was going to happen.

But, again, the idea of they made a demonstration in 2007, that was not their first test. It was their first impact test. There had been two prior. There had been no response to those two prior tests that led the Chinese to believe that there would be the kind of reaction, very justifiable reaction, that occurred.

And after that 2007 test, I'm sure we all recall in 2008, United States "showed its gun" with Operation Burnt Frost. Even though it was a test to bring down a malfunctioning satellite, there were headlines in U.S. papers of declaration of we, too, have this ASAT capability, and I'm sure the Chinese were very aware and reading those.

So everyone showed that they have the capability. You don't have to do it again. What the Chinese did learn is don't create the debris mess and call these capability tests missile defense tests because those are internationally acceptable. So there is this idea of recognition of sustainability of the environment, and the irony of having the U.S. have to warn the Chinese to move some of their satellites so that it doesn't get hit by their own debris is not lost on the Chinese.

So I share the pessimism because I see so much of this it's inevitable, let's just move towards it, and, again, I don't see myself here as arguing against counterspace capabilities; I am here arguing that we ought to pursue all policy options, and that includes dialogue, that includes resilience, that includes putting more efforts on our own space capabilities.

I think the way to stay ahead is to stay ahead, not to try and put the genie back in the bottle in China and, again, control what they are doing. So my argument, again, is, yeah, I'm a pessimist, but I'm not a pessimist because it's inevitable. I'm a pessimistic because of the increased characterization of it.

HEARING CO-CHAIR FIEDLER: Thank you. I don't think anybody, by the way, thinks anybody is putting the genie back in the bottle.

Commissioner Tobin.

COMMISSIONER TOBIN: Thank you, Mr. Chairman.

I'm not convinced that what has been said here is mutually exclusive either, so I'll put that to the side. I think you're also saying it's not only a tool in the tool box, but we the U.S needs to do our own improvement work too. We need to regain our strength and make the significant investments.

Now I'd like to turn to the cyber area, and let me start with questions for Mr. Cheng, and then if others have comments on it, please add.

Having heard your caution about being careful in assessing others'intent, I still want to ask the question about what is it China intends and what is its ability to conduct both peacetime and wartime cyber operations against U.S. satellites and/or U.S. ground-based facilities that interact with the satellites?

And the second part of that, Mr. Cheng, is in light of the recent cyber attack on U.S. weather satellites linked to China, what are the implications of relying on Chinese weather data for our U.S. security?

MR. CHENG: Well, let me begin by further caveating the caveats. Most importantly, of course, is the issue of attribution. The world of cyber is extraordinarily dark and murky. Even if you have IP addresses that pop up in China, whether that was where things actually came from is never clear.

However, it is noteworthy here that I believe that a number of sources have attributed the cyber attacks on satellite systems to China so working on the assumption that those attributions are, in fact, accurate, with that caveat, why would the Chinese be doing something like that? What is

the significance of this?

Several things. To begin with, as the Chinese note, cyber actions, things like that, are something that you need to do in peacetime simply to build up your what might be called a cybernetic or electronic order of battle.

Here the Chinese are not unique. Pretty much a roster of major cyber powers, including the United States, Israel, Great Britain, Russia, all do similar sorts of things. This is, in fact, one of those de facto norms, that people are able to go rummaging around in other people's computer networks. What you can't do or you're not supposed to do is destroy things.

So far most countries have held to that. In wartime, of course, the purpose of this is to impose delay and confusion. Interestingly, part of the Chinese concept of information operations is it divides into three parts: electronic warfare; computer network warfare; but also psychological warfare, psychological in the sense that if decision-makers don't trust the data that is coming across or if they are delayed in decision-making, this has as much effect or can have as much effect as putting a JDAM on a command post or a strategic backhoe again breaking the communications, the physical communications links.

With regards to weather satellites, one of the things we forget is how important weather actually is for the conduct of military operations. A very quick example here is D-Day. For three years, for two years prior to D-Day, we, the Allies, and the Germans waged a "weather war" in the North Atlantic. We scooped up every German weather station, weather ship, sank as many submarines as we could, to prevent them from stationing boats off of Newfoundland and Greenland and establishing stations.

One of the few German forces ever captured in North America, in fact, was a German weather team captured, I believe, in Canada, where because the weather in Europe begins over North America.

We deleted their systems. They could not affect ours, and so late in the evening of June 5, Eisenhower's meteorological officer came to him and said, "Sir, we have about an 18-hour window tomorrow we can try to put the forces ashore." The Germans meanwhile, without that data, were confident that the terrible weather that they had already seen would continue, so much of the German high command ironically went to war games to practice against a possible invasion, probably at the next full moon. June 6, 1944 comes along, and, of course, we all know what happened after that.

The hundred miles of water between China and Taiwan are some of the worst water in the world. Weather for an amphibious invasion is essential--good weather information. Our ability to respond quickly will, in fact, be affected by our access to good weather data. It would be a real scary thought of the Chinese knowing what the weather will look like over the Taiwan Straits over the next 24, 48, 72 hours, and us, courtesy of cyber and other things, no debris, no damage, not even norms being necessarily affected because how would you know and when would you find out, but if we kept our forces away from the area because we thought, well, this is not a time when they would invade.

The Gulf War, other wars have, again, demonstrated the importance of weather information, and again psychologically speaking, the fact that we found out about this raises questions even now about how good is our data and how good will it be, and that is part and parcel of winning information dominance.

COMMISSIONER TOBIN: Thank you.

HEARING CO-CHAIR FIEDLER: Commissioner--

COMMISSIONER TOBIN: Yes?

MR. POLLPETER: Oh, sorry. Excuse me. Yeah, I'll just chime in to say that the Chinese are ebullient over cyber warfare. They view this as the new face of war that can change warfare as we know it, and this is one of the reasons why they're investing so heavily in it.

I think that Chinese cyber operations provide them a couple of advantages. One is the intelligence gathering, and that in peacetime they can gather intelligence on the way our satellites operate. They can gather intelligence on what our satellites may be collecting on. They could gather intelligence on vulnerabilities within our system.

In peacetime, if they can get in, the concern is if they can get into our systems during peacetime, they could upload what is called the Trojan horse that at some time later on during wartime that could be activated, that then could somehow interfere with or disrupt the operation of our satellites, and I think this is the big concern, that if they can get in just to do reconnaissance or intelligence gathering, they can get in to actually do some real damage.

And the concern here then is, as Dean said, it could be simple things like turning the satellite around, but the problem is the ambiguity of the effect. Is it just the satellite is malfunctioning and we need to repair it, or is it a hacking problem, and the two different occurrences could require different types of responses, and we wouldn't know. If we think it's just a malfunction, we could try to repair the satellite when, in fact, it's been hacked into and we couldn't repair it or it would take longer to repair.

The concern here again is China's the home team. We're the away team. We need to flow forces over to the Pacific. So even if a cyber attack, whether it's against satellites or logistics or what have you, it's not that maybe so much that they could knock out our entire system and the lights go dark, iis can they delay our forces long enough that they can achieve the initiative to seize Taiwan or seize some islands in the South China Sea?

So it's not an all or nothing. It may be just how much can they gunk up the U.S. military so that they can't get there, as somebody once-- "soonest with the mostest."

COMMISSIONER TOBIN: My question time has elapsed, but if we have a second round, I'd love to hear your thoughts, Doctor.

HEARING CO-CHAIR FIEDLER: We are likely to have a second round.

Commissioner Slane.

COMMISSIONER SLANE: Mr. Pollpeter, thank you for coming all the way from San Diego, and I hope you enjoyed the snow yesterday.

My question involves funding, and, as you know, NASA's budget has been cut substantially, and it just seems to me that we're shooting ourselves in the foot here, and I'm wondering what you're experiencing on your grant applications at the University of California? Have they--are they more difficult to obtain? Are they declining? Can you address that?

And if others have any thoughts on that, I'd be interested to hear it.

MR. POLLPETER: Well, a chance to market is always good.

[Laughter.]

MR. POLLPETER: Thank you, Commissioner Slane.

I can't speak to the UC-San Diego as a whole. I can speak to our institute, the Institute on Global Conflict and Cooperation, and I know that funding, as many people here in D.C. will tell you, is getting harder to come by. It's becoming more difficult, and many of us are spending more and more time just trying to do business development activities rather than actually doing the research that we all value.

But as a whole, I would say getting back to the funding for China's space program, China benefits from their economy actually doing very well. The space program has been a beneficiary

of that. But I would also say that they have top leadership support for their space program, which translates into more funding.

If you look at the current President Xi Jinping, he's met with the Shenzhou astronauts, he's gone to congratulate China's Lunar Exploration Program, so they have top leadership support. They have adequate funding, some would say very significant funding, and also they are able to program their activities out into five-year plans and to 15-year plans, and this gives them a long-range goal that they have to work towards.

So all of these factors are very important in how China has been able to succeed, but funding sort of provides the foundation for why China has been able to succeed so well in space.

DR. JOHNSON-FREESE: I'm glad you're asking about funding in that I think in the United States part of our problem has been that we have had goals that are not matched by funding to achieve those goals, and I think that puts us in a very precarious situation of again creating this image of not having political will.

I've said before, I think what China has that the United States doesn't have, at least in its manned program, is political will. The United States, we have seen since the Apollo years, the American public is very supportive of space, but when you ask it to rank space as a priority when it comes to funding, it goes to the bottom of the list.

If it's a question of defense, roads, education, health care or space exploration, unfortunately space exploration does not get the same kind of support, and that has--when you start within a program like Apollo, that sets your bar very high for the space spectaculars that will keep the public's attention.

China right now is experiencing its Apollo years. It has an aggressive and very ambitious manned program and a lunar program, which is under discussion right now for potentially combining it into a manned lunar program. Interestingly enough, I've had discussions in China where I've had people ask me what does NASA do to convince its politicians to keep up its funding? So I would say that support is not without political basis for continuation. They have their issues as well.

But right now because it is getting successes, it is getting international recognition, it is getting a significant amount of regional techno-nationalist credibility for China and legitimacy for the Party, China gets the funding it needs. I think what the United States needs to do is settle on a goal and get adequate funding to achieve that goal rather than setting goals and then getting budgets that immediately put it in a precarious situation.

MR. CHENG: I would break your question up into two parts, sir. One is space funding and one is China funding. Let me note here the Heritage Foundation does not take any government money; we don't do any contracts, et cetera. So this is without prospect for Heritage gain.

With regards to the space sector, I agree with Joan's comments. We fail in terms of long-term planning. We fail to stick-to-itiveness. Norm Augustine's famous observations regarding the Constellation Program of a few years back--"there ain't no way to get from here to there." And funding-wise, that's absolutely true.

I would suggest that the private sector, and here the Obama administration should be praised for this, the willingness to rely more on the private sector has opened up opportunities for folks like SpaceX, and the reality is SpaceX, Virgin Galactic, others, are far less bureaucratic than NASA, which is not to say NASA's funding should be cut but rather a multitude of approaches. If that's good for China, it's certainly good for the United States.

I would note here, however, from where I'm sitting, the key issue of funding is on that of

China analysis. There are simply not enough China analysts. There are not enough of them. You have at this table a goodly proportion of the open source public folks who think about China's space program.

There's probably a number in the intelligence community, but I would suggest that you could, you know, bring everybody into this room and still have plenty of room to spare even if everyone sat down. China linguists, Chinese linguistics. The Chinese rightfully say "We are transparent; we publish lots of stuff. You can't surely ask us to then translate it for you and serve to you on a silver platter with a cherry on top." Not an unreasonable position on their part.

The number of people who are language proficient, oriented towards China in terms of on this set of subjects, is tiny. The reality is, however, that our academic institutions send students into areas where there's a future, and that means money, and that means grants, and that means, you know, opportunities to obtain funding, and that is limited.

COMMISSIONER SLANE: Thank you.

HEARING CO-CHAIR FIEDLER: Commissioner Shea.

VICE CHAIRMAN SHEA: Well, thank you for being here.

This has really been very, very interesting. I'd initially created a question around the dialogue/cooperation debate, but I won't hit that horse too hard again. But you, Dr. Johnson-Freese, mentioned it in an answer to a question, the fact that the U.S. government, U.S. Space Command, I believe, notifies China when the debris that China created might be on its way to hitting a Chinese satellite so move it.

Now that to me is a level of significant cooperation. Of course, we have a self-interest because we don't want to create more debris in space, but to me this is a, you know, real, a good example of cooperation, good neighborliness in space. Have we gotten anything out of that other than a thank you?

DR. JOHNSON-FREESE: What we got out of it is not more debris. Again, I think your question is exactly on point of self-interest. Identifying areas of self-interest is my idea of cooperation. You know, I'm not saying we need to build a space station together. I'm saying in areas where there is self-interest such as not creating more debris and therefore protecting the space environment, the sustainability of the environment, which we all rely on, that those are areas. There are areas, such areas, where we should deal more with China.

What we get back from, do we get a big thank-you back from them, not that I know of. I don't know. Perhaps Kevin or Dean has read something to that regard. What I think you get, though, is a recognition, what I think there is, is a recognition in China of we don't want to put ourselves in this situation again.

There was a meeting of the Debris Coordinating Committee that was scheduled to be held in China the same month as they conducted their ASAT test. They not surprisingly canceled that meeting given the international, the rightful international condemnation that they were receiving. But they have since worked very closely with this organization, and, in fact, the IADC put out a report last year that talked about the space debris issue and the need to address that issue, and that issue cannot be addressed on a national level.

There are legal issues, there are technical issues, there are political issues dealing with space debris that require that it be done on a multilateral basis, and the Chinese, the consensus report that was put out by the IADC, including countries Russia, the Ukraine, the United States, China, not exactly a group of countries which you would expect to agree with each other, talked about the dangers of the space debris issue and the need to work on it together. So that is where I would put self-interest, and that's where I see the potential for work being done.

VICE CHAIRMAN SHEA: Do you have anything else to add, Mr. Cheng? I have another question as well.

MR. CHENG: I believe that, in fact, we have now moved the ball massively forward because now the Chinese apparently acknowledge receipt of the data.

VICE CHAIRMAN SHEA: Okay.

MR. CHENG: No. This is from Air Force Space Command that they finally now have a specific e-mail--

VICE CHAIRMAN SHEA: They didn't want it to go through the U.S. State Department. They recently requested that the information not go through the U.S. State Department--

MR. CHENG: Correct.

VICE CHAIRMAN SHEA: --but go directly to--

MR. CHENG: And now the Chinese have been forthcoming enough to actually give us an e-mail/contact point for this.

VICE CHAIRMAN SHEA: That's wonderful. Thanks. Great to hear that.

Dr. Johnson-Freese, you mentioned that China does not have an approved human lunar space flight program. Do we actually know that? Do you actually know that? Is this one of those unknowables or known unknowns or whatever Rumsfeld used to say?

DR. JOHNSON-FREESE: We know they have the manned Shenzhou program. We know they have that. They have laid out a three-step plan. They are following that plan. They've been relatively, relatively transparent about that plan because they want publicity, and the only way you can get publicity is to let people know what you're doing.

They have the lunar program, the Chang'e program, which they've also been relatively transparent about, again, because they want the publicity. When they had the Jade Rabbit rover die and personified and reborn again several times, they got a lot of international publicity from that.

We also know they are funded by different organizations. They are not, it's not as though their space agency, or what that is, funds both of them. They are separately funded.

We know that they are in talks considering combining the two into a human space flight program, but they, I don't think they will do that until they, number one, complete all three steps of their manned program, which includes a large space station.

VICE CHAIRMAN SHEA: Well, this is the issue of transparency. They may have an approved human--

DR. JOHNSON-FREESE: No.

VICE CHAIRMAN SHEA: --but we just don't know it. I mean--

DR. JOHNSON-FREESE: There is no--I, I think we know that they have not approved it as yet.

VICE CHAIRMAN SHEA: We do know that. Okay. Yes.

MR. POLLPETER: Yes, sir. The Chinese officials have only stated they are conducting feasibility studies at the moment. They have not actually stated that they have approved a manned lunar program.

VICE CHAIRMAN SHEA: Right. That's my point about transparent--we know that they've stated that, but we don't really know the reality, what's behind the public statements; correct?

MR. CHENG: They have given no confirmation.

VICE CHAIRMAN SHEA: Okay.

MR. CHENG: Either way. Yes, sir.

VICE CHAIRMAN SHEA: Okay. Thank you.

HEARING CO-CHAIR FIEDLER: Commissioner Bartholomew.

COMMISSIONER BARTHOLOMEW: Thank you very much, and thank you to all of our witnesses.

One of the hazards of coming at the very end is a lot of the questions have been asked and there's all sorts of other issues that come up, but I wanted to start by thanking you all, to acknowledging for our chairman and vice chairman the wonderful thing that we've got somebody from the California system here, and that we're tapping into the resources of the California system.

I also wanted to wish everybody a happy new year, the happy Year of the Sheep or the Goat, I guess, depending on how you translate that.

Dean, a quick question. You made reference to a Chinese general speaking at Davos. Yes?

MR. CHENG: Yes, ma'am.

COMMISSIONER BARTHOLOMEW: So I just have to point out the irony that, you know, some high-ranking person in the Chinese Communist Party is hanging out at Davos is just to me really ironic.

MR. CHENG: Yes, ma'am. She is, however, one of the most extraordinary of people. She was the Party representative for the Academy of Military Sciences, their Congress. She has been rated one of the top ten most powerful women in China, and she is also a noted I don't think it's derogatory to call her a "barbarian handler."

She was educated, I believe, at the London either School of Economics or School of Oriental and Asian Studies and spent a year at Harvard.

COMMISSIONER BARTHOLOMEW: Still the irony of--

MR. CHENG: Yes.

COMMISSIONER BARTHOLOMEW: --people of the Chinese Communist Party hanging out in the bastion of capitalism is just can't go unnoted.

Okay. Dr. Johnson-Freese, but for all of you, particularly, you as a political scientist, as I was listening, I just kept thinking of the totality of the circumstances here. You focus on space. You all focus on space, but I think some of the skepticism that you're hearing comes from looking at the broader range of issues where China could have been a responsible stakeholder, to use Mr. Zoellick's term, but has not exactly done so.

So the concept of international norms and what that means as China comes in, the different interpretation we might have of what international norms are and should be and their interpretation, you know, if you look at China's record on trade issues, for example, or its assertiveness or aggressiveness in the South China Sea, in the East China Sea, there are just a lot of questions I think. So it's difficult to look at these issues just in the context of these issues.

But I want to ask a broader question actually of all of you, which is should there be some cost or any cost when a government represses its own people because that's some of the issues that certainly you see members of Congress trying to grapple with?

I mean, you know, the Chinese government has run over with tanks peacefully protesting young people. It imprisons people who disagree with it. It imprisons people who organize. It imprisons people who are trying to freely worship. And I just wondered, for each of you, do you think that there should be some cost for a government that's doing that? Nobody stepping up to answer.

DR. JOHNSON-FREESE: That's a very difficult question obviously. I think--I've had

many discussions about human rights with individuals in China. I've had the same discussions with people all over the world, and I think we all agree that human rights are to be protected.

I have often been called hypocritical in China for discussing human rights when they say they talk about our death penalty and that we have a high population of incarceration with racial overtones.

I'm not saying that the argument is right; I'm saying that trying to argue human rights in other countries can put you in a situation, can immediately, has put me in a situation as being seen as hypocritical. So I'm not sure trying to link them at the foreign policy level has ever been particularly successful, I mean trying to link big issues like human rights, freedom of religion in authoritarian countries.

We tried it with the Soviet Union. It didn't work. Actually it was even involving space. Perhaps if we do cooperation in space, they will change their Communist ideology. It didn't work. I don't think linking human rights to space issues is going to prove particularly fruitful.

COMMISSIONER BARTHOLOMEW: Dean.

MR. CHENG: I think, as you said, there are larger issues involved, and I think here the key question, it breaks into two parts. On the one hand, it is inevitable for all politics to have to balance what are our goals, what happens when the goals are not necessarily mutually supporting but may be contradictory, China being the number two economy, China being a cyber player, et cetera?

But I think that what the human rights issue goes to is a very fundamental question that we have not asked sufficiently, which is what norms are we going to hold China to at all? Human rights, well, you know, it's a really big problem, and I agree with Joan, you know, you get awkward questions in response. Okay. Maybe not human rights.

Maritime, Law of the Sea? Well, but you didn't sign the Law of the Sea Agreement. Well, the Philippines did, and they took them to court and the Chinese told them to basically go bugger off.

Well, WTO? Well, you know, they are the number--I mean eventually, yeah, we come to the conclusion that really China is such a big player that they should be able to set their own norms, and if they violate those norms, then we still shouldn't be so rude as to call attention to this.

At some point, two things come to mind. One, what norms will we hold China to? And two, what norms do we care about? And maybe in some cases, human rights won't be the most important thing--maybe. But I sure as heck hope that it's worth it to us if we decide that our principles on those issues need to take a back seat. Maybe it should be on--higher priority should be on strategic dialogue because China has nuclear weapons. How many? We can guess, again, on the transparency issue.

Maybe we should ask them, you know, we'll lay off on human rights if you'll just tell us how much you spend on space, a number that no one, I believe, at this table has any confidence in providing, a broad one umbrella figure, how much do you spend?

So where do we draw the line? Which norms do we think that we should try and hold China to when they really want to be able to say we'll determine our norms, and you should just go away?

COMMISSIONER BARTHOLOMEW: Mr. Pollpeter?

MR. POLLPETER: I would just say it's building on what Dean had said and also what Joan had said, that we should hold China to some sort of standards on human rights, and we should hold them accountable to that. How we do that may be different according to each

situation and each venue.

I would also caution, though, in my discussions with especially Chinese young people, of whom there are many on the UC-San Diego campus, is that often our attempts to tell China how to act on human rights sometimes backfires, and they may fully understand living here in the U.S. how it is to live in a free country, but they may not necessarily want another country beating them over the head about human rights.

And so we have to do it in a way that is productive and gets our message across, let us stand up as the leader of democracy in the free world but, on the other hand, don't alienate the people that we are trying to do good for.

DR. JOHNSON-FREESE: May I add? I recently had the opportunity last November to give several lectures at a Chinese law school, and I've been a judge in some of their moot court competitions, and we have I think it's 200 law schools in the United States; they have 2,000. That could be good for us.

But my point is that the Chinese law school students are, they come the closest to the Western-style education of questioning and questioning and dealing with these really tough questions like human rights and norms and laws. I think it's good for us to have this growing cadre of Chinese to be able to speak to and even have a common language of what is a norm and what does it mean.

It's also interesting that these very much more assertive in their inquisitiveness students has become such an issue or a concern to the Chinese that as of last year, all Chinese lawyers have to join the Communist Party because I think it's actually, it's kind of a freedom of thought that will, in another five or ten years perhaps we'll see a different attitude among at least some of the younger generation because, as Kevin said, beating them over the head with human rights issues does not serve us well, but perhaps having more of the Chinese, more of the Chinese population familiar with the obligations and responsibilities of norms will have an impact.

COMMISSIONER BARTHOLOMEW: Well, on that, I would just note, of course, that the Chinese government is cracking down on those very ideas in Chinese universities and in the nonprofit sector so.

Thank you very much.

HEARING CO-CHAIR FIEDLER: Or jailing more lawyers than they have in the last four or five years.

I want to change the subject just a little bit. Anybody have any knowledge of any space-related people getting caught up in the anti-corruption campaign at all?

MR. CHENG: No.

HEARING CO-CHAIR FIEDLER: So it's--

MR. POLLPETER: I would say no. The only thing I would add is, is that there was an article in China Space News where auditors had come down and had audited the China Aerospace Science and Technology Corporation, and they got a clean bill of health.

HEARING CO-CHAIR FIEDLER: Okay.

MR. POLLPETER: But I haven't seen anybody being caught up in it.

HEARING CO-CHAIR FIEDLER: So we have a long and checkered history of mil-to-mil exchanges, arguably not particularly productive from our point of view. What knowledge do any of you have about space being part of the content of any military-to-military exchange given the fact that Chinese space seems to be significantly military oriented?

I don't think Mr. Wolf's or the law that was passed inhibits mil-to-mil exchanges on space; does it?

MR. CHENG: No, but the FY2000 National Defense Authorization Act prohibitions, I believe, did include space items that were supposed to be off limits. I don't have that in front of me, but it delineated ten items, and I think space may have been included in that.

HEARING CO-CHAIR FIEDLER: On the mil-to-mil exchange?

MR. CHENG: The restrictions that were in place, there were ten areas on mil-mil exchanges that were limited, and I believe one of them was space.

HEARING CO-CHAIR FIEDLER: One of them was space.

MR. CHENG: Yes.

HEARING CO-CHAIR FIEDLER: The Chinese student population in the United States and its space orientation, are we educating a great many of their scientists?

MR. CHENG: Well I believe that you'll find lots of Chinese students at MIT, Caltech, Berkeley, et cetera, but how many of them are in which departments, I'm not sure we have that data in front of--

HEARING CO-CHAIR FIEDLER: We--really? We don't know?

MR. CHENG: Well, somebody may be tracking it. I'm saying, sir, I don't have that data.

HEARING CO-CHAIR FIEDLER: But you guys don't--

MR. CHENG: Yes.

HEARING CO-CHAIR FIEDLER: --look to see? So, we, in fact, may be significantly assisting scientifically their--

DR. JOHNSON-FREESE: There's been a long problem in the STEM fields generally of attracting more foreign students than American students. So I think we can certainly say that there are a number of them. I don't know the exact number.

HEARING CO-CHAIR FIEDLER: The Chinese espionage vis-a-vis space is significant or insignificant--public knowledge? I'm not asking for classified.

DR. JOHNSON-FREESE: From the student population or just in general?

HEARING CO-CHAIR FIEDLER: No, no. Totally different question. Are they stealing our stuff?

DR. JOHNSON-FREESE: Well, the Chinese have a very active open source, far more active than we do open source collection that they get a great deal out of our--

HEARING CO-CHAIR FIEDLER: I'm not talking about open source. That's not stealing. If it's open, it's not stealing. I'm talking about espionage.

MR. CHENG: I think, sir, it would be safe to say that anything on a computer somewhere if it's hooked in probably has somebody from the PRC rummaging through it. That certainly is the impression we get in terms of open source coverage, and given the importance of space as what the Chinese term a dense collection of technologies, advanced materials, communications, power, energy, et cetera, even if they aren't breaking into the systems, the subsystems, the componentry likely is an area that is subject.

But whether that's a higher or lower priority than information technology, cyber, et cetera, I mean the Chinese are engaging in espionage for agricultural items. There was a report last year that several Chinese scientists were stopped at the Des Moines International Airport with seedlings in their suitcases that they had dug up.

HEARING CO-CHAIR FIEDLER: If I was responsible for a 1.3 billion people, I'd be worried about food, too.

MR. CHENG: Yes.

HEARING CO-CHAIR FIEDLER: The question of redundancy in our space satellites, we have 500 and something space satellites. They have a hundred and something. Numbers, I

mean I learned long ago from Robert McNamara that numbers mean nothing. I learned it the hard way. And so the--do we have redundant systems that make our satellite capabilities less vulnerable than theirs because they have fewer?

Do we have to take out as many as they have to take out of ours?

MR. CHENG: Sir, part of the problem, and Kevin alluded to this earlier--sorry--Mr. Pollpeter alluded to this earlier--

[Laughter.]

MR. CHENG: --is the reality that we are playing an away game, and they are playing a home game. So if we swept China's satellites completely out of the sky, which would be quite a feat, the fact that we would be operating on behalf of Taiwan, on behalf of Japan over the Senkakus in the South China Sea, means that they can rely on aircraft, fishing boats, prelaid sonar arrays, UAVs, aerostats--

HEARING CO-CHAIR FIEDLER: No, no. I understand.

MR. CHENG: Yes, sir. But so whether or not they don't need satellites to do most of their things, we do. So that fundamental asymmetry.

HEARING CO-CHAIR FIEDLER: Which is why they are asymmetric thinking--

MR. CHENG: Yes.

HEARING CO-CHAIR FIEDLER: --given our dominance--not dominance, our--

MR. CHENG: Right.

HEARING CO-CHAIR FIEDLER: --greater advances. I don't even want to use the term "superiority" because I'm not sure what superiority means with a the level of vulnerability that exists in space.

Senator Talent has another question.

HEARING CO-CHAIR TALENT: Yeah, a quick follow-up on our inevitability discussion before. And I just thought I'd throw this out to you because the Soviets have also been mentioned. Well, in the '40s and '50s, we sort of diagnosed what the Soviets were up to, developed the doctrine behind a policy, containment, whatever you want to call it, built a national security architecture, assembled allies, and a lot of people thought war with the Soviets was inevitable. It never happened.

We had obviously ups and downs and other issues, some other wars. I mean is there any reason we can't affect the Chinese strategic thinking by simply responding in such a way that--not simply, I know it's difficult--but by responding in such a way that changes their calculus about the benefit to them vis-a-vis the cost of trying to dominate space?

I mean is there reason, at least in principle, that we couldn't do that?

DR. JOHNSON-FREESE: I don't think so. I think that's exactly what all of our space policies have been set up to do, and I think we set up that deterrence that I think you've described using a multiplicity of tools, and I think technology is one of them, and that counterspace technology will be part of that.

But I think, again, there are other aspects as well that get into the resiliency, that get into the STEM fields, that get into staying ahead with our own space activities, and that get into the kind of the dialogue that I've been suggesting that gets into discussion of norms, a code, a code that the Chinese may or may not abide by, but we do know that they want to at least present a face of being a responsible spacefaring nation, and they've been not a proponent of this code of conduct because they have, of course, been advocating a treaty which the United States has not been in favor of.

So I think what you've described is what is described in the space policies and what we

ought to be pursuing: a multi-pronged approach to making a cost-benefit analysis by the Chinese too costly to pursue.

MR. CHENG: I would somewhat disagree here. I would agree that we are affecting the Chinese--our space policies, our space strategies, but more to the point is everything we do affects--I don't think that we are going to affect the Chinese on space because we are frankly reliant on space.

So if we really want to affect the Chinese with regards to space, then, in that case, us moving away from space towards terrestrial aerostats, et cetera, would do more to affect China's investment because the Chinese aren't stupid. If we don't rely on space, then it's not an especial vulnerability.

But to take you a step back, everything we do does affect China already. The problem is it often doesn't affect China the way we want it to. So sequestration was not about the Chinese, but when aircraft aren't flying, ships are tied up, we reduce our exercise levels throughout the world, the Chinese see that, and they factor that into their calculations.

When we draw red lines and then declare that they're not really red, they're kind of a light pink, and we don't really mean to hold by them, then people start asking the question whether Crimea is really Russian for South China Sea or whether Syria is, you know, Arabic for South China Sea?

So our actions do affect things, and conversely when we launch a new aircraft carrier, when we develop new capabilities, when the X-37 takes flight or the X-47 lands on an aircraft carrier, the Chinese factor that in as well. Our statements, our declarations, they're all factored in.

But the outcome, it's a black box. What comes out the other side may or may not be what we intended, and as often as not, it may be a completely different interpretation of what it was that we did.

HEARING CO-CHAIR TALENT: Yes. As I've often said with regard to sequester, one of the--and you know my position on that, Dean, but one of the problems is that other governments and other people take what our government does seriously even if the American people often don't, in other words. They're drawing conclusions about things that happen here for domestic political reasons, but they're assuming that it's a reflection on, you know, our resolution or strategic thinking, et cetera.

So I wanted to bring it up because I don't think there's anything inevitable about this. I think it's a question of how we respond, and I would agree, Dr. Johnson-Freese, to be a multi-channel response. I'm not sure I agree that cooperation right now is the way to send the right signal to the Chinese, but thank you.

HEARING CO-CHAIR FIEDLER: Commissioner Wessel.

COMMISSIONER WESSEL: Let's also just differentiate cooperation and dialogue. No one is saying we that we shouldn't engage in talks. I think the question is when I view cooperation, it also has a modicum of assistance, of helping them along rather than just saying here's our views, what are your views, how do we rationalize the two? But let me step away from that.

The title of this panel is "China's Civilian/Dual-Use and Military Space Program." And I've read through your testimony, but help us along, help me along. Is there any truly civilian space entity in China? How has the development of their industry advanced, and how would you compare in a very short way their capabilities and how far they're moving and at what pace and how you rate ours?

Do we have declining returns so that they are catching up? Give us some idea of where they are in the sort of the spectrum, and each of the panelists if you could?

MR. POLLPETER: I would say I don't think there's any truly civilian organization that is involved with space because they are all feeding into China's military space program because it is inherently civil, civilian and military. So, for example, our U.S. military may operate its own meteorological satellites, but the Chinese meteorological satellites are both for civilian and military use.

COMMISSIONER WESSEL: So, for example, China telecom, we have some that are truly just civilian, as I understand it, not that they couldn't be repositioned or rechartered, if you will. Do they have anything that's truly civilian in that sense?

MR. POLLPETER: There are satellites that are owned by a Chinese company in Hong Kong. Whether those are purely civilian, it looks like some of them are mainly used for civilian, but whether they could be used by the military in a crisis--

COMMISSIONER WESSEL: Repurposed.

MR. POLLPETER: --during peacetime, they appear to be purely civilian.

COMMISSIONER WESSEL: Okay. Others?

DR. JOHNSON-FREESE: I agree. I think basically China takes the approach that this is dual-use technology, why would we bifurcate it and spend more money than we need to. In fact, they specifically see benefits of taking any new piece of technology and examining it for how can it be used for dual use for efficiency purposes.

So I think it's pretty safe to say everything has a government finger in it at some point.

COMMISSIONER WESSEL: Okay.

MR. CHENG: I think it goes beyond the government though. If we look at, for example, China National Space Administration, which is nominally the counterpart to NASA, it's a third-tier entity. The head of CNSA is listed in protocol-wise first as the Vice Minister for the Ministry of Industry and Information--of Information, Industry--Industry and Information Technology, MIIT. Second, he is one of the deputy heads of the State Administration for Science, Technology and Industry for National Defense, which runs their arms industry. And only third is he the head of their National Space Agency.

Commissioner Bolden met with the China Manned Space Engineering Office because that's actually higher up, but the head of CMSEO is one of the members of the General Armaments Department, a uniformed military officer.

With regards to China's space industry, I think one of the important things here to keep in mind is demographics. The Russian space industry is dying. Their people, you know, Russian life expectancy is unique in that it's dropping. It's not only dropping between generations, it's dropping within cohorts, meaning your older brother will actually live longer than you will. I believe that's Nicholas Eberstadt's conclusion.

The American space industrial complex is aging. We get sometime infusions, every so often, going to Pluto, I think, is going to probably excite some people to go into the space industrial sector, but, you know, China's space industrial workforce is perhaps the youngest of the major space powers. They will be working at this for a long time.

Innovation at the end of the day, present company, of course, excepted, tends to come from younger people, and the reality is that China is going to have, while their overall population is aging, within that workforce, it will stay younger certainly than the Russians and probably younger than ours.

COMMISSIONER WESSEL: Thank you.

HEARING CO-CHAIR FIEDLER: Commissioner Tobin.

COMMISSIONER TOBIN: Great. A quick technical question that concerns me. Mr. Pollpeter, you mentioned in your oral testimony, you talked about the 35 satellites for the Beidou system, and then said our system, GPS, has a very weak signal. To your knowledge, are we doing anything specifically to improve its strength or do you recommend anything specifically in terms of staying competitive?

MR. POLLPETER: I think the fact that the GPS is a weak signal is sort of the nature of the beast. All satellite navigation signals will probably be very weak and are very easy to jam.

So jamming will be very easy. We have an encrypted code that the military uses. China also has a military code which prevents hacking into it, but the prospect of jamming will always be there.

COMMISSIONER TOBIN: Okay. Thank you.

And it's no more weak in signaling than their system?

MR. POLLPETER: Correct, ma'am.

COMMISSIONER TOBIN: Okay. Thank you.

Now, my policy question; all of you have spoken about STEM, and everybody in this room knows the importance of our country moving forward in that area, but you're the space experts on China, as you said, Mr. Cheng; given what you know, what specifically should we recommend to Congress? What would you recommend we do that relates to the space needs, the interests that you described, Doctor, what should we be recommending specifically?

MR. CHENG: Money. I mean at the end of the day, you know--

COMMISSIONER TOBIN: Through NSF or direct to the universities?

MR. CHENG: University grants, but, you know, you really want to capture younger folks, and so, you know, sponsoring the equivalent of the X Prize but for younger people.

I was fortunate enough to attend what's sometimes called the "Space Ball." It's basically folks who are from the space industry, and they brought in a young man, he was, I think, around 25, 26 years old, and you could just feel the excitement coming off him, and he was talking about going back to his high school, and, you know, when he was in grad school, and just corralling a bunch of folks to go do rocketry out on the beaches and how that just excited the kids that are his younger siblings, this age.

That's the kind of thing. It doesn't take a lot of money in the aggregate, but it is the kind of thing that, you know, by the time you're in college and grad school, if you haven't been prepared in math and science, that's not your pathway.

COMMISSIONER TOBIN: Right.

MR. CHENG: But if you can get younger folks in elementary and high school the equivalent of the old Westinghouse Prize, but that's one prize. I think it's now called the Intel Prize.

COMMISSIONER TOBIN: Right.

MR. CHENG: But, you know, a proliferation, and this is an area where I think that the Elon Musks and the Jeff Bezoses would be more than happy to partner with.

COMMISSIONER TOBIN: Good point.

MR. CHENG: Because if they want to--Elon Musk says he wants to be buried on Mars. If he wants to do that, I think that, you know, a low level investment on his part, again, a government-private partnership--

COMMISSIONER TOBIN: That's great.

MR. CHENG: --is likely to generate that kind of effect.

COMMISSIONER TOBIN: Let me hear from the others. Doctor?

DR. JOHNSON-FREESE: Reliable money.

COMMISSIONER TOBIN: Yeah.

DR. JOHNSON-FREESE: Part of the problem is anyone going into a doctoral program in astrophysics or something thereabouts, in a 20- or 30-year career, they might be, they might have two satellites or two programs to work on. You don't go into a doctoral career if you don't know that you can fly your experiment, and when there is money for satellites that gets canceled, and your entire work goes down the drain, it's not motivating for students.

So I know the National Academy of Sciences has done multiple studies. Their Decadal Studies talk about we need to have a plan that we can stick to so that people coming into these STEM careers know they have a future, so that they know that they can have a career where they can fly their experiments, where they can get their science returns.

But what we have now is we have these Decadal Studies that lay out here's the program we're going to have, but unfortunately so many of them get canceled, that the students who might want to go into those aren't motivated, and they need a career, and they go elsewhere.

COMMISSIONER TOBIN: Thank you.

MR. POLLPETER: I would just agree with the other two panelists. That sort of occurs on both ends, one on the lower-level education, one on the higher-level education. What Joan has said is exactly right, is that we need, we need more research funding for space to keep the people in graduate schools working towards their Ph.D.s or have post-docs to keep them involved with space and innovating in new space technologies.

The other side, though, is really more difficult, and that's how do we make science and technology more attractive to young people? In a previous occupation, I I was responsible for managing 20-plus China analysts, and there are a number of China analysts who I hired who had an interest in science but couldn't break the math barrier, and at some point, math just becomes too difficult, and so they start studying Chinese if that's not difficult enough.

[Laughter.]

MR. POLLPETER: But there has to be a way within elementary school and high school to make math interesting, to make science interesting, to make it easier to learn, and whether it's creating competitions like Dean has said or changing somehow the way that we teach math and science in high school I think is critically fundamental to our country.

COMMISSIONER TOBIN: Thank you.

HEARING CO-CHAIR FIEDLER: Commissioner--

COMMISSIONER BARTHOLOMEW: Just one comment on STEM, which is that I recently read somebody who was referring to STEAM rather than STEM, which is including arts back into the curriculum, and that might be one way to get people through the math barrier and interested in science more.

COMMISSIONER WESSEL: Governor Walker.

[Laughter.]

HEARING CO-CHAIR FIEDLER: Commissioner Shea will have the final question.

VICE CHAIRMAN SHEA: Just a question. I think this is a topic we probably should touch upon. Dr. Johnson-Freese, you mentioned in your statement, you implied that Europeans are moving towards the Chinese as their primary ally in space activities, and I was wondering if all three, three witnesses, could comment on China-Europe-U.S. space relationship?

DR. JOHNSON-FREESE: My point that I was making was China, number one, is viewed as a huge market. So satellite industries, they are, the Europeans are very willing to work

with the Chinese. They advertise their satellites as ITAR-free, meaning you don't have to go through the U.S. regulation process, which they view as byzantine and restrictive and probably rightly so.

So there is that aspect. There is the market aspect. There is also this idea of, again, China has a three-step program for their manned space program. They've been implementing it. They are moving forward. They have their robotic lunar program. They will likely be doing at some point a manned lunar mission, and this gives the perception--and perception can be reality--that it's China that is becoming the space leader because the U.S. space program is floundering.

And in that regard, I think there is this idea of China is easier to work with. They are--it does China great PR advantage to offer opportunities for international cooperation. China was stung by not being included in the International Space Station so it has already made pronouncements that it will welcome the Europeans and others, other countries, especially developing countries, to their space station, and I think, again, it's this perception that China has the program that's ambitious and moving forward, and the U.S. is floundering, and they are willing to take advantage of that.

MR. POLLPETER: I would also add on to that that yes, this perception that China is the rising space power, that U.S. is stagnant or may be declining, incentivizes Europeans to want to cooperate with China, first at a more strategic level in that in an era where the U.S. is not cooperating with China, they can show that they are more friendly to China, and this, they hope, will increase the overall investment environment for Europeans in China.

On a more tactical level, they view this as a way to sell strategic or space technologies into China. Germany is involved with China in its space robotic arm program. University of Strathclyde in the UK is training Chinese engineers on rocket technology. The European Space Agency astronauts are now learning Chinese in case one day the Europeans will go onto the Chinese space station.

So as China's space program develops, increases in capabilities, it will give more opportunities for the Europeans to demonstrate that they may be more friendly to China than the U.S. is.

MR. CHENG: If we are lacking in China expertise, Europe is a desert. The number of China experts over there is tiny relative to the population, and with regards to space, it's even less so. So that being said, Europe keeps thinking that it will somehow be able to outmaneuver the Chinese. I would suggest that in the wake of the Galileo fiasco, the European navigation satellite system, where the Chinese were rudely shown the door after putting in their 150 million or so euros, that any expectation of massive cooperation is the height of optimism.

That being said, that didn't keep Jacques Dordain, the head of ESA, from suggesting major cooperation in manned space literally within two months of the ASAT test in 2007. I suspect that this is continuing the fine tradition of selling amphibious ships to Russia.

That being said, however, going back to the issue of human rights, it is noteworthy that efforts to lift the Tiananmen sanctions, which had been raised in various European quarters, have consistently been defeated at the national level.

VICE CHAIRMAN SHEA: Has any space-related article been withheld from China as a result of those Tiananmen-based restrictions from a European country? Has that been cited to withhold the sale of--

MR. CHENG: Sale of specifically military technologies have been--

VICE CHAIRMAN SHEA: Space-related?

MR. CHENG: I'm not sure about space related. That being said, however, the issue of

Surrey and other companies have engaged in space cooperation with the Chinese, which apparently did not violate any of the Tiananmen sanctions.

VICE CHAIRMAN SHEA: Thank you.

HEARING CO-CHAIR FIEDLER: Thank you very much. Right on time. We will reconvene at 10:50 with panel number two. Again, thank you very much.

PANEL II INTRODUCTION BY COMMISSIONER JEFFREY L. FIEDLER

HEARING CO-CHAIR FIEDLER: Our second panel will examine the research and development efforts behind China's civilian and military space programs. It will also explore the factors that have contributed to China's recent space technology advances.

I do want to remind our witnesses to please hold their remarks to seven minutes if possible so there is time for questions and answers.

Dr. Alanna Krolikowski--close? Good enough?

DR. KROLIKOWSKI: Krolikowski.

HEARING CO-CHAIR FIEDLER: --kowski--is a postdoctoral Princeton-Harvard China and World Fellow at Harvard University's Fairbank Center for Chinese Studies.

Her research focuses on China-U.S. relations in high-technology sectors, particularly in civil-commercial aircraft and spacecraft manufacture.

Mr. Tate Nurkin is the Managing Director of Thought Leadership--that sounds ominous--

[Laughter.]

HEARING CO-CHAIR FIEDLER: --for IHS's Aerospace, Defense and Security. His current research focuses on China's military modernization and the future of military and geopolitical competitions across the Western Pacific.

Among other topics, Mr. Nurkin also looks at emerging disruptive technologies and capabilities.

Mr. Mark Stokes is the Executive Director of Project 2049 Institute. A 20-year U.S. Air Force veteran, he previously served as Team Chief and Senior Country Director for China, Taiwan, and Mongolia in the Office of the Assistant Secretary of Defense for International Security Affairs.

Dr. Krolikowski, you start first please.

OPENING STATEMENT OF DR. ALANNA KROLIKOWSKI
PRINCETON-HARVARD CHINA AND THE WORLD FELLOW, FAIRBANK CENTER FOR CHINESE STUDIES, HARVARD UNIVERSITY

DR. KROLIKOWSKI: Senators, Chairman, Commissioners, good morning. I thank the Commission and its staff for the opportunity to testify today on the subject of inputs into China's space programs.

My remarks today are based on my academic research, much of it conducted in China and with Chinese sources. My work focuses on China's civil and commercial space activities, but most of my remarks today can extend to developments in China's space sector as a whole, including dual-use and defense-oriented space activities.

My testimony this morning comprises three points: first, the inputs into and factors behind advances in major Chinese space programs; second, the impact of U.S. policies on Chinese advances in space including, in particular, export controls; and third, the implications of this situation for U.S. interests and policy.

First, let me turn to inputs into China's space activities. The remarkable advances in Chinese space programs that we heard about in the preceding panel owe to three main factors: resources; vision; and volume.

The first input is resources, or money. Specific figures about China's public investment in space activities are scarce, as we heard, but it is apparent that China's major space programs today are funded reliably and predictably at levels suited to their objectives.

Scientists and engineers in these programs have the means to pursue their goals. China's central government, today wealthier than ever, seeks out science and technology projects that will yield high social returns to fund. This funding is a necessary condition for success in space activities but not a sufficient one.

For that, funding must be guided by a strategic vision. China's space programs are guided by such a vision – a vision at once ambitious and realistic. The programs to date have produced significant accomplishments, making China only the third country in history to achieve core capabilities in human space flight, for example.

Still, so far these programs have aimed at reproducing earlier Soviet and U.S. technical achievements. In this sense, they have pursued objectives known to be within reach, attainable and feasible. At the same time, these programs have been set on carefully considered long-term trajectories within forward-looking, multi-decade strategies for the space sector, to which top leaders have for nearly two decades shown unfaltering political and practical support.

This foresight and the programmatic stability it allows have been important ingredients in China's success in space.

Beyond that, this vision for space development is integrated into a larger strategy for national science and technology development, a strategy aiming at nothing less than a comprehensive transformation of the economy

and military power.

The vision for space is also coordinated with a range of supporting policies to foster the application and commercialization of space-based goods and services. Implementing this holistic vision for how space activities should serve societal goals also increases the likelihood that the returns on public investment in space activities will be captured to the fullest.

This overarching strategy has translated into numerous large-scale programs carried out by a sprawling complex of organizations, which brings me to the third factor: volume. The sheer volume and scale of China's space activities, measured by any number of indicators, in and of itself creates conditions that foster continued success.

The effects of volume, tempo, practice, and experience on space activities are well recognized by space experts here in the United States and within other established spacefaring states. They create complementarities, synergies and virtuous cycles that contribute to the advance of space programs. So these three factors, resources, vision, and volume, are the fundamentals - or the building blocks - of China's success in space endeavors.

As a result, China's space community has developed core capacities and capabilities in every major area of space activity. China has reproduced or is expected to soon reproduce some of the major achievements of the United States and the Soviet Union and Russia in space. Chinese capabilities in important respects already exceed those of Europe's leading spacefaring states.

At this stage, then, China's space establishment is poised to begin pursuing world firsts, not just Chinese firsts. The next set of long-term goals for the Chinese space program may include unprecedented missions and achievements unique to China.

If these three factors - resources, vision, and volume - are the main factors behind the success of China's programs, it follows that China's advance in space is a largely domestic process. It also follows then that the major factors driving China's progress in space activities are beyond the reach of U.S. policymakers. Even if U.S. policymakers seek to affect China's pursuit of space capabilities, the tools with which they could pursue this goal are few and limited.

The most important of these tools, export controls, is already used to the fullest. U.S. export control policy decisions have undoubtedly had impacts on Chinese space activities. But these impacts were felt over a decade ago. Today, China's space establishment, like the U.S. space establishment, has adjusted to an international landscape shaped by tight U.S. controls on space items - or at least tight U.S. controls on the legal trade in space items.

Today, Chinese space programs are less impacted by these controls than in the past. In general, the foreign inputs that Chinese space organizations would seek to procure by legitimate means on international

markets are now likely to be shrinking in volume and narrowing in scope to select, specialized items.

Moreover, this outcome at least partly reflects an aspiration to indigenize space capabilities that predates the 1999 tightening of U.S. export controls.

This brings me to my third point about implications for U.S. interests and policy. I'll just say a few words about this in the remaining minute I have.

First, the United States has an interest in seeing Chinese space organizations become capable and responsible users of space and partners in sharing the use of space.

Second, China's space establishment is on the cusp of major accomplishments and is poised to set ambitious new goals. These are deserving of the Commission's continued attention.

Third, it is difficult to overstate the significance of the U.S.-developed space systems that literally shape the world we live in today: the hidden plumbing sustaining our economy, our communications and our defense. The U.S. Global Positioning System is an example of such a system.

Perhaps the most important action that U.S. policymakers can take now is to continue supporting the next generation of transformative space technologies - in other words, the next space technologies that would be as impactful as GPS - here within the United States.

Thank you for attention. I look forward to your questions.

HEARING CO-CHAIR FIEDLER: Mr. Nurkin.

PREPARED STATEMENT OF DR. ALANNA KROLIKOWSKI
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Vision, policy, and organization in China's space sector[1]

Testimony before the U.S.-China Economic and Security Review Commission
Hearing on "China's Space and Counterspace Programs"
18 February 2015

Alanna Krolikowski, PhD
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Harvard University

Introduction

I thank the Commission for the opportunity to testify before it on the topic of China's space activities.

The first part of this statement surveys the state of policymaking and related processes in China's space sector. The second part considers the space establishment's record of innovation. The third part examines the pursuit of civil-military integration within the space industry. The fourth part discusses foreign sources of space technology. The final substantive section discusses the impacts of U.S. export controls on China's space sector.

Policies and processes in China's space establishment

The setting of policies and processes within which Chinese space activities occur evolves incessantly. This section examines continuities, changes, and other major features of the environment in which space programs are designed, adopted, and implemented. The major entities forming China's space establishment and their roles are described in the Appendix.

Space policy is still set within broader strategies to develop science and technology.

China's top leaders continue to emphasize that advances in science and technology are necessary to achieve the twin objectives of developing the economy and strengthening the military. Space policies and programs are a sectoral expression of this overarching agenda.

Space policies and programs figure in central-government plans for building an innovative, knowledge-based economy and increasing domestic consumption, in particular of high-technology

[1] This statement is based on sources including: in-person interviews and consultations with current and former participants in the Chinese and U.S. space sectors; primary- and secondary-source documents in Chinese and English, including policy statements, media reports, trade and technical journal articles, and think-tank reports; and remarks made by authoritative Chinese and U.S. space-sector participants at public conferences in China and the United States.

goods. Developing space-related products and services serves the center's goal of transforming the economy and moving up to the higher value-added rungs of the export ladder.

Space activities also feature in plans to transform the military into a modern, battle-ready force. In this view, space systems will enable the People's Liberation Army (PLA) to harness the potential of the information revolution for military operations and fight technologically sophisticated adversaries.

Top leaders still pay close attention to space activities.

China's top leaders have taken a personal interest in domestic space activities since their beginnings in the 1950s. Chinese experts have long stressed that success in space starts with top leaders, sometimes identifying personal attention by senior officials as conducive to the advance of particular programs. This situation persists under the administration of Xi Jinping today. Leaders continue to frequently visit facilities and receive briefings on the progress of projects. Through his tripartite role as head of the party, state, and military, Xi himself oversees and dotes upon civil, commercial, and defense space programs and related entities.

Leading small groups still facilitate inter-agency coordination.

Space programs require the participation of numerous and diverse entities, both civil and military. Leading small groups are designed to provide high-level coordination between these units. They are a mechanism for overcoming the fragmentation of authority and barriers to communication across organizations involved in space activities. Often without a dedicated institutional home, the groups comprise representatives from existing offices in participating organizations on a project-specific basis. There are reportedly leading small groups for the lunar projects, human spaceflight, Earth observation satellites, and heavy-lift launch vehicle development. Officials at the highest levels lead or belong to several of these groups.

Expert input into policy decisions has grown more systematic.

The space sector is a highly specialized and technical domain of activity. High-level leaders making policy and programmatic decisions rely on expert input, which they receive through several channels. While these channels remain both formal and informal, the transmission of expert advice to decision makers has grown more institutionalized and systematic. For example, space experts in the large industrial groups contribute policy advice through newly formalized advisory channels.

Policymaking and programmatic processes are increasingly developed and sophisticated.

Since 2006, space organizations have published a range of policy and programmatic documents, which, considered together, suggest that processes for designing and implementing space activities are growing more systematic, institutionalized, and developed. Space policy white papers, plans and strategies for space science and technology development, and other documents now identify priorities, set goals and schedules, and convey structured long-term visions for space activities in far greater detail, with greater transparency, and in language more accessible to international readers than in the past.

The implementation of on-going programs is the main current task.

Xi Jinping's administration is likely to preside over the maturation of major programs and their culmination in important technical achievements. The forthcoming milestones are several. By or around 2020, the lunar program expects to complete a sample-return mission, the human spaceflight program expects to complete the on-orbit assembly of a space station, and the Beidou satellite navigation system expects to begin providing global signal coverage. Today, major space organs are preoccupied with the implementation of these on-going programs. Their focus is effective program management, maintaining the pace and function of already established units, and carrying programs that have a record of success to fruition. Many of these activities are, within the Chinese context, still experimental and new, so particular units continue to face major technology development challenges. However, scientists and engineers now pursue their goals within more stable, mature and institutionalized organizations and programs than previously.

Another important task is designing new programs.

While carrying out these activities, the space establishment as a whole also faces major decisions about the next set of long-term goals to adopt. Units within the system are now envisioning and designing the programs that will shape the course of China's space development beyond 2020. The highest levels of government will decide which of these proposals to adopt. If successful, these new programs will become the signature achievements of the Xi administration in the space arena.

Innovation in China's space sector

The Chinese space establishment's record of achievement includes remarkable feats of technology development, adaptation, and refinement, but it has yet to blaze trails toward original objectives and historical firsts in space.

Innovation to date

Since 1986 and, in particular, the late 1990s, China's space organizations have made steady progress and achieved major technology milestones. In a general sense, China's space programs already match or approach U.S. and Russian programs in core areas of space engineering. China's space establishment assures independent access to space for cargo and taikonauts aboard nationally built and operated vehicles. China is only the third country in history to place humans in space and built orbital habitats. China is now the only country possessing and operating an independent, stand-alone facility capable of supporting short-term stays on orbit by humans. If the program proceeds on schedule, at the end of this decade China may be the only country to operate an independent national space station capable of supporting humans on medium- to long-term stays in space.

At the same time, China's space agencies and firms are building large and complex systems expected to become space-based infrastructures supporting a modernized national economy and military back on Earth. The Beidou satellite navigation constellation, high-resolution Earth-observation satellites, and a fleet of more capable telecommunications satellites are backbones for the development of emerging and strategic technology-intensive industries. In this role, space systems will support innovation in a range of adjacent and downstream sectors serving

commercial, civil, and defense users. These sectors encompass activities as diverse as commercial data processing, fisheries management, and public security.

Factors conducive to success

The success of China's space establishment in these respects owes to several factors. Three in particular stand out.

Resources and commitment. For at least the past 15 years, the Chinese state has been in a unique position to invest in science and technology programs. While estimates of state spending on space activities are contentious and data on this subject scarce, it is clear to outside observers that Chinese space organizations are steadily and reliably funded at levels suited to their programmatic objectives. The enormous size of China's internal market for space-based products and services also creates opportunities for sectoral growth and development virtually unparalleled elsewhere.

Strategic vision. Chinese space organizations owe their success to what has over the years coalesced into a coherent overarching vision for space development. This vision is at once ambitious and realistic. It encompasses bold, technologically demanding, and large-scale programs. Yet the intrinsic technical feasibility of China's goals in space is not in doubt, since for now these consist largely in reproducing earlier achievements of the Soviet Union/Russia and the United States. The aspirations are lofty, but known to be within reach. As a result, space organizations enjoy a stable and predictable policy and programmatic environment, within which they can reliably forecast and organize their activities with a view to optimal long-term results.

Volume and scale. The sheer volume of China's total space activities – whether measured by total number of launches, satellite platforms built, programs executed, or other indicators – in and of itself creates circumstances that foster continued success. Particular examples of these volume effects, including practice and learning-by-doing effects, are discussed below in the section on civil-military integration. The volume of activities also creates opportunities for rapid workforce development, yielding long-term benefits likely to become apparent only in the coming decades.

Challenges ahead

Like actors pursuing other demanding, technology-intensive endeavors, China's space organizations face technical, commercial, and economic risks. These imperil their efforts at innovation in distinct ways.

Technical risks. Technical risks facing China's space establishment include the self-evident likelihood of major failures, delays, and ballooning costs within space programs. Such problems are typical of the space programs of even the most established spacefaring states. Technical challenges are not necessarily indicative of fundamental problems; many are transient obstacles that can be overcome with time, labor, and money.

Commercial risks. Commercial risks imperil those actors within China's space industry that are oriented toward domestic and international markets, rather than government customers. For example, China's satellite operators serving consumer markets may face competition from terrestrial alternatives to space-based telecommunications. Prospective

exporters of Long March launches may face a new glut of supply depreciating global launch prices.

Economic risks. Economic risks exist for the space establishment as a whole. To an extent, progress in space activities is likely to track the rest of the economy. If major disturbances (such as an unmanaged mass of defaults on obligations by local governments) upset the fiscal landscape, then space activities may be affected. For example, local and/or provincial government support to space-focused industrial parks could dwindle. If China faces a larger economic downturn, then space budgets are likely to contract indefinitely, slowing the pace of technical progress.

In addition to these general and ever-present risks, China's space establishment now enters a stage in which new challenges to innovation arise.

World "firsts." Having nearly completed building a suite of core space capabilities, China's space establishment now aspires to produce historical firsts and make unique advances. For example, China's scientific community aspires to make distinct contributions to global space science and exploration. Finding such niches and filling them is difficult, even for longer-established spacefaring states.

Staying the course while setting new goals. Sectoral leaders must now sustain a sprawling complex of institutions and facilities executing demanding programs, while also steering this establishment toward the next set of objectives. The complexity and magnitude of this task are unprecedented for China's space community.

Cross-sectoral policy coordination. To realize the innovation potential and other social returns on public investment in space activities that they envision, policymakers must coordinate space activities with a range of other policies, including an array of cross-sectoral and industrial reforms and regulatory measures in other parts of the economy. As the technological sophistication and complexity of China's hybrid socialist-market economy grows, so do the challenges presented by this monumental task.

The promise of civil-military integration in the space sector

Several experts appearing before the Commission have discussed Chinese policymakers' pursuit of civil-military integration and related goals, including through reforms of the defense industries. The guiding principle of civil-military integration was adopted formally in its current version by the administration of Jiang Zemin in 1997.

Within the space sector, it is helpful to think of civil-military integration as the policymaking and programmatic principle that civil-commercial and defense high-technology industries should be mutually supportive. Industrial reforms and development in the space sector should maximize the synergies and complementarities between the civil-commercial and defense segments of the sector. For example, in a narrow sense, technical space professionals should make the most of commercial off-the-shelf solutions to meet defense needs. Similarly, they should explore the commercial potential of defense systems.

Advantages and potential of civil-military integration

Both Chinese and international analysts agree on the substantial benefits of pursuing civil-

commercial and defense space activities in a simultaneous and coordinated fashion. These benefits reflect the interchangeability of facilities, personnel, equipment, and certain products between civil-commercial and defense programs. At minimum, utilizing these resources toward both civil-commercial and defense ends reduces the long-run fixed costs of programs. Moreover, space technologies originally developed for military applications are now embedded into national and global infrastructures supporting a vast range of economic activity and generating benefits beyond the context of their initially intended military use.

Analysts often characterize space technology items as "99%" dual-use or otherwise represent all or nearly all space items as indistinguishably civil-commercial *and* defense-applicable in nature. While many space items are indeed dual-use, it is most helpful to think of the *capacities* required to conducts civil and commercial programs as often applicable to defense objectives and vice-versa. It is often in this systemic and diffuse sense that Chinese policymakers and decision makers reason about the viability of civil-military integration in the space sector.

The potential and benefits of civil-military integration are concentrated in three dimensions of space programs and activities: organizational efficiencies to result from pursuing the parallel development of civil-commercial and defense space activities; manufacturing and operational processes applicable to both types of activities, and dual-use articles of hardware.

Organizational efficiencies in dual development

Simultaneously pursuing commercial and defense space activities brings synergies, complementarities, and economies at the levels of individual facilities and of the space industry as a whole. Units within China's large space industrial groups, Casc and Casic (discussed in the Appendix), are poised to capture these benefits because they make both commercial and defense products.

In the industries of other major spacefaring nations, firms and programs have benefitted from the integration of their commercial and defense activities on an organizational level. In the United States, the major commercial communications satellite manufacturers, Boeing and Lockheed Martin, also build a range of other satellite platforms for NASA and the Department of Defense. The same is true of major U.S. manufacturers of satellite sub-systems and components. In launch vehicle manufacture, both U.S. policymakers and specialists have identified important complementarities and synergies between the commercial and defense launch segments.

In China, the parallel, concurrent, and coordinated implementation of commercial and defense programs similarly promises synergies, complementarities, and economies in the manufacture of launchers and satellites. In both types of products, the organizational benefits of dual development are, at minimum, threefold. They result from economies of scale, experience effects, and modularization.

First, integrating the commercial and defense manufacture of launchers and satellites promises economies of scale and risk reductions in development and production for Chinese firms. Launcher and satellite manufacture are sensitive to volume. In general, as production volumes for a given vehicle or satellite platform rise, average unit costs drop. Development costs are very high for new vehicles and platforms. Transaction costs involved in reaching agreements with sub-system and component suppliers are also high. Maintaining assembly, integration, and testing facilities for launcher and satellite production is costly. Retaining skilled personnel as demand for either commercial or defense products fluctuates also imposes high fixed costs. At high volumes,

these burdens are distributed over a larger number of launches or satellites. Because most launch systems carry extremely high fixed infrastructure costs, launch rates (volume/time period) have an especially profound impact on the cost of access to space.

For manufacturers facing these burdens, consolidating production of commercial and defense articles is optimal. Firms seek to capture the highest possible market for any given product, using common vehicles or platforms to carry both commercial and defense payloads where possible. Producing commercial launchers or satellite platforms for export can also increase the total production volume of a given article, further reducing its average unit cost. This cost reduction can, in turn, benefit both the commercial and defense sides of the integrated manufacturing industry.

Second, at higher production volumes, experience effects also kick in. These bring further cost reductions and other benefits. Learning effects in launch vehicle manufacture, launch operations, and flight operations are significant. Practice is an important determinant of the success of launch vehicle programs. Even launch failures themselves provide learning opportunities. In addition, the more times a vehicle had flown, the longer its record of reliability. Reliability is a priority in operators' choice of launch solutions for military and intelligence payloads, because these items are of high value, irreplaceable, and/or often uninsured. Reliability is also a concern to international commercial users, who are sensitive to launch insurance rates. Using common vehicles to launch both commercial and defense payloads is a means for Chinese manufacturers to capture these experience effects.

Satellite platform and component makers also benefit from experience effects attained at high levels of production. For example, users of both commercial and defense satellites prefer platforms with a reliable track record of smooth operation. The higher the volume of satellites using a given platform flown, the greater this particular form of experience effect for the manufacturer. Using proven platforms also reduces design and development risks on specific projects. Increasing the overall volume of satellite production by expanding commercial production, including for export, could benefit China's defense satellite programs.

A third set of economic and organizational benefits to result from dual commercial and defense space development has to do with modularization in launcher and satellite manufacture. Developing modular designs brings efficiencies in production and flexibility. During the past two decades, these benefits have been most accessible to China's launch-vehicle industry, but they have also existed for satellite manufacturers. By adopting modular designs, Casc has been able to serialize more of its fabrication and reduce costs. Modular designs have also allowed more efficient assembly and testing of launch vehicle and satellite systems and sub-systems. To deliver the greatest advantages, modularization and serialization require production at a high volume. Taking advantage of commonalities in commercial and defense hardware to achieve a higher volume of production on a given satellite platform, launcher, or element allows firms to reap these economic and organizational benefits. As China's space establishment maintains launch rates around or exceeding 20 launches per year, manufacturers are optimizing the modularization and serialization of various elements of launchers and satellites in this manner.

Manufacturing and operational processes applicable to defense programs

Commercial launch vehicles and missiles share general features at the levels of systems and major sub-systems. Launcher technologies are not identical to missile technologies, but improvements

in Casc's launcher manufacture have the potential to bring improvements to the company's missile manufacture under certain circumstances. As in other high-technology sectors, even though items of commercial and defense space hardware differ in their particular features, defense programs can, in a general sense, benefit from improvements to processes on commercial programs.

While general commonalities make some launcher manufacturing processes applicable to missile production, differences between the two types of vehicles limit this transferability. Modern launch vehicles and missiles are designed to distinct specifications, tolerances, and performance requirements. Missiles generally use different rocket motors and launch methods than satellite launch vehicles. Their technical features also differ at the levels of smaller sub-systems and components.

Beyond manufacturing processes, certain operational processes are also common to commercial and defense space programs. These include the integration of payloads with launchers and launch-site operations. These processes are similar or identical for launches of both commercial and defense satellites. Improvements' to Casc's commercial launch processes may also improve its launches of defense payloads.

Dual-use space hardware and related knowledge

Particular items of commercial space hardware can be repurposed for defense applications with only minor modifications. These items include entire systems, such as launch vehicles, which can launch both civil-commercial and defense payloads. They also include sub-systems, such as sensors and robotic arms on spacecraft, which can be applied or adapted to intelligence or counterspace missions. Finally, dual-use technologies also include many smaller components, such as amplifiers and radiation-hardened electronic elements.

These dual applications are apparent to Chinese experts and policymakers, who advocate using commercial technology to modernize and develop the defense industries. While stressing autonomous development, sectoral policies and directives guide Casc and Casic to resort to commercial solutions available on world markets when indigenous defense technologies are not available.

Limitations on civil-military integration efforts

Several factors, both domestic and international, still hinder the pursuit of civil-military integration in China's space sector. These factors are discussed in recent reports on China's military modernization and defense industries submitted to the Commission. In addition to organizational and institutional obstacles to integration, U.S. export controls and other restrictions on trade in space items with China limit opportunities for Chinese firms to use commercial solutions to meet defense needs.

Foreign sources of China's space technology

With few exceptions, it is difficult to state with any confidence when and how international actors have supplied China's space industry with space technology items. While characterizing these transfers is challenging, observing the course of China's space development nevertheless reveals changing conditions that affect the likelihood of Chinese actors seeking and using foreign inputs

today and in the future.

Since at least 1999, the main thrust of China's space development has been national and relied in large part on technology developed by domestic actors. Chinese space experts explain that, given the sector's strategic role, their country must assure its independent access to and utilization of the space environment. The goal of sectoral policy, it follows, has been building a comprehensive industrial base within China, so as to ensure national control over critical processes in satellite and launcher manufacture. At the same time, this approach has allowed the selective pursuit of international trade and cooperation projects, where these bring significant benefits, but carry few risks. In this approach, foreign partners' inputs can supplement, but should not substitute for or interfere with, homegrown capabilities.

Having pursued this strategy for many years, China's space industry is by now so advanced in many areas that it may in fact seek or need fewer foreign inputs than in the past. As Chinese experts explain, major programs avoid importing entire foreign systems or sub-systems. Instead, they prefer to seek out partnerships with foreign firms that have special competencies to co-produce or co-develop major systems or sub-systems. For example, the China Manned Spaceflight Engineering Office has sought an international partner to develop in-space robotics for the space station program. China's space industry is now more likely to seek foreign inputs of specialized components, instruments, or sub-systems than foreign-made platforms or complete systems.

Moreover, as a result of its advances, China's space establishment is today as likely to be a supplier of technology to newer entrants into the sector as an importer. For example, through their role in the Asia-Pacific Space Cooperation Organization, Chinese space organs provide opportunities for training and access to data to member states that have relatively modest space capabilities. China's space industry has also concluded a string of agreements to export satellites and/or launch services to developing countries that theretofore had no significant space assets.

Impacts of U.S. export controls

The impact of U.S. export controls on China's pursuit of space capabilities today is difficult to assess: some observations suggest that its effects are mixed and declining.

Much of China's success in space owes to structural factors and Chinese policy choices that lie beyond U.S. influence. Among these factors are China's enormous internal market for space goods and services, large and stable budgets for space activities, and strong political commitment to success in space endeavors, all discussed above.

Chinese specialists interpret the 1999 tightening of U.S. export controls on space items as part of a U.S. strategy to suppress China's peaceful rise. In this view, the 1999 controls are not merely a denial of trade opportunities, but one facet of a larger U.S. effort to block China's national rejuvenation: a "space containment policy" targeting China's core development and security interests. In this view, the embargo constrains China's economic advance by excluding it from world markets for high-technology goods and stifles its defense modernization. These depictions underpin and rationalize policies to rapidly and autonomously develop capabilities in civil, commercial, military, and intelligence space.

Whether or not U.S. policy has in fact had the hindering effects identified by Chinese experts, China has achieved an impressive record of national firsts in space technology while U.S. export

controls have been in place. Further complicating the assessment is the fact that China's high-technology industries have made significant advances both in areas that are tightly export-controlled, such as space technology, and in areas that are more loosely controlled, such as aeronautic technology.

Conclusion

In sum, the environment of policies and processes in which Chinese space activities occur continues to evolve. However, the setting within which space programs are designed, adopted, and implemented today is more institutionalized and stable than in the past.

Overall, the Chinese space establishment has made remarkable technical achievements, producing a string of important national firsts since 1999. In particular, China is only the third country to develop advanced capabilities in human spaceflight and among only a handful to be building a global-scope satellite navigation system. Now possessing core space capabilities in every major area, China's space establishment is poised to contemplate achieving global firsts in space science and engineering.

As China's space development forges ahead, its leaders stress the benefits of pursuing civil-commercial and defense space activities in a simultaneous and coordinated fashion. These benefits are systemic and institutional. They include organizational efficiencies, improvements to processes, and the dual applicability of certain systems. Still, domestic and international factors continue to hinder the pursuit of civil-military integration.

While it is difficult to assess the contribution that specific foreign-origin technologies have made to China's space efforts, its advancing programs are geared toward the domestic sourcing of inputs and the development of independent capacities. This situation suggests that the Chinese space industry's need for foreign inputs may be narrowing in scope. Similarly, the impacts of U.S. export controls on China's pursuit of space capabilities today remain difficult to assess. Some observations suggest that their effects are mixed.

Please accept my sincere thanks for the opportunity to share with you the results of my research. I would be pleased to answer any questions at the hearing or in writing.

Appendix: Leading institutions in China's space establishment

China's space policies and programs consist in the implementation of a technology development strategy, of which the broad outlines were decided in 1986. Several government organs are involved in making and implementing space policy. These range from units that formulate and oversee policies and programs to those that produce and operate space hardware.

China Aerospace Science and Technology Corporation (Casc) and China Aerospace Science and Industry Corporation (Casic)

Casc and Casic are the two large state-owned defense industrial groups that build virtually all the hardware for Chinese space missions and projects. They are sometimes regarded as the most influential actors in the space sector. These conglomerates' major clients are the government organs that run the space program. Both the civil and military space budgets flow into these two companies.

Casc and Casic each subsume vast and diverse facilities and organizations performing the research, development, and production of space systems. Their facilities are located across China, but cluster around Beijing, Shanghai, and Harbin. Each of these industrial groups comprises system integrators, sub-system integrators, and component makers.

The larger of the two conglomerates, Casc, focuses on more powerful launch vehicles and larger satellites. Casc subsidiary China Great Wall Industry Corporation is responsible for marketing Chinese launch services and satellites abroad. The smaller Casic focuses on missiles and smaller satellites. Casc and Casic both develop and manufacture civil, commercial, and defense space technology and both are also involved in industries other than space. Each has undergone profound reforms and several rounds of restructuring since 1998. In addition to these two major players, a number of small and medium-sized enterprises have emerged as users and processers of space-derived data and space-based services over the past two decades.

State Council

The State Council brings together the heads of major ministries and equivalent organs throughout the state. This body formally decides and adopts major policies and strategies for science and technology, including major space programs.

State Administration for Science, Technology, and Industry for National Defense (Sastind)

In 2008, Sastind succeeded the Commission for Science, Technology, and Industry for National Defense (Costind). Unlike its more autonomous predecessor, Sastind is a unit within the Ministry for Industry and Information Technology (MIIT), designated a 'super-ministry' because it subsumes units of formerly ministerial level. Costind and Sastind have been the main state entities involved in space policy and technology development programs. Guided by the long-term strategies discussed above, Sastind formulates and coordinates the implementation of policies and programs between the large state-owned enterprises in the sector, military and other government end-users, research facilities, and concerned ministries.

Ministry of Science and Technology (MOST)

MOST formulates and publishes major top-level long-term strategies for the development of science and technology with the approval of the State Council. In 2006, MOST issued the national *Medium- and Long-Term Plan for the Development of Science and Technology.* This strategy for the 2006-2020 period updated and accelerated the pursuit of goals set out in the *State High-Technology Development Plan* of 1986 (also known as Program 863), which set China's space development on its current course. The *Medium- and Long-Term Plan* identifies and funds sixteen unclassified technology mega-projects, including several large projects in space exploration, human spaceflight, and satellite navigation.

State-owned Assets Supervision and Administration Commission of the State Council (Sasac).

Sasac oversees and guides reforms of China's large state-owned enterprises. Among these are the ten defense-industrial groups, which include Casic and Casc. Among other corporate and industrial restructuring goals, these reforms aim at improving the efficiency and business viability of the defense manufacturers and their capacity to supply domestic end-users and, in some cases, compete in foreign markets.

China National Space Administration (CNSA)

This small bureaucracy conducts relations with external parties on non-commercial space matters. As part of this function, it concludes international space cooperation agreements and represents China's space establishment at international meetings. The CNSA also plays a formal role in policy coordination. The CNSA Administrator is an influential figure concurrently appointed to positions in Sastind and key program offices.

National Space Science Center (NSSC) of the Chinese Academy of Sciences

Formerly the Center for Space Science and Applications research, the NSSC participates in and coordinates scientific missions. The Center also researches, develops, and produces certain scientific instruments and payloads for spaceflight missions.

General Armaments Department (GAD) of the PLA

Critical space infrastructure, including launch facilities, and the day-to-day management of civil and military space operations, are the responsibility of PLA organs. Within the PLA, the GAD plays the most important role in space activities. The GAD, in partnership with dedicated program offices, leads China's major space technology development programs. In civil space, the GAD acts mainly in and through the China Manned Space Engineering Office, the entity responsible for the human spaceflight program.

OPENING STATEMENT OF MR. TATE NURKIN
MANAGING DIRECTOR OF RESEARCH AND THOUGHT LEADERSHIP, JANE'S IHS AEROSPACE, DEFENSE AND SECURITY

MR. NURKIN: Thank you. I'm going to start by thanking the Commission and all the Commissioners for allowing me the opportunity to participate in this panel during what is a very active time in China's space program.

My written testimony include a lot of detail on the sources of and prospects for China's space program, and clearly I'm not going to go into that detail in this forum, but I would like to extract three pervasive themes from that document and from my research on China's space program and military modernization more broadly.

The first is while China is certainly not a peer competitor in terms of technology to the United States, it has made steady and significant progress in its space program in terms of the development, acquisition and application of increasingly sophisticated space technology, and I think that this is due in large part--well, first of all, China has certainly benefited from previous space programs and technology and knowledge of more advanced programs. There are some commonalities between China's program and other developing programs, particularly in terms of viewing space technology as an important component of a broader dual-use aerospace capability.

But I think that some of this steady and significant success is due to the infusion of China's space program with uniquely and distinctly Chinese characteristics, and one of those characteristics, it's worth noting, is that because China is not undertaking this program within the context of an intense or urgent bilateral space race, and because its technology goals are on more deliberate timelines, there is a preference for and a demonstration of a technology development model that is incremental, that prioritizes the iterative prototype technology fielding over the rapid development of full systems.

And I think that you can see this in many of the areas, in many of the products that China's space program has produced, the Chang'e lunar missions, the manned space program, the Long March launch vehicles, even the Beidou navigation system. There are iterative steps here, and that has I think contributed to their success and is likely to be a feature going forward.

The second point I'd like to highlight is that China's program is a multifaceted approach to acquiring technologies from foreign sources, and I think there are a couple of different methods that I'd like to highlight. The first is direct relationships with foreign space organizations and aerospace industries. Russia stands out as the most important historically, and I think there is a rejuvenation of this relationship coming out of May 2014 and the implementation of sanctions against Russia for its actions in Ukraine.

From May to around November, the China Airshow in November of 2014, we saw over 30 memorandums of understanding, agreements to cooperate, even financial deals between China and Russia on space-related and aerospace-related topics, including the potential for manned space exchanges at different space stations.

The second relationship is with Europe, and it was touched on briefly at the end of the last panel, but China does maintain a healthy relationship with the European Space Agency and national space agencies and national aerospace industries in European states, particularly Italy, France, Germany and the United Kingdom, as well as research institutes in those countries.

And I think that these countries and their industries view China as a very attractive export market, and they are indeed designing out ITAR-restricted technologies for ITAR-free export, which will obviously give flexibility to European aerospace industry to trade with China.

The second kind of method I'd like to talk about is espionage. It's really tricky to talk about espionage in any setting, particularly one that's on the record, but I'm going to have a go at it. But I think, you know, espionage is clearly a component of this, of this technology acquisition strategy, and it occurs through institutions of higher learning and research institutes. It certainly occurs through more traditional corporate espionage and national espionage techniques, but I think the area that has garnered the most attention recently, and rightfully so, is around cyber espionage--very difficult to attribute definitively, particularly through open sources, cyber attacks, but there is a growing body of literature that is compelling and consistent that this is a primary or increasingly important lever that China has at its disposal to acquire technology surreptitiously and satellite programs, aerospace, defense, and telecommunications are certainly targets of this.

The last point I want to make is that while there has been steady and significant progress in China's space program, there are still challenges, I think significant challenges, around innovation. And I think taking that next step that my colleague on the right just spoke about, that going from adapting and reverse engineering technologies that other people have developed to actually developing new technologies and integrating complex systems, that's a big step, and China, I think, recognizes that it has some work to do, some gaps to fill to take that step.

And there are three that I would highlight. One is the technological gap. There are still gaps in China's space technology. Propulsion, remote sensing, space navigation, engineering standards, I think all stand out.

I think the second gap is organizational. The highly centralized nature, which is one of the defining characteristics of China's space program also, and the sort of redundant industry that supports the China space program sort of inure these actors from some of the competitive dynamics and free market forces that would drive innovation.

And lastly, and certainly not least, there is a mindset gap. For a long time, China has focused on the acquisition and development of single technologies rather than the incorporation of broad and complex systems, and to move to that mindset of now focusing on systems rather than technologies does take some time, and I think it will take time no matter how much money China throws at this problem, and they are throwing a lot of money at this problem, as best we can tell.

One of the levers that China has recently pulled in terms of driving this innovation, one of two big ones, is increasing funding for CASIC and CASC, the two main industries, groups, conglomerates associated with the space program, through extended credit lines of Chinese banks and loans, which obviously creates opportunities for these organizations. It may well create a vulnerability because if these are the same banks that are vulnerable to some of the corruption and debt challenges, then here might be a vulnerability for continuing to fund this program.

The last point I'll make is the other lever that China has pulled is industry consolidation of the aerospace and defense industry, which dates back to 2008 but accelerated over the summer of 2014 when it was announced that CASC and CASIC were consolidating some activities, not a merger. It would take a very long time to merge these two organizations, but it is an effort to reduce inefficiencies, create new efficiencies, and I think create a collaborative scale for these two companies that will allow it to be more competitive technologically and, more importantly, I think allow it to be competitive with Western aerospace and defense primes. And I'll stop my testimony here.

HEARING CO-CHAIR FIEDLER: Thank you very much.

Mr. Stokes.

PREPARED STATEMENT OF MR. TATE NURKIN
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Wednesday, February 18, 2015

Tate Nurkin
Senior Director, IHS Aerospace, Defense and Security Thought Leadership
Testimony before the U.S.-China Economic and Security Review Commission
Hearing on "China's Space and Counterspace Programs"

Overview and assumptions

I want to thank the commissioners for their invitation to speak on the important topic of the status of and approaches to technology development and innovation in China's space program. It is an honor to be a part of this hearing being held at an exceptionally dynamic time in the development of China's space program.

Over the last decade and a half the Chinese space program--much like China's broader military modernization--has made *steady and significant* progress in the acquisition, development and application of increasingly advanced space technology, knowledge and platforms and systems, especially in the incremental execution of the manned space program, the lunar program, improved launch vehicles, the Beidou satellite navigation system and anti-satellite warfare.

Challenges remain, however, especially around China's ability to continue to innovate in a way that will allow it to create new--rather than merely leverage old--technologies and applications. China seems aware of its innovation challenge and it is clear that in addition to the steady and significant progress of the last 15 years, China's space program of 2015 is also marked by a growing amount of activity in terms of engagement with foreign partners and reform of internal structures, processes and modes of thinking.

Before providing a more in-depth assessment of this active time for China's space program , I first want to articulate two core assumptions. First, that China's space program has several critical and generally consistent objectives driving its growth: prestige and supporting human advancement are important, of course, but the more fundamental goals are to support China's comprehensive national development and the salutary objective of being the most technologically advanced country in the world by 2050.

The program is also an important cog in China's growing aerospace and defense export strategy. China is the seventh largest defense exporter in the world, according to IHS Jane's--including exports of space technologies. It is increasingly seeking to establish export markets for its aerospace and defense products, less for the economic impact that these exports bring and more for the geopolitical influence and soft power they confer on China in countries that either hold natural resources or economic influence, border regional competitor India or are located in strategically vital region of the world. A cursory survey of active or planned space launches of foreign owned satellites in China includes launches on the behalf of Venezuela, Indonesia,

Pakistan, Nigeria, Bolivia, Sri Lanka and Belarus while China has a long-standing space partnership with Brazil.

The second assumption is that China's space program does not have structures in place that make meaningful divisions between military and civil programs and those technologies acquired and systems developed for ostensibly civil purposes can be applied--and most frequently are --for military purposes. This dynamic indicates that China's space program is also a critical element in the country's on-going military modernization program.

A program with Chinese characteristics

A key theme of discussions both within China and among those watching China's military modernization and technological development--including development of China's space program--is that this innovation is happening with "Chinese characteristics"; that is, while China's space program has leveraged the history, science and technology of more advanced space programs--especially Russia's-- the program has been emphatically marked by its ability and desire to apply these lessons and technologies within a context marked by the distinguishing characteristics described below.

Centralized control: China's aerospace and defense community and industry is highly-centralized --with the PLA in control of the program and exerting influence not only over military applications and programs, but also civilian--and relies on large state-owned enterprises that either have strong commercial / civil elements to their business or have close relationships with other state-owned enterprises that do. Two conglomerates dominate the space industry.

China Aerospace Science and Industry Company (CASIC) operates about 620 subsidiaries, both companies and research and development institutes. China Aerospace Science and Technology Company (CASC) operates about 130 subsidiaries, including eight major research and development institutes. Together the two firms employ approximately 250,000 people. Both CASC and CASIC develop systems and equipment, such as launch vehicles, for the space program and also develop military systems, such as missiles, for the PLA. Nearly all products and systems are capable of fulfilling both explicitly military and civil purposes.

The close and frequently opaque ties between the state-owned enterprises, civilian aerospace and the central Chinese government allows China to acquire technology through civilian enterprises that can then be reverse engineered and adapted for China's specific military or dual - use purposes-- a sort of "acquisitional osmosis." This civil-military integration is a key element of the development of China's space program.

Incremental and steady pace: As a second generation space power imbued with a strong sense of deliberate purpose to achieve goals that are in many cases decades away and possessing strong political and financial support, China is not currently compelled into a "space race" that would require an urgent or particularly risky development approach.

Rather, China has repeatedly demonstrated an effective model in both the aerospace and defense industries that relies on incremental development and prototype launch of technologies over rapid full system development. This steady approach to technological improvement and development is

central to the most recent successes of the space program, such as the Tiangong and Chang'e programs that used multi-phase deployment programs to demonstrate and study technologies before fully developing final systems or pursuing more ambitious applications of these technologies.

Funding and political support: Because the space program is so closely tied to China achieving its goal of national development, military modernization, expanding geopolitical influence and becoming the global science and technology leader by 2050 and to China's geostrategic ambitions in the Western Pacific and beyond, the program enjoys considerable funding and political support.

Strategies for acquiring space and aerospace technologies:

Perhaps the most distinguishing characteristic of the Chinese space program -- indeed the whole of China's on-going military modernization and technological development--is the varied means through which China has sought to acquire the technologies and science critical to the further growth of its space program. Four linked methods are of particular interest.

International Relationships: China has been very active in and successful at developing relationships with foreign organizations, industry and academic and research institutions that have provided enhanced access to technologies, best practices and scientific knowledge, which has, in turn, underpinned a significant amount of China's recent aerospace progress. A cursory review of China's State Administration for Science, Technology and National Defense's (SASTIND) website shows China National Space Agency (CNSA) engagement with an impressive range of countries' space programs in 2014: Turkmenistan, Algeria, Russia, Holland, Italy, India, Germany and Sudan as well as the European Union. This list reflects not only China's desire to acquire new technologies from technologically advanced states (Europe and Russia), but also its ambition to export space technologies to states with space programs lagging behind China's.

Russia has long been the most significant supplier of aerospace and defense technologies to China and has been the most significant technological patron to China's space program, particularly in support to China's spacecraft development, astronaut training and the provision of a spacesuit for China's first spacewalk. China's current modular design for its space station strongly resembles Russia's Mir space station.

The aerospace relationship between Russia and China was reinvigorated in May of 2014 as U.S. and Western sanctions against Russia in response to the annexation of Crimea and support for separatists in Eastern Ukraine forced Russia to seek import substitution alternatives for its defense industry and newly reformed space industry. During the course of a series of international events between May and November 2014--the St. Petersburg International Economic Forum in May and the G-20 Summit and China Airshow in November-- Russia and China signed several collaboration deals related to space and aerospace activities. Deals included agreements to establish a joint high-level working group for strategic space coordination and to continue negotiations on the exploration of Mars and Venus; memorandums of understanding on cooperation between Russia's GLONASS navigation system and China's Beidou navigation

system; and a strategic partnership between Russian state owned defense technology firm Rostec and CASIC.

During the China Airshow in November, Roscosmos--the Russian space agency--and China National Space Agency discussed opportunities to collaborate on navigation satellites, remote sensing, production of electronic component parts, materials science, construction of spacecraft and rocket engines and manned programs. The two organizations also discussed the possibility of an exchange of manned spacecraft visits to Russian and Chinese orbiting stations. In their entirety, these deals constitute an exceptional opportunity for China to not only leverage more Russian space technology, but also to attempt to penetrate an in-need Russian market with space and aerospace exports.

Europe also continues to be an important source of technology and know-how for China's space program, through direct engagement with the European Space Agency (ESA) as well as the national space agencies and industries of individual European states.

China and the ESA have a relatively long history of successful collaboration, including the successful Double Star mission, which launched two satellites into orbit in 2003 and 2004 to study the planet's magnetosphere. In January of 2015, the relationship took a significant step forward as the Chinese Academy of Sciences and the ESA announced a call for proposals for a jointly developed robotic space mission that will be launched in 2021. The program is the result of two planning meetings in 2014 that assessed challenges of the program, laid out parameters of collaboration and discussed technologies of interest to the effort. According to presentations delivered at the first of these conferences held in Beijing in February 2014, any element of the mission--platforms, payload, system integration and testing, launch services, spacecraft operations, receiving stations, science operations and science exploitation--can be provided by China, Europe or jointly.

China also has established collaborative relationships with the space programs within individual European states and with European space industry, particularly France, Italy, Germany and the United Kingdom, all of which view China's growing space program as a high priority target for exports of robust domestic space industries that are dealing with budgetary pressures in home markets.

For example, in December of 2013, the UK Space Agency announced a new five-year, £80 million Global Collaborative Space Program designed to allow the UK to access new international markets for British industry and to share British expertise. China was explicitly mentioned as a priority market in UK government releases about the initiative. In addition, on 30 January of 2015, China's SASTIND announced that China and France signed agreements to foster collaboration across a range of hi-tech sectors, including satellites. China has previously collaborated with France on the China France Oceanography Satellite (CFOSat), which was built jointly by the CNSA and Centre National d'Etudes Spatiales (CNES), the French national space agency.

Academic and research institutes: China also uses growing connections between domestic and foreign academic and research institutions to acquire technologies and know-how in both licit and illicit ways. As with the line between civil and military industry activities, the line between

academic and military research is blurred in China, meaning that the typically open and engaging world of academia and scientific research can be an effective avenue for the transfer of scientific knowledge and advanced technologies.

U.S. authorities, including Federal Bureau of Investigation, have expressed growing concern about the general proliferation pathway of academia over the last several years, either via foreign students studying in American institutions or through witting or unwitting American academics and researchers that export controlled technologies through foreign students with whom they work.

Of course, not all knowledge gained through academia is done so in a surreptitious fashion. China's research institutes and universities offer an additional means of engagement with states possessing advanced space and aerospace programs through conferences and collaborative research initiatives.

In May of 2014, Science and Technology China and United Kingdom Trade and Industry co-funded the 9th UK-China Workshop on Space Science and Technology held in Shanghai. The event was organized by Rutherford-Appleton laboratory in the UK and China's Beihang University, according to a press release on the event from the UK government. Attendees included 40 delegates from the United Kingdom and 150 from China. A total of 61 areas for collaboration were identified and 26 memorandums of understanding were signed for collaboration in earth observation / remote sensing, planetary exploration and training. Specific examples of collaboration included an offer from CNSA to use UK instruments and payloads on CNSA space exploration vehicles.

Another significant collaboration between research / academic institutes is the Launch Joint Laboratory, a 2012 initiative between the University of Strathclyde in Glasgow, Scotland and the China Academy of Launch Vehicle Technology (CALT), a subsidiary of CASC. The Laboratory is based at Strathclyde, but provides research funds two CALT engineers to work at the university. The purpose of the program is to advance research in key areas such as mechatronic mechanisms, space robotics for satellite servicing and refueling, sustainable space exploration and related manufacturing technologies.

Espionage: It is difficult to develop a comprehensive picture of how much aerospace and defense technology China acquires through espionage, but open source reporting on the subject strongly suggests that espionage, both traditional forms and cyber-espionage, constitute an important avenue for the acquisition of aerospace and defense technology, including space-focused technologies.

A March 2014 Department of Justice report detailing major US export enforcement, economic espionage, trade secret and embargo-related criminal cases from January 2008 through March 2014 included over two dozen cases of prosecuted espionage regarding / theft of controlled items relevant to China's space and broader aerospace programs, such as: multiple cases focused on thermal imaging cameras and aerospace grade carbon fiber as well as cases involving electronics used in military radar and electronic warfare; radiation hardened materials and gyroscopes; military accelerators; military optics; unmanned systems; rocket / space launch technical data; restricted electronics equipment; source code; and the theft of space shuttle and rocket secrets for China.

China is also pursuing the illicit acquisition of advanced aerospace technologies from the United States via cyber-espionage, though direct attribution of cyber-attacks is exceptionally difficult. China's cyber-espionage capabilities and activities have received particularly acute attention since the release of a series of high-profile reports in early 2013, including reports from the US Defense Science Board, the private Internet security firm Mandiant, and a classified National Intelligence Estimate, elements of which were leaked to the press. Collectively, these reports and several subsequent U.S. government and private sector reports describe a significant and sustained cyber-espionage campaign against US companies in a variety of industries emanating from China and initiated by the Chinese government. Satellites, defense, aerospace and telecommunications were all listed among targeted industries.

Joint ventures and acquisition of Western aerospace and technology companies: China has also engaged in several joint ventures with Western aerospace companies, including American aerospace companies. These deals provide an additional mechanism for the proliferation -- knowing and unknowing--of technologies from Western companies to China's web of closely linked commercial and military aviation enterprises.

China's aerospace industry has also made over a dozen significant acquisitions of Western commercial aerospace and aerospace technology companies--including several US companies--over the last five years. These acquisitions have been strongly focused on commercial aerospace companies with competencies in light aircraft and technology areas, such as aero-engine development and sensors that can support China's efforts to fill the People's Liberation Army's most pressing defense technology gaps. None of the acquisitions have been explicitly focused on space technologies--though the 2013 acquisition of Luxembourg sensor company constituted CASIC's first direct foreign acquisition--but it is certainly an approach that could be applied to adjacent aerospace industries to help fill technological and scientific gaps affecting the trajectory of China's space program.

Strengths and successes of China's space program

China's attempts to acquire technology via foreign sources have been pivotal in driving China's space program's successes to date and in closing the gap on more technologically advanced states. Below is a list of key products and programs and recent areas of technical success for China's space program:

Satellite launches: China has over 100 satellites in space currently, according to IHS Technology. These satellites are performing many missions, including explicitly commercial functions. However, given the PLA control and closely-linked civil-military elements of the program, it is reasonable to believe that most satellites have the capacity to carry out both civil and military functions and those that can, will be tasked to carry out both.

Yaogan: The launch of five triplets of Yaogan satellites--an advanced electro-optical synthetic aperture radar and electronic reconnaissance satellites--since 2010 has created concerns in the U.S. military that the architecture is a maritime signals intelligence system designed to replicate elements of the U.S. Navy's Naval Ocean Surveillance System and will be used to observe naval

deployments in the Western Pacific.

Gaofen: The Gaofen satellite is a satellite used for optical and radar reconnaissance of the earth. The Gaofen was launched in 2013 and is a high resolution optical satellite with 2 meter resolution.

Shijian: The Shijan system is a terrain mapping system satellite with the capacity to produce 3-D terrain models that is also thought to possess infra-red sensors capable of detecting missile launches. It could be used as an early warning system for the PLA.

Beidou Satellite Navigation Network: The Beidou (Compass) system constitutes China's attempt to develop a global navigation system to compete with (or at least reduce Chinese commercial, civil and military reliance on) the U.S. run Global Positioning System and Russian run GLONASS. The system became operational in late 2012 at a regional level and China anticipates having a fully operational global system in 2020. The global system will include 35 satellites: five in geostationary earth orbit, 27 in medium earth orbit and three in inclined geostationary orbits. Beidou will consist of "open" and "restricted" services navigation, timekeeping and positioning functions and is expected to be a critical component of China's missile and intelligence, surveillance and reconnaissance capabilities.

Manned program: China's manned program is among its most compelling successes to date and includes activities around the Shenzhou series of spacecraft, Tiangong-1 space lab and on-going development of subsequent Tiangong missions, including the development of Tiangong-3, a large space station expected to be assembled around 2020, at approximately the same time the International Space System is scheduled to lose its funding.

China's manned space program is following a three-step strategic plan, which began with the successful completion of the Shenzhou-5 to Shenzhou-7 missions from 2003 to 2008 and was designed to launch Chinese astronauts into low earth orbit, conduct multi-day and multi-manned spaceflights with a safe return to earth. China is currently in the second stage of the plan, which seeks to introduce and perfect extravehicular activity, rendezvous and docking, launching a habitable space module into space and performing short-term manned space applicable experiments. This stage involves the launch of up to three Tiangong missions. Tiangong - 1 successfully docked with Shenzhou 10 on 13 June 2013 and performed a manual re-docking exercise on 23 June. No future manned missions have been announced and the spacecraft is expected to stay in orbit until its fuel runs out in approximately two years. Tiangong-2 is expected to be launched in 2015 or 2016 and will focus on earth and space observation missions.

Long- March Launch Vehicles: China has made progress in the development of the next generation of Long March / Chang Zheng launch vehicles. LM-5 is expected to have its first launch in 2015. The LM-5 is a heavy lift rocket capable of launching up to approximately 25,000 tons into space--more than double the current capacity of China's launch vehicles to place assets in geostationary orbit--and is expected to be the rocket used to launch the Taingong-3 space system and its modular components into orbit. The LM-5 is expected to be around 60 meters long with a core diameter of 5.0 meters. The three main stages are reported to use liquid oxygen and liquid hydrogen YF-77 engines mounted together, being developed by the Beijing Aerospace Propulsion Institute. China is currently building a fourth launch site at Hainan Island in order to accommodate the LM-5.

Additional LM vehicles are expected to include the LM-6, which will be used to lift payloads of 1,000 kilograms to 600 kilometer orbits; the LM-7, which is expected to lift payloads of 5,500 kilograms to 700 kilometer orbits; and the LM-11 the largest solid fuel rocket in the Chinese fleet, which is expected to be launched in 2016.

Kuaizhou Launch Vehicles: China has also developed a solid fuel launch and transportable launch vehicle known as Kuaizhou designed to be able to rapidly launch microsatellites into orbit during times of crisis. While China has focused on Kuaizhou's utility in responding to fast-moving natural disasters, the capability could also be used to rapidly replenish or augment satellite coverage in space during a security or military crisis or conflict.

Tianlian data relay: The Tianlian data relay constellation was completed in July of 2012 and will be a critical component facilitating communication from and to China's space-based civilian, commercial and military assets.

Lunar exploration program: The lunar program, like the manned space program, consists of three discrete stages designed to build upon the incremental advancements of the previous stage. Stage one (2002 - 2007) included the orbiting of Chang'e 1 around the moon. Stage two (2008 to 2014) included the launch of Chang'e 2 into a lunar orbit to collect data. Chang'e 3 landed on the moon and released the Yutu rover, which conducted a short exploration of the surface of the moon. On 1 November 2014, the Chang'e 5 T1 return vehicle landed safely on earth, successfully completing its mission to obtain experimental data and validate re-entry technologies such as guidance, navigation and control, heat shield and trajectory design for use during the third phase of the program set to begin with the launch of Chang'e-5 scheduled for 2017 or 2018.

Anti-satellite capability: China's 2007 kinetic strike against one of its expired weather satellites clearly demonstrated China's anti-satellite warfare capacity. While subsequent kinetic tests have not taken place, China continues to demonstrate capabilities -- such as co-orbital satellites equipped with robotic arms and high altitude missile tests--that show China's evolving capability to threaten competitor and potential adversary military satellite architectures.

Innovation challenges and technology gaps

As much progress as China has made in the last ten to fifteen years, the space program still faces developmental tests that will require it to mature enhanced skills and structures and get beyond the mere leveraging of civil-military integration and innovation initiatives focused on single technologies rather than complete systems. China will be required to create new technologies and perfect complex systems to move its program forward, meaning that the space program is currently confronted with an innovation challenge that is likely to grow more acute in the next decade as its space technologies advance to parity or beyond that of its closest partners.

China's ability to address three significant gaps-- integration and mindset; technical and scientific; and organizational--will determine the pace with which China is able to meet its current innovation challenge.

Integration and mindset gaps: China's space program is still developing its capacity to innovate in the more complex, highly-engineered and systems-focused sectors, such as aero-engines / propulsion systems, advanced sensors and C4ISR systems (outside of unmanned systems, an area in which China has demonstrated rapid growth). China's innovative capacity has long been focused on single technology innovation rather than systems focused innovation, and making this shift in mindset and approach, even with high levels of funding, will require time.

Technical and Scientific Gaps: A review of the focus-areas of China's extensive international engagement as well as writings by members of China's space industry and scientific community reveal several technical areas in which China's current space technologies and know-how are lagging:

- Engines / propulsion systems
- Sensors / remote sensing
- Radiation hardened components
- Satellite navigation systems
- High-speed communications for deep space
- Integrated applications
- Engineering standards and best practices
- Space science
- Carbon fibers

Organizational gaps: China's complex and overlapping network of centrally-controlled companies and subsidiaries supporting the aerospace and defense industry broadly has not engendered sufficient competitive dynamics to drive high-degrees of more systems-focused innovation.

China's attempts to drive innovation

China has recognized these three vulnerabilities and is in the midst of an effort to reduce inefficiency and redundancy; change mindsets; drive innovation; and, ultimately, provide China's aerospace and defense industry with sufficient scale to compete with the largest and most capable of Western primes both in terms of technological capability and in the global aerospace market. China's attempts to address its space innovation challenge include the following components.

Funding: China has demonstrated a sustained financial commitment to its space program and the industry that supports it. In August of 2014, CASIC signed a funding deal with the Industrial and Commercial Bank of China (ICBC) to support CASIC's development of a "new generation of technologies" related to space launch technologies, unmanned systems, 3D printing technologies, sensors and communication systems. The funding was also designed to support CASIC's renewed focus on exports, especially to Russia. The value of the funding deal is not immediately known, but is suspected to be between the hundreds of millions of dollars and low billions of dollars.

In addition, in January of 2015, CASIC and the China Construction Bank signed a new strategic cooperation agreement designed to strengthen cooperation in the development of the next generation of spacecraft and launch applications as well as cloud manufacturing platforms.

According to SASTIND, the deal extended CASIC's credit line with the China Construction Bank from 10 billion yuan to 20 billion yuan (from around $1.6 billion to $3.2 billion).

China has also sought to drive increased funding thought to be required to enhance competitiveness and innovation in China's aerospace and defense industry through the private placement of stock in state-owned companies. In December of 2013, Aerospace Communications Holding, a subsidiary of CASIC, raised approximately $127 million through the sale of just over 9 million shares of stock to select Chinese companies, including CASIC and its subsidiaries, which accounted for roughly 25% of the placement. The money raised through the stock sale will be used in part to help ACH expand its international presence and technological base through mergers and acquisitions.

Industry consolidation: The most impactful of the current reforms affecting China's aerospace and defense industry is the recent move toward consolidation of core state-owned enterprise activity, including activities carried out by CASIC and CASC, the industry pillars of China's space program. In June of 2014, SASTIND somewhat unexpectedly announced the signing of a cooperation framework agreement between CASIC and CASC that would require the two companies to "deepen consolidation further in order to improve competitiveness and sustainable development and support the realization of a strong space, military and aerospace industry", according to SASTIND. CASC's activities are more focused on space, but both companies produce satellites, communications equipment and missiles.

While the agreement does not explicitly mention merging the two companies, it does create a pathway for such an eventual move if SASTIND believes it would further enhance competitiveness with Western aerospace and defense primes and if such a complicated and politically tricky move could be effectively accomplished. CASC and CASIC were originally established through the breaking up of the Chinese Aerospace Corporation approximately 15 years ago.

The CASC and CASIC consolidation agreement is just one of a series of agreements and measures taken recently to consolidate commercial aerospace (2008) and shipbuilding (on-going) and to engender increased collaboration across its heavily redundant defense industrial base.

China's efforts to address its innovation challenge are likely to help move its space program beyond its current state, but, given the massive challenge associated with restructuring these large organizations and engendering new mindsets and processes into well-established organizations, it is unlikely that the full effect of these reforms will be felt until the end of the decade or beyond.

Effects of U.S. Export Control Restrictions

U.S. export control restrictions have affected the ability of China to procure or acquire critical technologies either directly from the United States and its space industry or indirectly through non-sanctioned providers, especially in Europe. China continues to lobby against both the U.S. space trade restrictions and broader U.S. and European Union arms bans against China. During the signing of the most recent agreement between China and France on 30 January of 2015, Chinese

Premier Li Keqiang lobbied French Prime Minister Manuel Valls, to "ease restrictions on export of high technology products to China", indicating that China still viewed these measures as an obstacle to the development of its space industry.

However, the combination of current U.S. policies, broad shifts in the global space industry and market and China's growth as a potential market are shaping both proximate challenges to the U.S. space industry as well as possible larger future strategic challenges to U.S. space policy and programs while not effectively managing the flow of advanced--even if not American--space and dual use technologies to China.

Concern over U.S. export controls on space-related items and confusion over which items are on the list of banned items for export and, importantly, which ones will be in the future, has led international industry, especially the European space industry, which has far less severe export guidelines for space technologies, to endeavor to design ITAR-free solutions, effectively cutting out U.S. based suppliers of ITAR - restricted items from international supply chains. Indeed, the presentation on Technical Constraints for the China Academy of Sciences - European Space Agency Joint Mission delivered at the first planning workshop between the two institutions in February 2014 highlights the importance of the "entire space segment" being "ITAR free."

The increasingly competitive and lucrative space industry is driving interest from high-end suppliers in the West in working with China on programs that do not involve the transfer of explicitly military technologies. The end-result is that more advanced--though not U.S.--space technology is being transferred to China *and* U.S. companies are increasingly being cut out of the supply chain for European partners or, alternatively, many U.S. companies are beginning to reconsider creating products that could be export controlled. Both outcomes have the potential to affect the U.S. space industrial base.

A longer-term concern related to U.S. refusals to engage China collaboratively on space science and technology issues is that over-time U.S. relationships with allies and partners could suffer, especially after the early 2020s when, barring a shift in current plans, China will be the only country in the world with a habitable space station. Space connections between U.S. allies and partners and both Russia and China are already being made. In early 2012, ESA openly discussed the possibility of Chinese space craft docking at the International Space Station--the U.S. has prohibited China's ability to access the station--or that a European spaceship will dock at the Chinese space station. Russia, too, has discussed similar manned spacecraft exchanges with China and is working with ESA on the ExoMars program after NASA removed itself from the program in 2011.

Certainly, the U.S. remains Europe's closest and most important space partner, and terrestrial geopolitical environments have shifted in a way that could limit the depth of engagement between these partners and Russia and China. Still, in a complex and uncertain geopolitical, economic and technological landscape, it is worth considering some plausible, if currently unlikely, scenarios in which U.S. export control and space policies enable growing isolation in space and what types of new or different policies, relationships, capabilities or approaches may be required to avoid this isolation.

Recommendations

Continue the export control review and refinement with a focus on increasing protection of a small number of systems and technologies that the U.S. is and should be unwilling to offer to the open market, for example technologies related to manned spaceflight. Such a fencing off of critical technologies should also allow U.S. companies to engage more fully around markets for technologies that do not pose a significant risk of supporting a shift in China's military capabilities and that China is likely already receiving through other technologically advanced suppliers.

Increase engagement with academia and law enforcement / intelligence to better understand technology transfer and proliferation challenges posed by cross-border academic interactions in areas of interest to China's intelligence services while maintaining the integrity and utility of the majority of these academic exchanges.

Engage China on space science, a relatively low risk area of engagement, that China's Academy of Science has identified as an area of development.

Increased / improved cross-government and industry engagement with allies and partners in space, cyber and joint domains.

OPENING STATEMENT OF MR. MARK STOKES
EXECUTIVE DIRECTOR, PROJECT 2049 INSTITUTE

MR. STOKES: Mr. Chairman, Commissioners, I'd first like to also express my appreciation for an opportunity to come here and make a presentation before this esteemed Commission, and it's an honor to speak here today.

The People's Republic of China, or China, for short, certainly has an ambitious space program and presents a number of challenges for U.S. interests in peace and stability in the Asia-Pacific region and in the world at large. In my presentation this morning, I'll focus on some of the PRC investment in the space technologies, but mostly focus on organization and process as it relates to research, development and acquisition.

Space in general is a broad topic because there's a lot of components to the various space programs, and the organizations involved in the space program, organizations that sponsor programs, are diverse, the bulk of them being within the PLA. There is a centralized approach to managing space programs, which is the People's Liberation Army, but with some leeway given to civilian organizations that also sponsor space programs to be able to suit their unique organizational missions.

If one wants to look at sort of the process, the research-development-acquisition process, you can start with the end user, the organization that would establish requirements, who says exactly what capabilities are required in terms of programs. Then move to acquisition management, then move over to the engineering, research and development, and then back to the end user who actually applies the technologies, particularly military relevant technologies.

Starting off with the end users, there's a whole range of organizations in the PLA that have requirements for space vehicles as well as counterspace assets within the People's Liberation Army. The main organization--bear in mind that, of course, that space programs and their research acquisition process is relatively opaque, particularly compared to ours and in other open societies.

But one can presume that a key organization, the requirement are the warfighters, the operators, particularly in the joint aspect, which would be the General Staff Department. Of course, there are four first-level Departments: General Staff Department; General Political Department; Logistics; and then Armaments Department, and I'll get to Armaments Department later.

But General Staff Department, or GSD, for short, presumably is going to be a major entity in establishing requirements, but even the GSD is not a monolithic entity because there are subordinate second-level departments within GSD that would establish, presumably establish requirements. Start with the Operations Department. The Operations Department is responsible for monitoring current operations and for managing joint operations, but also issues like meteorology, for example, weather satellites, things like navigation, navigation satellites, issues such as mapping satellites that would establish, for example, terrain elevation data, for example.

They would also establish long, for example, 15-year range or at least coordinate among the different entities for longer-range requirements out 15 years or so. Generally, short-term requirements tend to be a guide, five years. For example, five-year plans, which a lot of the programs operate within.

The second, the General Staff Department Second Department, or their Military Intelligence Department, is also a key, presumably is going to be a key organization driving requirements for electro-optical satellites, synthetic aperture radars, and may perhaps synthetic

aperture radar satellites.

The Third Department, or the Technical Reconnaissance Department, responsible for signals intelligence and cyber reconnaissance, presumably has a significant role in perhaps signals if there is a communication intelligence packages and satellites, for establishing that requirement, as well, they also have a role in space surveillance, passive space surveillance, working with other organizations.

Of course, the services and other branches, the Navy, Air Force and Second Artillery, presumably would have a role also in defining their requirements in working in conjunction with the General Staff Department.

The Fourth Department, of course, is another one in terms of counterspace, a major role in counterspace. The Fourth Department is responsible for electronic countermeasures and radar. So when it comes to, for example, jamming, satellite jammers, the Fourth Department will play a significant role.

But in terms of satellite procurement and also satellite launching, the General Armaments Department is also a key player. They also manage large national level engineering projects, and they have offices dedicated, for example, the 921 Engineering Office has responsibilities for program management and acquisition management for the manned space program.

So there is a broad range of players that are involved, and there's also civilian players as well. For example, the State Oceanography or Oceanographic or Maritime Administration would also presumably play a role in developing requirements for maritime assets.

There's, of course, also the space surveillance, the ground-based space surveillance is also a key, is also a key organization that is often not given enough attention.

So within this requirements development, you have the engineering research or the Research, Development, and Acquisition system, which has been in place since the 1960s, influenced in part presumably by the United States in the 1960s. PPBS, Planning Programming, the PPBS system plays a role, but also the former Soviet Union's system of chief designers and the design system. China is unique in certain aspects because they also have a program manager that is responsible for administrative aspects of the program so there's a dual command system for various programs.

They operate in at least four different phases for satellite research-development-acquisition. Preliminary research would be the first phase focused on basic technologies, then move on to the concept, concept development and program validation phase to be able to sort of focus in on whether or not, to decide on whether or not to invest resources in the engineering R&D.

And then you mentioned the two major organizations, China Aerospace Science and Technology Corporation, and Science Aerospace--Aerospace Science and Industry Corporation. But the key organization would be the design departments that would focus on particular types of satellites of which there are two major ones, one within the CASIC Fifth Academy. They have a Design Department. And then within the Eighth Academy based in Shanghai. Sort of two clusters of where they sort of focus on satellite, satellite development.

There has been discussion, of course, on sort of reaching out to international partners and traditional forms of intelligence collection to be able to augment or inform their requirements process. It's difficult, it's difficult to say exactly what role this plays in terms of how, in terms of breakthroughs, but one could say with some reassurance that if there are programs, presumably there are programs, clandestine programs and technical collection programs, that a lot of these would focus on the early stages of their research and development cycle to be able to master

specific technologies and overcome bottlenecks that would plague some of their programs.

So with that, I'll turn it over and try to attempt to answer some of your questions.

PREPARED STATEMENT OF MR. MARK STOKES
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Prepared Statement of
Mark A. Stokes
Executive Director
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Before
The U.S.-China Economic and Security Review Commission

Hearing on China's Space and Counterspace Programs

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Mr. Chairman, thank you for the opportunity to participate in today's hearing on an issue that is important to U.S. interests in peace and stability in the Asia-Pacific region. It is an honor to testify here today. The evolving capacity of the People's Republic of China (PRC) to leverage space assets presents a number of challenges for the United States, allies, and friends in the Asia-Pacific region. In my presentation this morning, I will address PRC investment into militarily relevant space technologies and offer a basic outline of its research, development, and acquisition system.

The PRC has embarked upon an ambitious dual-use, civil-military space program that is predominantly driven by the desire to stand among equals in the international community. However, as in most space programs around the world, there is a prominent military application. The Chinese People's Liberation Army (PLA) is gradually developing a 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 PRC is improving its ability to research, develop, and field innovative capabilities and advanced weapon systems. Increasingly sophisticated space-based systems expand PLA battlespace awareness and support extended range conventional precision strike systems. Space assets enable the monitoring of naval activities in surrounding waters and the tracking of air force deployments into the region. The PLA is investing in a diverse set of increasingly sophisticated electro-optical (EO), synthetic aperture radar (SAR), and electronic reconnaissance assets. Space-based remote sensing systems also provide the imagery necessary for mission planning functions, including automated target recognition technology that correlates pre-loaded optical, radar, or infrared images on a missile system's computer with real time images acquired in flight. A constellation of small electronic reconnaissance satellites, operating in tandem with

SAR satellites, could provide commanders with precise and timely geolocation data on mobile targets. Satellite communications also offer a survivable means of linking sensors to strike systems, and will become particularly relevant as PLA interests expand further from PRC borders. Existing and future data relay satellites and other beyond line of sight communications systems could transmit targeting data to and from theater command elements. An increasingly diverse and reliable family of launch vehicles is available to support various missions and payloads. In addition, the PLA is developing mobile or air launched solid-fuelled launch vehicles for placing small tactical satellites into orbit during crisis situations.

The PLA also is modernizing its ground-based surveillance and tracking system in order to meet demands presented by its expanding presence in space and defend against perceived air and space challenges. Supported by an improved surveillance and tracking system, the PLA has demonstrated a rudimentary ability to engage flight vehicles in space, such as polar orbiting satellites and medium range ballistic missiles. The PLA appears to be investing resources into ground-based radar systems capable of providing queuing quality data for engaging targets in space. The PLA also has invested in electronic countermeasure technologies that could degrade an adversary's satellite communications, navigation satellite signals, or SAR satellites operating within line of sight of an emitter.

Overview of Military Space Organization and Requirements

Guided by the Chinese Communist Party Central Committee Political Bureau, the Central Military Commission (CMC) and State Council establish national space and counterspace requirements. Within a broad and fragmented party and state policy framework, a diverse set of end users develop space-related requirements for CMC/State Council approval, based on organizational roles and missions. The end user of a particular system most likely drafts detailed requirements documentation based upon short (e.g., five year) to long term (e.g., 15 or more years) plans. Civilian organizations, such as the State Oceanic Administration, appear to develop requirements for satellite programs in support of their unique missions.

The PLA's operational and technical requirements development system remains opaque. However, second level departments within the General Staff Department (GSD) presumably develop and coordinate operational requirements for militarily relevant space-based surveillance, communications, and navigation systems. More specifically, the GSD Operations Department probably develops operational requirements for navigation, weather, and mapping satellites. The GSD Intelligence Department (also referred to as the GSD Second Department) most likely is responsible for dedicated military EO and possibly SAR satellites. The GSD Technical Reconnaissance Department (also referred to as the GSD Third Department) and GSD Electronic Countermeasures and Radar Department (also referred to as the GSD Fourth Department) and probably shape requirements for space-based electronic reconnaissance systems. The Fourth Department also is responsible for satellite electronic countermeasures, while the Third Department supports China's space surveillance system. The GSD Informatization Department would establish requirements for dedicated military communications satellites. Operational requirements presumably are coordinated with the PLA Navy, Air Force, Second Artillery Force, and the seven regional military commands.

The PLA's General Armaments Department (GAD) supports the CMC/State Council in the development and acquisition of technical solutions to satisfy operational requirements. The GAD develops, coordinates, and oversees defense acquisition and technology policies for the CMC, and likely manages space systems acquisition on behalf of GSD. The GAD is responsible for development of space launch requirements, as well as tracking and control of civilian and military satellites and other orbital systems. The GAD also manages China's National Space Command and Control Center, and oversees large national-level space engineering projects, such as the manned space program. The GAD S&T Committee functions as the CMC's principle advisory group addressing China's long term defense technology development. GAD-managed working groups, comprised of leading authorities from across China's civilian and military S&T community, establish technology development and acquisition priorities. The State Council's China National Space Administration coordinates and executes international space cooperation agreements.

Space Research, Development, and Production

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 R&D were established in the 1960s and, with some exceptions, appear to have changed little over time. How much China spends on defense and space R&D remains unclear. Based on CMC/State Council planning, programming, and budget guidance, however, space-related R&D may consist of four phases. A phased approach calls for multiple variants of the same basic space system to be 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 GAD, GSD, and other end users function as important supervisory bodies for projects in this phase.

During the *concept development and program validation phase*, an end user, working in conjunction with defense industry, identifies key technologies, determines the feasibility of a program, and assesses alternatives that could meet basic operational and technical requirements. The concept and program validation phase draws heavily on results from preliminary research projects. PLA equipment research academies, technical bureaus, and research institutes appear to play a major role during this phase. Major programs likely require CMC/State Council-level approval before investing in engineering research and development (R&D).

During the *engineering R&D phase*, two civilian defense industrial enterprises -- the China Aerospace Science and Technology Corporation (CASC) and China Aerospace Science and Industry Corporation (CASIC) support the CMC/State Council and end users 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 the PLA'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 hold concurrent positions within CASC's China Academy of Space Technology (CAST) General Design Department and Shanghai Academy of Space Technology's Institute of Satellite Engineering. Chief designers are also assigned for space launch vehicles, including those delivering anti-satellite kinetic kill vehicles. To ensure requirements are met, PLA end users 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 or not 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.

Concluding Remarks

In short, PRC space-related ambitions are driven by political, economic, and military considerations. With a broad mandate granted by party and state authorities, the PLA plays a leading role in developing operational requirements for militarily-relevant space systems, overseeing technology development that could satisfy operational requirements, and managing the national space launch, tracking, and control system.

China adopts an incremental, phased approach to space-related R&D. In supporting CMC/State Council-approved acquisition projects, the PLA GSD, GAD, and other end users rely on the space and missile industry for engineering R&D. Engineering R&D is characterized by an industrial dual chain of command that divides administrative and technical responsibilities.

China's space and missile industry – CASC and CASIC – stand out as perhaps the most technically successful defense enterprises in China today. While basic approaches to R&D appear to have changed little over the decades, innovative organizational changes within the PLA and space industrial structure could enable significant advances over time. Among these include establishment of formal and informal organizations intended to facilitate collaboration between the PLA, industry, and academia for purposes of diffusing space technology.

The PRC's capacity to field increasingly sophisticated space systems is largely a reflection of its organizational efficiency and an expanding pool of capable engineers. Chinese space development also has benefitted from foreign successes. In addition to formal bilateral space cooperation relationships with Russia and other space-faring nations, each industrial academy oversees an information collection and dissemination institute that diffuses publicly available technical data from around the world. PLA operational requirements, technology development, and engineering R&D are also likely informed by intelligence collected through traditional clandestine human sources and signals intelligence (including cyber espionage).

END

PANEL II QUESTION AND ANSWER

HEARING CO-CHAIR FIEDLER: Let me start off, and I am certainly not a scientist or an engineer, but I understand a couple of things, I think, that in science you have to build on the previous discovery, even technology you have to build on, so incremental doesn't surprise me once you accomplish something.

I'm interested in Chinese space activities focused on their littoral defense. So we do a pivot to Asia, they are most concerned about their shoreline and their immediate neighborhood, and they have "x" number of satellites, 100 and something satellites, and there is the capability to put satellites in geosynchronous orbit that are virtually stationary; right?

And they're concerned about Japan, they're concerned about India, and they're concerned about the United States in the Western Pacific. That's, I mean I think--am I correct that that's fairly accurate in terms of their immediate concerns?

So explain to me how their space assets are directed towards that objective. Surveillance, remote sensing, weather--are they concentrated in their own backyard?

DR. KROLIKOWSKI: I'll just take a really quick stab at this and let my fellow panelists say a few more things to fill it in.

I think that of China's space programs and space pursuits that have the greatest implications for its littoral defense, the most important are probably the programs that support military communications, that support precision guidance, satellite navigation, and weather satellites - so satellites that support the actual conduct of military operations in that area, and intelligence-collection satellites, like the range of Earth observation satellites that China is currently developing, including for maritime domain awareness. Those are probably the programs that have the greatest impact on the area you're describing.

As for the GEO satellites--

HEARING CO-CHAIR FIEDLER: Let me just interrupt you. Do we know that of the 100 and some odd satellites that they have that those are concentrated in the areas that you just described?

DR. KROLIKOWSKI: If you mean physically concentrated--

HEARING CO-CHAIR FIEDLER: I mean I understand--

DR. KROLIKOWSKI: Like focusing on them?

HEARING CO-CHAIR FIEDLER: Well, I understand that satellites are earth usable, right, unless you put something up in a geosynchronous orbit and station it there. So, for instance, a simple question: how many geosynchronous satellites that are stationary that over the Western Pacific are there that China controls?

Anybody know?

MR. NURKIN: No.

MR. STOKES: Are you talking about pure military use or both civilian and military? Because if you're--because, of course, you're going to have--

HEARING CO-CHAIR FIEDLER: You can use them. They're synonymous to me in terms of the state in the PRC. If they want to use them for military purposes, they will.

MR. STOKES: I don't have the number off the top of my head.

HEARING CO-CHAIR FIEDLER: Okay.

MR. STOKES: But one could easily say, at least roughly on the civilian communication side that they can have direct control over, notionally let's say at least six civilian and maybe four military.

HEARING CO-CHAIR FIEDLER: Okay. Mr. Fisher, who is on the next panel, is raising his hand. He's got the numbers. So I will leave that to the next panel then.

You all paint a sort of picture of organizations, but it's less possible to paint a picture of the dynamic, the decision-making dynamic; is that fair? Do we have any real insight into the decision? I mean somebody has got to be superior. I mean not entirely superior all the time, but somebody has got to be calling the shots a little more often than some others, and, Mark, what are you--

MR. STOKES: You can start at the top. Ultimately it is the Chinese Communist Party Central Committee Political Bureau that gives general direction on overall requirements for their space program, and that's the ultimate decision authority.

At the next level down, Central Military Commission and the State Council would approve any program that is defined as a major and key.

HEARING CO-CHAIR FIEDLER: Let me rephrase my question actually. On the 2007 ASAT test, have we learned anything in the subsequent eight years, seven plus years, about that decision-making process?

MR. STOKES: I assume within the U.S. government there are people that have insights on exactly what happened in that, but sitting from the outside, there's--

HEARING CO-CHAIR FIEDLER: You wouldn't think that the U.S. government stuff would leak out into the open source material on the decision-making process? I mean you don't have to get into sources for that.

COMMISSIONER BARTHOLOMEW: Let him answer his question.

HEARING CO-CHAIR FIEDLER: Yeah, go on.

MR. STOKES: But in terms of--this is where process comes in in about exactly what we were talking about in that test, and exactly who is the one who at what stage in the process, in the research-development-acquisition process, was that in? If it was in the industrial R&D process, then that would have been the, notionally, let's say China Aerospace Science and Industry Corporation, CASIC, Second Academy, and the chief designer which would want to be able to prove the feasibility or to be able to prove, to be able to test the prototype that they had.

And they would rent out, they would rent out space, work with the General Armaments Department on leasing. In this case, it would be the Xichang Space Satellite Launch Center, and the decision would be, again for the testing and the approval authority, would be Central Military Commission, the State Council. It would be what's called the Design Finalization Committee that is manned by representatives from both CMC and State Council.

HEARING CO-CHAIR FIEDLER: Yes.

DR. KROLIKOWSKI: I think in the years since 2007, we've learned that major space programmatic decisions usually are approved at the very highest levels of the civilian leadership, and the early speculation around the 2007 anti-satellite test about military actors going rogue and testing programs without any oversight were probably not substantiated.

We also know that the circumstances that led to the conduct of that test in the way that it happened probably don't obtain anymore. So we're not likely, we haven't so far, and we're not likely to see in the future, the conduct of another test without a more coordinated, developed and sophisticated communication strategy around it occur again.

So essentially I think the leading experts who look at this subject agree that today you're not likely to see an event that compares to the 2007 test. It's likely to be a much more coordinated, orchestrated effort with much more effective communications to external audiences. China's tests of similar systems since then bear that out.

HEARING CO-CHAIR FIEDLER: So their stealth aircraft flying around the day before the Secretary of Defense was just a smart message-sending exercise?

Senator Talent.

HEARING CO-CHAIR TALENT: I wanted to follow up on a piece of Mr. Nurkin's testimony, and maybe he might want to comment further, and then I'd like to know what the two of you think. You made the comment with regard to innovation that what we know about the Chinese system is that it's pretty top down. That tends to be true in every area of governance that they really care about; right? We just heard that decisions are made, even programmatic, at the highest levels.

And also that we have this sprawling system of a bunch different entities that have input, and we're not certain what kind of input they have.

Now, in my familiarity with American government is that--I'm about to agree with you, Mr. Nurkin--when you've got a top-down system, number one, and number two, you have a bunch of different offices and entities involved in decision-making, it tends to slow things down; it tends to retard innovation. You tend to take a passive risk-averse approach to things.

So if you want to elaborate, Mr. Nurkin, please do, and then do the other two of you agree with that, that this is an inhibitor on innovation? And does it suggest that they might have great difficulty getting these quantum leaps, these whole new systems going which might then place a greater emphasis on further cyber espionage and attempts to steal what they can't produce?

MR. NURKIN: Very quickly elaborate. I would say that the one, one of the areas, I wouldn't say the only, but a big one, that Dr. Krolikowski mentioned, that I think maybe doesn't fully eliminate the top-down--obviously, I believe that it does inhibit innovation at that level--but I think the idea that there is a compelling vision here, and this is a program with enormous political support in large part because its objectives go beyond just putting satellites in the sky. I mean this is obviously geopolitical and military. It certainly is part of a national development objective to get China to be the leading science and technology country in the world by the middle of this century.

So I think there is some, you know, I think that that top-down structure can certainly inhibit innovation, but I think the idea that there seems to be some overarching strategic viewpoint about this program, you know, doesn't eliminate that, but I think it's something worth mentioning as one of the ways in which innovation might be able to eventually crop up. I think underestimating China's ability to innovate over time is probably a bad idea.

So just simply saying it's top-down and it will never work, I think it just means that we have to build in a little bit of a realistic expectation of the timelines and what sort of measures, policies could they, could China enact that could speed this up, and we see them trying new things to varying degrees of success.

MR. STOKES: I can make a few points. First, it's hard to define what innovation is, but the greatest room for innovation would come in a realm in which it's a wide open playing field in which the United States actually just isn't playing. The most obvious, the sort of sister counterpart of the space issue on the industrial side, of course, would be missiles, and it's a wide open playing field for China, and they have room for innovation because there's nobody else developing land-based conventional ballistic missiles with ranges, well, with some few exceptions, but generally nobody else is developing ballistic missiles with ranges, conventional ballistic missiles with ranges between 500 and 5,500 kilometers. The U.S. and Russia, with the INF treaty.

But organizationally, there are changes that are being made that could aid in innovation, particularly the establishment of what are called research and development centers, which are related to Design Departments but are focused on developing innovative technologies, but to iterate, this last point, I think to pull a thread on something that Tate threw out, which is the idea of incremental approaches to research and development, they have what's called the "three moves on a chessboard" approach to research and development, and again why the phases in the R&D process are important. The idea is that once you have an initial, a variant of a particular space system that enters into low-rate initial production and it's signed and certified, then they will initiate roughly around the same time, afterwards, they will initiate research and development on a follow-on variant with some incremental improvement.

In the same time, they will begin preliminary research on a generation-after-next system. So it's a relatively standardized process, roughly maybe equivalent to what we have in our spiral development programs in the U.S., and so there is this incremental approach.

But the key thing is that it also gets people thinking from the very start about a generation-after-next system, and that once the system enters, a first variant enters in initial production, then there is already thinking about a generation-after-next, not just a follow-on, but even a follow-on-after-next.

DR. KROLIKOWSKI: I agree that a top-down system is a mixed blessing. It can inhibit innovation if we understand innovation broadly as the set of processes that lead to building better products, cheaper, or more highly performing products. If that's the case, then I agree that top-down institutions and structures will sometimes inhibit innovation, but other times they won't.

I think it depends on what your space programs are trying to achieve. If a space program is pursuing world firsts, if it's operating at the frontiers of technical possibility in many areas, if it's doing proof-of-concept-type activities, then probably for a program like that, rigid, long-term strategies are going to be suboptimal or maybe even unfeasible. For projects like that, the top-down coordination and integration of strategies and policies serving different users and different needs is likely to be clunky, hindering, or unworkable.

But for now that's not what China's space programs are doing. They're largely pursuing objectives that they know are technically feasible. They're not operating at the frontier of technological possibility so they're able to identify long-term, distant technology goals and plot a relatively systematic course for how to reach them.

So a more rigid or a more structured, top-down, coordinated strategy that actually attempts to harmonize different elements of different space programs is probably optimal for that stage of space development. At minimum, it appears to bring significant advantages in the Chinese context.

U.S. space experts talk about the stability of Chinese budgets and the stability of major programs that their Chinese counterparts enjoy as circumstances that they wish they had. We also hear U.S. space experts, as my colleagues have said, speak of the strong, lasting political support that their counterparts in China enjoy.

And there are also ways in which a holistic industrial strategy that is probably rigid and top-down can actually bring some efficiencies. It might be more wasteful in the case of some particular space activities, but for most of them it is likely to be more efficient.

We know that, for example, that U.S. government agencies would prefer to buy space services or assets in bulk, which they could only do if they had longer timeframes within which to plan and conduct their procurement and acquisitions. In China, those types of efficiencies can be realized because of this top-down system.

HEARING CO-CHAIR TALENT: Yeah. Everybody here likes to say you can't solve problems by throwing money at it. Actually there are some kinds of problems, not the most efficient way of solving, but you can solve by throwing money at.

HEARING CO-CHAIR FIEDLER: Commissioner Wessel.

COMMISSIONER WESSEL: Thank you all for being here.

I saved on my phone a headline from a year or so again, "Pentagon Using China Satellite for U.S. Africa Command." And I'm aware of what happened afterwards. But I don't think that's something the Chinese would ever do is try and procure services for their military commands from a U.S. or foreign satellite.

So help me assess our capabilities. We're going to be talking about implications later on. But China is now continuing its launch presence. The U.S. launch capabilities are in question. We're privatizing some, et cetera. I understand that there are many aspirational goals, but it seems that China has done a pretty good job of closing the gap.

What gaps should we be concerned with? When you look at our own military that has to procure services from a Chinese satellite service provider, and that, of course, never should have happened in the contracting system, what risk assessments can you help us with, and what crosses the line in terms of what we should be doing with the Chinese or what you think they would ever do with us?

Mr. Stokes, do you want to jump in?

MR. STOKES: You mention the word "gaps" between our capabilities in terms--and then our investments and Chinese investments, the first thing that comes to--

COMMISSIONER WESSEL: How important are those gaps? I mean--

MR. STOKES: The first thing I think of are our programs that the PLA is investing in which I don't think we're really investing very much at all, and the first thing that comes to mind is something that is not necessarily space but very near space, and it's actually called near space. It's that domain between roughly 20 kilometers and 100 kilometers, just doesn't quite reach orbit, but it's not necessarily breathing the normal air that aviation assets would.

And this is an area where China appears to be investing significant resources. It's an area where the U.S. Air Force, I know, was looking at and was investing in, let's say, middle, maybe five, six, seven, eight years ago. There was a couple of experimental programs that we had, but in the case of the PLA, there appears to be a significant cooperation between, for example, the Second Artillery and China CASIC, specifically on 68 Base on Hunan, that appears to have a significant responsibility for development of these, these platforms that operate at very high altitude, very slow movers, high-altitude airships, for lack of a better term, that are very difficult to be able to pick up on radar basically because some of the materials, but it also gives you a near field of view in terms of reconnaissance assets and electro-opticals are--so that's one area, one gap I think that that's significant.

And there are others, of course, in the area of counterspace. Jamming. Basically trying to master the electromagnetic environment is significant. I don't know what we have in terms of our investments, but the PLA most certainly seems to be investing significantly into that aspect of counterspace.

MR. NURKIN: I would pick up on the electromagnetic. I mean that was where my mind first went, is that this is an area that CNO has highlighted as being especially critical to naval operations in the Western Pacific, that the electromagnetic hygiene of the U.S. Navy is, it's not that it's bad. It's just that we haven't thought about for so long, and it's clear that China is thinking about electromagnetic hygiene, ours and theirs.

I would say, though, that I mean, you know, this is an iterative competition so whatever China does, whatever capabilities are developed in space, near space, you know, they will elicit a response. They also can create vulnerabilities. You know, we talk a lot about Beidou being a way to delimit its reliance on U.S. GPS, but at the same time it creates 35 satellites in space that it relies on for civil and military operations. So I think that's one thing to also remember, is that China will be taking steps that it also has to think about its implications.

We always, you know, it's sort of a Clausewitzian axiom that we always give our adversaries more credit than we--we highlight their strengths and highlight our deficiencies, and I think that's probably a nice place to start, but it's also worth mentioning that there are vulnerabilities that will be introduced.

The other thing I would say is around the vision again, the vision in our space launch capability. In the last panel, it came up towards the end again that our allies are watching with close interest what happens, and if it turns out that after 2020, there's one space station in orbit, and it's not ISS, and it's Chinese, and they already have a good relationship with China, particularly the Europeans, and they don't necessarily perceive the China threat or challenge in the same way that the United States does in the Western Pacific, that there may be opportunities there for diminishing of U.S. relationships with key allies as well.

COMMISSIONER WESSEL: Doctor.

DR. KROLIKOWSKI: Thank you.

I take a similar view in the sense that I think it can at times be misleading to overfocus on technology gaps that China is closing because that might direct attention toward areas that are not important. I think space technologies, space capabilities, are means to ends, and we have to first start reasoning from the ends that these means are supposed to serve.

So rather than letting Chinese advances define where U.S. interests lie or what capabilities the U.S. should be focusing on developing, I think U.S. decision-makers should ask themselves what type of war does the U.S. expect to fight in the future? What demands does it expect to be placed on its military? And what are the systems that will allow the U.S. military to meet those demands?

But trying to stay ahead of China in particular areas just for the sake of it might, in a sense, close one's strategic imagination. 9/11 was arguably one of the most disruptive and catastrophic events in the history of U.S. national security, at least in the post-Cold War period, and it didn't rely on sophisticated technologies.

So keeping a technological edge over your adversaries is no guarantee of security. I think the U.S. really needs to focus on what its own interests are, what the environment in the future is expected to be like, and build the systems that will allow its forces to perform in that environment, do what China may.

COMMISSIONER WESSEL: Thanks.

HEARING CO-CHAIR FIEDLER: Commissioner Shea.

VICE CHAIRMAN SHEA: Yeah. I would agree that having a technological edge is no guarantee of your security, but it's always good to have a technological edge. I'd rather have the technological edge than not.

But I'm going to use, Dr. Krolikowski, two of the three framework pieces that you cited in your testimony: vision and resources. And if we could just sort of kick it up to really a high level here. With respect to vision, what is China's vision in space? What does--and I'll ask a secondary question there. Does it want to be the leading space power in the world? Does it want to obtain military dominance in space? So that, you know, that's the vision question.

And then, secondly, the resources question, are they--I know we've received testimony that we don't know really how much money they're spending on their space program, but what, how would you--are the resources there to achieve the vision that they've set out? I just looked at this remarkable piece of technology and learned from a CRS report a few minutes ago that the Manhattan Project at the peak years of funding was one percent of federal outlays in the United States, the Apollo Program was 2.2 percent in the peak years of federal outlays, and both programs were about .4 percent of GDP, represented 0.4 percent of GDP, which represented a significant commitment behind both of those programs here in the U.S.

So is China adequately resourcing its vision, and even in time, we're going to see an economic--we're seeing an economic downturn in China. Is this a program that will have a special position when tougher choices need to be made about allocating resources? That's a lot of questions.

Who wants to start?

DR. KROLIKOWSKI: Okay. I'll just say--

VICE CHAIRMAN SHEA: Vision and resources.

DR. KROLIKOWSKI: Vision and resources. I think China's vision for space is essentially just one dimension of a much larger vision. I think the overarching vision of China's leaders today is to make China a strong country- a country with a very strong economy and a strong military that's able to defend what its leaders define as core national interests.

That strategy is pursued in many different areas, different sectors, especially high-tech sectors, and space is one area, one dimension in which that strategy is translated into concrete programs that serve that overarching objective.

So I don't know if Chinese leaders need to spend much time worrying about whether they would be the dominant space power. They probably spend a lot of time worrying about how space programs can make China's economy stronger and its military more capable.

But I don't know if the dominance question, per se, is intrinsically important. Space serves this broader vision for China.

On the question of resources, undoubtedly the the central government in China, as it siphons up taxes and other resources from across the Chinese economy, is in this decade wealthier than it has ever been before. Its coffers are full, and it's eager to invest public resources in areas that it thinks will be productive, will yield benefits. Space and other high-tech projects are such areas.

I think we are best to stay away from assigning specific figures to China’s space spending. Given the complexity of pricing mechanisms and other features of China's defense industries, even if we had figures, we wouldn't necessarily know how to interpret them or make much use of them. So I think it's just helpful to assume that Chinese programs are well funded. It is perhaps most prudent to assume that there's a range of possible funding totals for these programs and that they are funded at the top of that range.

VICE CHAIRMAN SHEA: Thank you.

MR. NURKIN: So to the first question on objectives, I think much like the technological development thing that we talked about. It's a bit incremental. I think there are stages into what China wants to achieve along different time lines, but I think most immediately, militarily, at least, certainly space is a huge, is a big component of national development. It very much wants to be the dominant space and technology power by 2050. It's a repeated goal by the China Academy of Sciences and other political leaders.

But I think in sort of the more immediate decade to 15 years, space is a very important

domain in order to fully develop and deploy counter-intervention capabilities, and it needs to be good enough in space to keep the U.S. from operating freely within the first island chain and the second island chain, and that's a key domain.

On the funding question, again, I don't know about the total funding except to say that I agree that it is sufficient. There is, at least anecdotally, two years ago, 2013, I think was the--the name of the conference slips my mind, but it was held in Beijing, and the question was asked. They had the head of the China National Space Association and NASA on a panel, and asked what the biggest challenge was, and NASA, the head of NASA said it's vision and it's funding, and the head of CNSA said it's technology, it's not money, it's not political support.

So my guess is that's reasonably enduring. It's a higher priority than some other. So if there's a hard landing in China, space would not be at the bottom or top of the list of things to be cut.

VICE CHAIRMAN SHEA: Thank you.

MR. STOKES: Vision and resources. Starting off with vision, I don't necessarily think that there's a single vision because, again, space is a very broad, broad subject, but one could break it down to political vision, economic vision and military vision.

Political, space means legitimacy. Being able to have a manned space program, particularly having one that's the highest profile at a particular time, gives the Chinese Communist Party legitimacy, both domestically and internationally.

For example, the United States and the former Soviet Union competed in space, again, for the dominancy. The competition was over whose, which particular political system is able to mobilize resources the best, and the competition in science, technology and space certainly was an area of this competition.

In terms of economy, I think there's some degree of competition with China's industry and their State Council, trying to gain advantageous position in space-related economic activities. Satellite launches, satellite sales, communication satellite sales, and I haven't done a comparison on how industry is doing as compared to Chinese industry, but they've had quite a few significant sales of communication satellites.

Maybe in the future sales of remote- sensing imagery, what we have, sale of remote-sensing satellites and a whole range of other services, navigation services, in order to be able to gain a dominant position in that domain.

Militarily, certainly the idea it's all about freedom of action in space. It's being able to deny the United States and other potential adversaries the freedom of action in space, particularly in the region and their main area of interest within, over China and the periphery of China, and also be able to maintain their own freedom of action in space, bearing in mind they're not in terms of relative comparison not quite as reliant as the United States is on space assets, but still in terms of over-the-horizon communication and a whole range of other military requirements, they certainly have requirements.

So those are three areas I would divide in terms of the vision aspect.

Resources. I think it would be a fascinating study actually to do, and you could get a whole range of people. Congress certainly has the power to be able to write in requirements to do reports to Congress on how much China spends on space, ensuring how you define space in terms of investments in different aspects of space programs.

I bet you would find, just a hunch, that you probably would find very little of the military budget going towards space, and you have a lot of those programs being funded under the State Council, the State Council budget, especially in terms of basic research and development. I don't

think we have a good handle on their research and development budget in general for military, defense R&D budget in general.

I think there is probably enough in there to get a general sense of how much they invest in R&D each year, but to me that would be a fantastic thing I think for Congress to look at to be able to answer that question.

VICE CHAIRMAN SHEA: Thank you.

HEARING CO-CHAIR FIEDLER: Commissioner Tobin.

COMMISSIONER TOBIN: Thank you.

I want to dig deeper in a couple areas, and it is in the gap area; in part because you're experts, and I want to get very clear on it.

Mr. Nurkin, you spoke about innovation and identified three areas where you think they have significant gaps: technologically; organizationally; and then mind-set gaps, and that's the one I want to go a little bit deeper on and hear from each of you.

Having worked in Silicon Valley and seeing what it takes to get new products and systems out, the toughest thing is the systems thinking. And the toughest innovation is that too. Is that the kind of gap you're looking at? Can you tell us more and, specifically, Mr. Stokes, Dr. Krolikowski, you spend a lot of time in China, what are those gaps and how capable are they of doing effective space integration?

MR. NURKIN: I think today this has been certainly something that shows up repeatedly or frequently as being a vulnerability. I think the mind-set, you know, again, back to Dr. Krolikowski's point earlier about this, some of it has to do with objectives. If the objective is to continue along these programs where the technological innovation isn't that much further progressed from 50 years ago--some of it is, but, you know, going to the moon and coming back is something that was done decades ago.

So I think it's really more about as China looks to take some of those big first steps, the ability to integrate these systems will become more, to my mind, more relevant, and I think it is a challenge. It's a demonstrated challenge today. So I, you know, I think that one point is the demographics, that there is, this is a younger industry in China so maybe there is--that is one thing that could be leveraged to drive more innovation is a more youthful mind-set, but I think right now it stands out as one of the challenges for China. Yeah.

COMMISSIONER TOBIN: Thank you.

Mr. Stokes.

MR. STOKES: You mentioned systems engineering.

COMMISSIONER TOBIN: Yeah.

MR. STOKES: I'm not sure if that's really a huge problem, or if it was a problem in the past, then it's not much of a problem now. Putting a man in space, when you look at the supply chain and all the different, all the different components to that, it's pretty significant, and they've proved the ability to be able to do that, put a human in space and bringing the human back alive. They've managed to do that.

When you look organizationally, again, not necessarily--let's look at, for example, just a simple, not a simple, but a satellite program. In terms of the supply chain, they have an organization that's established which, again, goes back to the design system, the system engineering. They have a system set up.

As a matter of fact, the system is Satellite System Engineering Departments, which the Chief Designer is assigned, and then you'll have roughly, let's say, maybe six Deputy Chief Designers, and you'll have what are called Leading Technicians, and so they have--but these

Leading Technicians are going to be in different research institutes, and they wear different hats, but the ability to bring these teams together--

COMMISSIONER TOBIN: Right, right.

MR. STOKES: --to be able to achieve breakthroughs I think is something that they made significant advancements in.

COMMISSIONER TOBIN: So less of a gap than I might have been concerned with.

MR. STOKES: I mean there's certainly, certainly shortcomings in overcoming some of the bureaucratic organizational hurdles. To me, the most significant gap isn't necessarily in the quality of engineers, not that they have good engineers. To me it's the omnipresence of the Chinese Communist Party and Party apparatuses that permeate throughout the bureaucracy.

COMMISSIONER TOBIN: Thank you.

DR. KROLIKOWSKI:

It's sometimes helpful to distinguish between innovation writ large and advances in system integration versus system engineering – because the difficulty of these tasks will depend upon what systems we're talking about. In general, I'm inclined to agree with Mr. Stokes. If we're talking about the challenge of integrating complex systems, then we've seen steady progress and a significant record of achievement in Chinese space programs.

If anything, the greatest challenges going ahead may lie in things like ensuring consistency in serial manufacture or other related processes, but not necessarily in areas like concurrent engineering or complex systems integration.

In terms of innovation writ large in China, I think Chinese scientists and engineers have been consistently underestimated. They have a significant record of accomplishments in space to show for their efforts.

I also think we're unaccustomed to the idea that there are many pathways to innovation. We tend to assume that innovation requires a Google-plex - modern management, open-concept offices and the freedom of subordinates to challenge authority – but, in fact, some very large and complex projects that require creativity can function best with a heavy hand at the top.

COMMISSIONER TOBIN: Good points. Thank you. If we get another round, I'll go further. Thank you.

HEARING CO-CHAIR FIEDLER: Commissioner Bartholomew.

COMMISSIONER BARTHOLOMEW: Thanks very much.

It's very interesting and I wish all of you a happy new year just like I did the previous panel.

I would like to dig in a little bit more, again, on sort of innovation. Mr. Nurkin, you mentioned, of course, that one of the goals of the CCP is to be a science and tech leader in the world by the middle of the century, and I wondered if you guys could talk a little bit about the role that space would play in achieving that.

I think, Dr. Krolikowski, you identified really well this issue that sometimes a heavy hand from the top can be helpful, but I'm also wondering, a second piece of the question is are there questions in which the Chinese government has succeeded in innovating in space? And I'm thinking about things like materials technology. Are there things that they are doing where it isn't just iterative, where they actually are forging ahead that might have applications elsewhere?

MR. NURKIN: Well, I'll deal with the first part of that question and say that actually I think space is a big part of this technological development, and there's been a reasonably open articulation of the areas where China needs to focus its investments--the Chinese Academy of Sciences and other sort of forward-looking documents that have been published from the

Chinese technological community--and it's around space science and the idea that being a great nation, you need to be able to improve the human condition, and you need to understand the universe around you. So those are things where I think there's investments and there's investments around navigation, and things like that.

So I think there is a focus on space as one avenue, one component to the development of China's technological base and its sense of great power status. So I would say it's a big component, one of several, but I think a prominent one.

MR. STOKES: In terms of by specific technologies that they could be investing in that if they continue to make achievements, they could have significant implicate--like what they call--there's a term for this--breakthroughs or--

COMMISSIONER BARTHOLOMEW: Paradigm shift.

MR. STOKES: Yes. I mean things like materials I think would be very important, particularly materials that enable, for example, a manned space program, to be able to withstand the heat that's incurred upon reentry. Being able to prolong a period, for example, in that domain of near space, for example, as you deorbit where you purposely maintain flight in near space at the upper reaches of the atmosphere or the lower reaches of space because if you're able to prolong flight, you're able to operate, very difficult for radar to pick it up.

It has significant implications for hypersonic flight vehicles, is a major one. There has been a lot of attention, for example, hypersonic, where you boost a post-boost vehicle, and then don't necessarily leave, go past 100 kilometers, but then you sort of level out and then you can sort of boost collide vehicle that remains in that area for significant period of time. It's very difficult to intercept, very difficult to see, and materials are key.

Being able to communicate and be able to have your sensors that are able to maintain use in that area when you have sort of a blackout period in that domain. That's just one example.

Other ones would be, for example, space surveillance, being able to keep track of space debris, for example. If they had a space-based space surveillance system, for example. Sensors I think would be another area to look at very carefully that could have significant implications.

MEMs--Micro-electro-magnetic Mechanical Systems would be another very small--the ability to be able to, to be able to miniaturize systems in space I think is critical, something to look at carefully.

MR. NURKIN: To very quickly jump in and say, we monitor a lot of recent media reporting coming out of almost unverifiable Chinese sources about, you know, ships en route to the Gulf of Aden 3D-printing parts en route. I mean, you know, again, the actual story may be apocryphal, but the interest in this technology is not. I think it is sincere, and we've seen it also in terms of, you know, again, completely unsubstantiated reporting, that fifth generation fighters that China is developing contain 3D printed parts.

But regardless of whether that particular fact is true, the idea that these stories are seeing the light of day reflect an interest in these types of disruptive technologies that I think we will see more investment in and could have implications for space and other aerospace technologies.

COMMISSIONER BARTHOLOMEW: Right. And the disruptive technologies have military consequences. They have economic consequences, too.

MR. NURKIN: They do. John Kennedy famously said at the start of the space race that space science, like nuclear science and all technology, has no conscience of its own. So whatever economic implications, positive and negative, that we foresee for these technologies, they will certainly have military and security implications as well.

COMMISSIONER BARTHOLOMEW: Dr. Krolikowski, anything?

DR. KROLIKOWSKI: Yes. I think there are several examples of what you're describing. China by and large hasn't, at least in recent decades, imported wholesale foreign space systems or entire space systems from abroad. So everything it's accomplished has required either significant adaptations of foreign systems or developments of partial systems obtained from abroad or developing indigenous solutions to whatever technology needs existed.

A lot of examples support this. The Shenzhou capsule, for example, is not just a reproduction of the Russian Soyuz. It's larger and updated. Chinese scientists and engineers are also proud of the fact that Chinese astronauts have worn a Chinese-designed space suit while conducting extravehicular activities.

In terms of the larger strategy toward becoming a science and technology superpower by 2050, it's apparent that space programs can play a role in that. Beidou, the Chinese answer to the U.S. Global Positioning System,is a good example. It's, of course, a system that is valuable in its own right, but it's also intended to foster the development of innovative downstream industries. For example, one area in which Beidou might stimulate this type of innovation is in mobile Internet apps for consumers and any other area of consumer, civil, military, or commercial application that requires positioning.

COMMISSIONER BARTHOLOMEW: Thank you.

HEARING CO-CHAIR FIEDLER: What would you--I want to get a little bit to her--what would you consider to be the most likely next military application beyond the near space that you've already discussed or Chinese space efforts in technology and experience because I--this iterative thing is necessary for smart people to get experience; right? I mean it's the same thing with soldiers. We've done it a lot, but you got to train the next guy that's going to be there.

What is their next breakthrough that we are worried about, that we think they're working on?

MR. STOKES: I would just, in terms of what I've been in, some of the research that I've done, I'm not sure what the term of art is, but reusable, reusable space launch vehicles, satellite launch vehicles would be done. Air-launched satellite launch vehicles, solid fuel, that you can take a bomber up, for example, and launch a small satellite.

HEARING CO-CHAIR FIEDLER: And replace the ones that we've taken down then.

MR. STOKES: Sure. For example, the term for this is responsive, responsive space launch capability that one could do from, that one could put on a small solid fuel launch vehicle. There appears to be investment in research and development in this area.

So like here would be, yeah, space transportation when that is efficient and effective in putting satellites up, up into orbit, would be something to keep an eye on.

HEARING CO-CHAIR FIEDLER: Yeah.

DR. KROLIKOWSKI: I think the most likely areas for what you're describing are in the precision guidance of munitions and in military communications. It's difficult to imagine any Chinese space systems that could have more far-reaching consequences for China's military modernization than precision guidance.

As a third area, I would add space-based intelligence in support of defense activities, particularly military operations during conflict.

MR. NURKIN: So I would agree with all of those. Going last, I can just say ditto, but I would also add that on the space plane, the reusable launch vehicle. There have been designs that have been floated at conferences throughout the world. Now, it's going back a few years, but multiple designs for that.

I think also in terms of capabilities that we're seeing being developed and refined now,

the solid launch mobile launch vehicle able to shoot satellites in space very quickly and rapidly reconstitute architecture. I think that's a pretty critical capability that will get more developed over time and more robust.

And I would say anti-satellite capabilities. Again, we're seeing some very novel types of capabilities. The co-orbital satellites with the robotic arm, I mean it's reasonably creative and I think early, reasonably early stage in terms of where that capability could go. So I would look at those areas as well.

HEARING CO-CHAIR FIEDLER: Commissioner Wessel.

COMMISSIONER WESSEL: Thank you all.

Let me, and Dr. Krolikowski, maybe since you spend so much time over there, you can help us and others in terms of your research and readings. To me, what I've heard today is the Chinese have extensive capabilities that can respond to U.S. assets, ASATs, et cetera. We've heard about this for years. And they're continuing to improve.

From what I've heard, if I were the Chinese, I would have some feeling of confidence and pride in what they've accomplished. It doesn't mean that they've reached their aspirations, but they should be proud of what they've done.

What are their views of the U.S.? Do they think we in this area have neglected? Do they admire us and view us as on a much higher par? How do they view themselves and how do they view us?

DR. KROLIKOWSKI: Well, that's a daunting question, and I'm sure I can only give a very partial answer, but my impression certainly is that Chinese scientists and engineers have great admiration and respect for the history of U.S. and Soviet and European accomplishments in space, but, in particular, of course, the U.S. Apollo Program.

I think that--

COMMISSIONER WESSEL: That's over.

DR. KROLIKOWSKI: Well, but it casts a long shadow, and I think it's still fresh in everyone's minds and memories. I think you're right, the Chinese space establishment as a whole is probably increasingly confident and takes some pride in what it's accomplished, but I also think it's very cautious in its optimism. It's, generally speaking, also a program that proceeds at a cautious pace.

It's often described as a very risk-averse program, set of programs. And the stakes in some respects are really mounting for the Chinese space establishment. So I don't think anyone feels overconfident.

COMMISSIONER WESSEL: The doctrine for asymmetric warfare focuses on space and cyberspace. So do they, again, in those areas, view that they are on a path, you know, will never reach perfection, but that they have been able to counter U.S. advances or capabilities in there? I mean the fact is, you know, sort of like IEDs at the beginning of the war, you know, they were tremendously destructive to our forces. If they have the ability to use ASATs, blind our assets, et cetera, even if they're a slightly more capable or much more capable satellite, if you have the ability of swing and a hit, you've, you know, you've done real damage.

Any thoughts?

DR. KROLIKOWSKI: I think the idea of this asymmetry in space capabilities and also the asymmetry in the cost and effort and expense of building space assets versus destroying them is very, very clearly held in view by Chinese experts.

I think most recently, especially since 2008, a lot of the defense intellectuals in and around the space establishment see China as entering a moment of strategic opportunity or a

window during which its economy is growing fast, and it has a unique chance to make great strides in space. Maybe not quite close the gap, but certainly make significant advances while its economy is growing and while growth is slower in North America and Europe.

COMMISSIONER WESSEL: Other witnesses, any thoughts?

MR. NURKIN: I would just offer that at the outset, you know, in the testimony, I used two words to describe the development of the China space program: steady and significant. And I think those were intentionally chosen. It is a steady progress against their goals, and over time it is something that clearly has closed gaps, asymmetric gaps, actual technology gaps. But it's still a work in process. It's still moving forward.

So I think that certainly Dr. Krolikowski spends more time talking to people in China who are associated with the space program so she would have a better idea of how they view themselves, but certainly that's, I think, the way that I would view the program and how it's developing.

COMMISSIONER WESSEL: Mr. Stokes.

MR. STOKES: I think it's fairly--I think the Chinese engineers have significant respect for U.S. technological capacity in space, both in terms of space launch vehicles and satellite systems. My impression is that they would love nothing more than to get back to the way things were in the late '80s and all the way up to '96 in terms of that type of economic interaction, in terms of them launching U.S. satellites or maybe even buying U.S. satellites.

However, as they continue the technological progress, it's not clear how much of a demand there would be for even U.S. communication satellites when they may be able to provide it themselves, but I think politically they certainly have an interest in sort of achieving and being able to at least offered a seat at the table along with the world's greatest spacefaring nation, which is the United States. I think that gives them a significant degree of political legitimacy that I think that they're really after.

COMMISSIONER WESSEL: Thank you.

HEARING CO-CHAIR FIEDLER: Commissioner Talent.

HEARING CO-CHAIR TALENT: Well, I'm going to tease out a little more on this innovation issue. We're going to have--we've had testimony before and we made findings regarding--and I think several of you referred to cyber espionage. We know that the Chinese have gotten a lot of technology that way, and we know that they also just took a lot of technology from various partnerships that they were in. That's the reason why their space station looks like the Russian space station; right?

I mean--in addition, we had testimony this morning that to this point they haven't done a lot of things yet that other countries didn't do first. Okay. So I guess I want to push you all a little bit further, and I'm usually on the other side of this argument because on other defense stuff, I'm the one, you know, people telling me, well, you know, they're not as capable as we are in terms of jointness and logistics and all this stuff, and I'm the one arguing, look, we're underestimating them.

But I want to push a little bit harder on this. I mean do you have any real evidence that they have proceeded organizationally, systematically to the point where they can achieve these goals without continuing to basically get technology from other countries? Discuss it a little bit more, if you would.

MR. STOKES: If the technology is out there for the taking, whether it's simply scholarly exchanges or through other means, technical means, human intelligence means, I think that there is no--they would grab onto it because it saves research and development time. It saves

resources. It gives ideas.

They have to invest in espionage for the threat requirements. They need to know what particular capabilities the United States and other defense establishments in the region are going to have in 2025, 2030, 2050 timeframe in order to be able to counter them.

So there is a whole range of incentives for them to engage in technical reconnaissance and human intelligence.

However, where this fits relatively in terms of their methodologies when there are so many dual-use technologies that are applicable to military applications, it's just incredible. There is, for example, in their counterspace program, back in 1998-1999, when they had a delegation responsible for developing some of the key basic technologies that go into an ASAT system, kinetic kill vehicle, for example, there's a certain gap, bottleneck that they faced, having to do with production technology, manufacturing machine tools for large, for their seekers, optoelectronics.

What did they do? They seek out the best, the best in the world, academia in the United States, and they make a visit. They brought him back to China. The guy had no defense contracts per se, but he still was considered to be the top in the area of manufacturing technology for sort of large-scale optoelectronics. And so there's a lot of this that goes on, and one shouldn't be surprised.

What's interesting, though, is to get a better feel for, because that's indicative of where the bottlenecks lie, is when you actually can pick up exactly what they're really focused on both on the cyber side and on the human side, where they're focused on. That would be great if we had more information exactly on what they're really looking at.

MR. NURKIN: I would second that all of those elements of acquisition of technology, whether it's through very transparent academic exchanges, there are conferences. Just in preparation for writing this testimony, reviewing different conferences being held in the UK in which if you look at the delegates lists--these are space conferences--probably ten percent, 15 percent of the 200 people who attend are from Chinese universities and research institutes.

It's not a China-UK conference. It's the Rutherford Space Center conference, and the opportunity to be there and be a delegate and listen in is something that will be taken advantage of.

But I would also agree that on the cyber side, I mean this is, there is cyber espionage against just about every industry out there, and certainly aerospace, defense and telecommunications and satellites are near or at the top of the list, but it's also because not only understanding the threats that are down the road but understanding the imminent threats and what needs to be held at risk.

I mean the Defense Science Board report from 2013, there were over two dozen systems and platforms that were compromised through--suspected to be compromised through Chinese cyber attacks, and they've certainly learned a lot about these systems and platforms and the technologies behind them, but also the technologies that needed to be held at risk in case something did happen from the Aegis systems, from the littoral combat ships, from the F-35.

So it is not just acquisition for technology's sake if it's an offensive weapon as well.

HEARING CO-CHAIR TALENT: Thank you.

It bears on the export control issue among other things. I mean what level of innovation they're actually at.

HEARING CO-CHAIR FIEDLER: Commissioner Goodwin.

COMMISSIONER GOODWIN: Thank you, Mr. Chairman.

Mr. Nurkin, I'd like to touch on an issue that you, a counterintuitive issue that you raise in your written testimony, and that's the question of whether our own export control restrictions hurt or at least have the potential to hurt our own domestic space program.

Citing the increasingly lucrative space industry and market in China, you indicate that due to many of these restrictions, U.S. companies find themselves increasingly cut out of the supply chain for these technologies or have even begun to reconsider investing in and creating these products that might be subject to such restrictions.

What is the harm, and how would you refine or modify the restrictions in a way to address these concerns?

MR. NURKIN: Right. So I mean I think there's been a fair amount of survey data conducted by the Department of Commerce going out and outreach to the space industry saying what do you think of ITAR, which is a loaded question, by the way because I think there's a lot of confusion about ITAR and what technologies are restricted now although you can get clarity around that and what will be restricted in the future.

So I do think it's the survey data and just more informal surveys reflect that the space industry is concerned about ITAR, and there are, you know, we see the European Thales Alenia and ESA engaging with China on collaborative programs in which the presentations that are given at these conferences where they discuss these programs reference ITAR-free technology.

So, you know, I think ITAR has been successful in keeping certain very sensitive, high-value technologies restricting Chinese access to them, but there are now very good advanced European, you know, primes that are providing very similar technologies going forward.

I do think, you know, so there may be a small qualitative difference there, but I think in terms of, you know, there are ideas around getting some of these items off the ITAR and on to the EAR and changing the way we look at this, but I think if we look at cyber security again maybe as a model from which to derive a policy around export control on space, you know, I think there's a pretty wide perception that you can't protect everything.

No matter who you are, U.S. government, Lockheed Martin, whoever it is, constantly under attack and probably there's ways to penetrate, and so the key is to build high walls around the things that really matter and then to learn from the attacks that do get through about what the attackers are really interested in and why they're there.

And so there may be some value in building those high walls around critical technologies, making sure that they don't, they aren't proliferated through either United States or second parties, but also, you know, some engagement here in understanding what technologies the Chinese are really interested in and what they're pursuing might be beneficial.

COMMISSIONER GOODWIN: And, of course, the efficacy of the restrictions is one aspect of this. The flip side is, of course, we need, as you said in your written testimony, the space industrial base if we want a thriving space program in the decades to come, and part of that is if we are inhibiting the ability of our companies, domestic companies, to compete in this growing global market, what does that do to our space program in the future?

MR. NURKIN: I think, you know, one of the reasons why the Europeans are so enthusiastic, I say not "so," but are engaging more with the Chinese on space is because they have some of the same budgetary pressures that the U.S. space program does, and that alternative is not open now to the U.S. space industry. So it's a somewhat declining budget, declining force levels at NASA, and the space industry that will necessarily feel the knock-on effect of that and not being able to engage as openly with European partners that it's engaged with in the past because they don't want to have to worry about ITAR.

They don't want to worry, look over their shoulder three years from now and say, well, we contracted with this American company in our supply chain, but now that technology is restricted. So I think it cuts them out of--and I don't know the scale and degree, but I certainly know it's of concern to the space industry.

COMMISSIONER GOODWIN: Thank you.

HEARING CO-CHAIR FIEDLER: Commissioner Reinsch.

CHAIRMAN REINSCH: Thank you.

I wasn't going to get into this, but Commissioner Goodwin's question prompted me to follow up a little bit. This is a very long story and one that I have some personal involvement in going back a ways, and I think congressional action in the late '90s really nearly killed off the commercial communications satellite industry. What you're talking about is what happened as a result of that action.

But Congress, at least in its own mind, corrected that problem two years ago in the NDAA Amendments. Is it your view that that didn't do the job?Have things not changed or have they changed?

MR. NURKIN: I would say that it was a very strong step forward. Now, I support those changes and in the testimony said to continue to move along those paths. The survey data that we've been looking and the conversations that we've had have all been within the last, you know, 12 months. And so in that respect, I think it takes some time to implement these programs, and the implementation needs to continue apace, but I would fully concur that the steps taken a couple of years ago were the right steps.

CHAIRMAN REINSCH: That's something to continue to monitor. Maybe we can stay in touch with you on that. My view at the time was that the measure that was passed was inadequate, but I was overwhelmed by my members, my business members, who all thought it wasacceptable.

But I have a lot of interest in figuring out whether or not it really did the job, and you're suggesting that at a minimum the jury is still out.

MR. NURKIN: Sure. I think that's true. I think the jury is still out, but I think there's also sort of an inertia here that, you know, objects at rest tend to stay at rest, and so we've pushed, begun to develop more nuanced ITAR and export control restrictions, and I think it takes a little time for those to be felt and the perceptions to change.

CHAIRMAN REINSCH: Will the ongoing Export Control Reform Program that the administration has underway change anything with respect to this?

MR. NURKIN: I think it could do, but I wouldn't want to comment too much on it because, quite--I haven't put that much thought in.

CHAIRMAN REINSCH: Fair enough. Do either of the other two of you want to get into that? Don't blame you. Okay.

Thank you, Mr. Chairman.

HEARING CO-CHAIR FIEDLER: And thank you very much. There are no more questions. I really do--we do appreciate your coming. It's been thought provoking.

We will adjourn for lunch, and if all of our panel three witnesses are here--I believe Mr. Saunders is on his way--we will reconvene at 1:15 instead of 1:30. Okay.

Thank you.

[Whereupon, at 12:27 p.m., the hearing recessed, to reconvene at 1:16 p.m., this same day.]

PANEL III INTRODUCTION BY COMMISSIONER JAMES M. TALENT

HEARING CO-CHAIR TALENT: Okay. We'll reconvene. For our final panel of the day, we're going to discuss the economic and security implications of China's space and counterspace programs.

As a reminder, I'd ask our witnesses to keep their remarks limited to seven minutes.

Mr. Richard Fisher, Jr. is a Senior Fellow in Asian Military Affairs with the International Assessment and Strategy Center. He is the author of China's Military Modernization, Building for Regional and Global Reach, and has published articles in Jane's Defence Weekly and Aviation Week and Space Technology, among other publications.

Dr. Roger Handberg is a professor in the Department of Political Science at the University of Central Florida. He teaches courses on government policies in science and technology and American security policy, including military space policy.

Dr. Handberg has published nine books and over a hundred articles and book chapters.

Dr. Phillip Saunders is Director of the Center for the Study of Chinese Military Affairs and a Distinguished Research Fellow at the Center for Strategic Research, both part of National Defense University's Institute for National Strategic Studies.

He is a co-author with David Gompert of The Paradox of Power: Sino-American Strategic Restraint in an Era of Vulnerability and co-editor of many books on Chinese military affairs.

Mr. Fisher, please begin.

OPENING STATEMENT OF MR. RICHARD D. FISHER, JR., SENIOR FELLOW, ASIAN MILITARY AFFAIRS, INTERNATIONAL ASSESSMENT AND STRATEGY CENTER

MR. FISHER: Mr. Chairman, I'd like to start by thanking this Commission for the vital work that you do to assist the deliberations of the Congress and to help the wider policy community in Washington to consider our future with China, and thank you for the privilege to of offering some thoughts to assist your deliberations today.

While China pursues a growing commercial, deep space and space science agenda, it's my conclusion that the foundation of its space program remains the pursuit of military advantage for the People's Liberation Army.

China's space endeavors are subordinate to the PLA. While the PLA does not offer public briefings or budget information about its space or space combat programs, there is a considerable body of secondary literature presumably based on actual strategy or doctrine which has long appeared to justify the PLA's development of the capability to wage war in space.

There is also a large body of gray data, academic, engineering journals, that provide insight into a number of possible military space weapons programs. Occasionally, however, statements by top officials do appear. Chinese media reported the December 5, 2012 speech by newly elevated CCP Secretary General Xi Jinping that he gave to the Second Artillery. It was one of his first speeches to a PLA audience as Secretary General.

Almost nothing of that speech was reported by Chinese media, but late last year on a prominent military historical Web page surfaced a journal by, article by a PLA general, long-serving general, who reported much more of the contents of Xi Jinping's 2012 speech. In it, he noted that Xi had essentially instructed the Second Artillery to build anti-satellite capabilities and to pursue anti-ballistic missile capabilities.

The original article quickly disappeared off that Web page, and a very prominent Chinese military blogger who had called attention to this article, his whole blog disappeared within, I believe, three weeks after pointing out this article.

Xi also made a speech to a PLA Air Force audience last April. Little was reported of this speech except the use of a very oft-seen phrase of "air-space military integration." It is certainly reasonable to suspect that Xi Jinping gave the Air Force detailed instructions on how to prepare for combat in space.

It's this analyst's conclusion based on the data that I've been able to survey for more than a decade that the PLA's apparent goal is to exercise denial and then dominance in low earth orbit and then to extend the ability to extend control to the earth-moon system.

Since the early 1990s, China has developed four, possibly five, attack capable space combat systems. China may be the only country developing such a variety of space weapons to include ground-based and air-launched counterspace weapons, unmanned space combat, and earth attack platforms, and then dual-use manned platforms, space stations and space planes.

It's also important, I offer in my testimony, to consider that the PLA's projection into space is integrated into the PLA's larger objectives to develop global military power projection capabilities into the 2020s and the 2030s. Control of low earth orbit is essential to this endeavor and to these goals and will end up justifying the PLA's attempts to secure control and then to extend its control beyond low earth orbit.

As with the former Soviet Union, China's pursuit of regional and then global military power is not rooted in an existential threat but in the Party's fear for its power position.

And as a consequence, China will be hostile, in my opinion, as it already is, to Western concepts of rules or control or transparency that might constrain China's power or power in space. This will enable China's pursuit of networks and relationships that are also hostile to democracy and to American interests.

One early intersection of space and projection of power and the promotion of an anti-democratic trend is happening today in Argentina. China is beginning a process whereby it could arm Argentina to make a second run after the Falkland Islands. Critical to this ability will be Argentina's ability to receive ISR, space ISR, from China's growing ISR network.

This will be facilitated by the fact that China is building a space tracking and control facility in the southern part of Argentina, and according to my sources, the quid pro quo is that for this facility, Argentina will have access to China's space information network.

For the United States, cooperation with China in space may yield some benefits, but it will likely have little impact on the direction or the severity of terrestrial conflicts that will dominate our relations with China. I certainly can see the value of meeting with Chinese space officials to impress upon them our concerns and to try to understand more about their objectives.

But at this juncture before China has achieved levels of space dominance, it's crucial to continue to link any real cooperation with China in space to its behavior on earth and in space and elsewhere that threatens American security.

The challenge for the United States is to maintain the means to compete with China in space both in military and non-military endeavors. China's potential for developing new space combat systems means the U.S. must be ready to rapidly develop and deploy appropriate deterrent capabilities. There should also be a more developed U.S. capability to rapidly repopulate satellite systems that have been taken down, as there should be terrestrial and airborne alternatives to compensate for lost critical space functions.

In addition, as the PLA moves substantially out into deep space, the moon or the Lagrangian Points, it will be necessary for the U.S. to consider a compensating presence that is affordable, attractive to a coalition of democracies, and helps to deter China from seeking strategic advantage.

Strategic priorities of this nature would suggest that a presence on or near the Moon is of much greater importance than going to Mars. A multinational government-private presence on the moon is one option, as is the less likely and less expensive option of a far Cis-lunar presence to develop manned deep space capabilities.

As was the case with the former Soviet Union, relative peace on earth or in space will not truly be possible until China evolves beyond its Leninist system. In its final years, the Soviet Union was on the cusp of deploying multiple space combat systems despite years of U.S.-Soviet space diplomacy. Real cooperation between Russia and the West became possible only after the fall of the Soviet Communist Party and cooperation that exists today is again becoming threatened by China's [sic] slide into authoritarian aggression.

Substantive cooperation with China in space offers no assurance that China will change its threatening behavior on earth or in space but does create opportunities for China to exploit U.S. and Western space technology to gain potential military advantages.

Thank you.

PREPARED STATEMENT OF MR. RICHARD D. FISHER, JR., SENIOR FELLOW, ASIAN MILITARY AFFAIRS, INTERNATIONAL ASSESSMENT AND STRATEGY CENTER

China's Military Ambitions in Space and America's Response

Testimony of Richard D. Fisher Jr. -- Senior Fellow, Asian Military Affairs, International Assessment and Strategy Center, before the U.S.-China Economic and Security Review Commission, Hearing on China Space and Counter-Space Issues, February 18, 2015

Introduction

Mr. Chairman, distinguished members of the United States-China Economic Security Review Commission, it is a privilege to present testimony concerning China's strategic and military ambitions in outer space. While China pursues a growing commercial, deep space and space science agenda, the foundation of its space program remains the pursuit of military advantage for the People's Liberation Army (PLA). China's space endeavors are subordinate to the PLA.

While the PLA does not offer public briefings or budget information about its space combat programs, there is a considerable body of "secondary" literature presumably based on strategy or doctrine, which has long appeared to justify the development of a PLA capability to wage war in space. Occasionally, however, statements by top officials appear. According to Chinese press reports on 5 December 2012, newly elevated Chinese Communist Party (CCP) Secretary General Xi Jinping gave a speech to a Second Artillery (SA) audience. Almost nothing of the content of that speech was reported, until the late 2014 surfacing of a journal article by SA veteran General Sun Mingfu. In that speech, General Sun said that "President Xi made clear the need 'to enhance the build-up of ground-based anti-satellite combat force to ensure the timely formation of combat capability', and to "accelerate the development of strategic anti-missile capability." This article quickly disappeared off of its hosting web page and a famous Chinese military-technical blog "KKTT" that gave it prominence soon disappeared as well.

On 14 April 2014, Xi was reported to have given a speech before a PLA Air Force (PLAAF) audience in which he called for an "integrated air and space capability." This phrase was also used by former PLAAF commander General Xu Qiliang during the 2009 PLAAF 60th anniversary, and by military academic commentators which listed space weapons the PLA should acquire. Perhaps Xi Jinping also gave the PLAAF specific space warfare preparation guidance. While there has been some discussion in the PLA of a new service or a "Space Force," today it appears that current services of the PLA are being encouraged to develop individual space combat capabilities.

Based on an accumulation of data, it is possible to conclude that the PLA's apparent goal is to exercise denial and then dominance in Low Earth Orbit (LEO) and then to extend control into the Earth-Moon system. Since the early 1990s China has developed four, possibly five, attack-capable space-combat systems. China may be the only country developing such variety of space weapons to include: ground-based and air-launched counter-space weapons; unmanned space combat and Earth-attack platforms; and dual-use manned platforms.

It is also important to consider that the PLA's projection into space is an integral part of China's development of military capabilities to dominate the Asia-Pacific region, and then to project power globally into the 2020s and 2030s. The PLA requires increasing space control in order to assure that space-based Information Surveillance Reconnaissance (ISR) systems can provide targeting and other and support for missile, air, naval and ground forces, future intercontinental Prompt Global Strike (PSG) forces, and for the forces of client/partner states. Sustaining superiority in LEO, in turn, will require control of the "High Ground," or the Moon and Deep Space.

The Chinese Communist Party (CCP) leadership's intertwined pursuit of global military power and dominant space power has three main motivations: 1) to help sustain the power position of the CCP; 2) to aid the CCP's pursuit of economic-political dominance in key regions to best assure resource/commercial access; and, 3) to eventually displace the United States from its position of global leadership. Space power will also be used to support new Chinese-led or promoted anti-U.S./anti-democratic coalitions as it will be used to crush democratic threats to its rule, beginning with the democracy on Taiwan.

As with the former Soviet Union, China's pursuit of regional and then global military power is not rooted in an existential threat, but in the CCP's fears for its power position. This requires a CCP-led "rejuvenation" of China, entailing mobilization for greater power, ever more control over its own people, and then increasing control over others. Another result is China's choice to be hostile to Western rules or concepts that may constrain China's power. This justifies an essential Chinese rejection of American or Western conceptions of transparency and restraint, or verifiable weapons control in space which might constrain its power.

This mirrors the CCP/PLA's repeated refusal of U.S. requests to consider real nuclear weapons transparency and control, transparency over its nuclear and missile exports, and --from many of its neighbors and Washington -- fair settlement of territorial disputes which threaten war. The latter, especially in the South China Sea, is instructive. As it has gained military power in the South China Sea, China has sought to change the strategic environment and dictate new rules to increase its security at the expense of others. Once it gains commanding strength and position in space, will China do the same?

For the United States, cooperation with China in space may yield some benefits, but it likely will have little impact on the direction and severity of terrestrial conflicts which will dominate relations with China. One can see the value of meeting with Chinese space officials, especially higher CCP and PLA leaders, to advance concerns over their actions in space and to promote transparency. But at this juncture, before China has achieved levels of "space dominance", it is crucial to link any real cooperation with China to its behavior in space and elsewhere which threatens U.S. security.

Furthermore, allowing China increasing access to U.S. space technology, space corporations, or government institutions at this time presents two risks. First it could encourage China to advance an illusion of cooperation with the U.S. and the West while differences on Earth become sharper. This could become useful for Beijing to deflect criticism on other issues, or even to obtain

leverage over U.S. options and actions. Second, as has been proven repeatedly, China will exploit any new access for espionage gains to strengthen its own space and military sectors.

China's increasing space power, however, like its growing economic and political power, cannot be "contained." Russia appears ready to greatly expand space and military cooperation with China as part of a larger strategic alignment, while the European Space Agency is edging toward greater cooperation with China. These attractions may only increase if China has the only LEO manned space station in the mid-2020s. Already a top commercial space service and technology provider, China will use its gathering space diplomacy tools to aid its pursuit of economic, political and military influence in critical regions like Africa and Latin America.

The challenge for the United States is to maintain the means to compete with China in space both in military and non-military endeavors. China's potential for developing new space combat systems means the U.S. must be able to rapidly develop appropriate deterrent capabilities. There should also be a more developed U.S. capability to rapidly repopulate satellite systems taken down by PLA attacks, and there should be more terrestrial or airborne systems to compensate for lost navigation, communication and surveillance satellites.

In addition, as the PLA moves substantially out to deep space, the Moon, or to the Lagrangian Points, it will be necessary for the U.S. to consider a compensating presence that is affordable, attractive to a coalition of democracies, and helps to deter China from seeking strategic advantage. Strategic priorities would suggest that a presence on or near the Moon is of greater importance than going to Mars. A multinational government-private presence on the Moon is one option, as is the likely less expensive option of a far cis-lunar presence to further develop manned deep space capabilities.

As was the case with the former Soviet Union, relative peace on Earth or in space will not truly be possible until China evolves beyond its Leninist dictatorship. In its final years, the Soviet Union was on the cusp of deploying multiple space combat systems despite years of U.S.-Soviet space diplomacy. Real space cooperation between Russia the West became possible only after the fall of the Soviet Union, and may again become threatened by Russia's slide into authoritarian aggression. Substantive cooperation with China in space offers no assurance that China will change its threatening behaviors on Earth or in space, but does create opportunities for China to exploit U.S. and Western space technology to gain potential military advantages.

The following will address questions posed by the U.S.-China Economic and Security Review Commission. But first, it is necessary to reflect on the relationship between China's pursuit of space power and its military buildup for regional dominance and global projection.

Space Power and China's Military Expansion

During the 1950s and 1960s, Mao Zedong sought to quickly exploit generous assistance from the Soviet Union, and the insights of U.S.-trained engineers like Qian Xuesen, to complete the early nuclear missiles to deter feared U.S. and Soviet nuclear strikes. His 651 Program succeeded in launching the Dong Fang Hong-1 satellite in 1970, while also aiding the development of larger missiles. But Mao's efforts to build broader space power, such as the 640 Program to build

strategic missile defenses, and his early 741 Program manned space ship, faltered largely due to his destructive politics. Mao, nevertheless, realized that China required the technology and prestige of space in order to increase its ability to compete with Moscow and Washington on the global stage.

Fears for political survival and ambitions for global leadership remain the basis for China's current surge for global military power and space power. The greatest impetus for the most recent phase of PLA modernization and buildup was the shock of the 1989 Tiananmen rebellion -- the only time the Party's power position was actually threatened by popular, though unorganized, reformist and democratic demands. In addition to ruthlessly crushing any potential for democratic dissent, the transitioning CCP leadership of Deng Xiaoping to Jiang Zemin decided to begin the broad military and space modernization and buildup we see today.

At first focused on coercing Taiwan and then securing control over disputed territories, the early 1990s saw the start of many PLA programs increasing its Anti-Access/Area Denial (A2AD) capability targeted on the "First Island Chain." These include the Chengdu Aircraft Corporation's 4th generation J-10 fighter and its J-20 5th generation fighter, and the large Xian Aircraft Corporation Y-20 heavy jet transport. China's aircraft carrier ambitions predate Tiananmen but second generation nuclear attack and ballistic submarine programs received greater emphasis. This period also saw the beginnings of the PLA's first "reconnaissance strike complex" of terminally guided medium-range missiles, and the ability to target them with high resolution surveillance, navigation and communication satellites. In addition, the PLA started developing its second anti-ballistic missile (ABM) system along with a new anti-satellite (ASAT) system, tested successfully on 11 January 2007.

The early 1990s also saw the beginning of China's second manned space program, code named the 921 Program. With substantial inputs from Russian space companies the 921-1 or *Shenzhou* spaceship made its first unmanned flight in 1999. While the PLA's General Armaments Department (GAD) took control of the manned space program in 1998, we did not learn of this until former CCP Chairman Jiang Zemin congratulated former GAD Director and then Defense Minister Cao Gangchuan as "chief director of the manned space program" after the April 2002 landing of *Shenzhou-3.* The dual-use nature of China's manned space program was starkly demonstrated by the first manned *Shenzhou-5* mission in 2005, when Astronaut Yang Liwei shared his ship with two optical surveillance cameras.

A little over a year later in December 2004, the current phase of PLA modernization and space development was signaled by the "New Historic Missions" enunciated by Chairman Hu Jintao, in which the PLA started preparing to defend the CCP's global interest, in addition to its regional ambitions. Over the following decade, better combat systems for regional dominance emerged, with new aircraft carriers, amphibious projection ships, and new large airborne projection transports designed to enable the PLA to defend more distant CCP interests.

Since the late 1990s, space systems have played an increasing role in the PLA's "Informationalization" strategy, providing commanders with higher resolution optical and radar satellite surveillance, new space electronic intelligence tools, space-based data relay and new infrared-multispectral early warning satellites. Space information systems give PLA platforms

global navigation and communication capabilities, as they help to target increasing numbers of precision-guided missiles and bombs. These capabilities are essential to the fulfillment of Chinese objectives which include the "recovery" of Taiwan, consolidating military control over disputed regions in the East and South China Seas, and undermining and eclipsing American-led alliance relationships in Asia.

China's space ISR power will also be used to help military allies and clients. Having helped North Korea, Iran and Pakistan to become current or imminent nuclear missile powers, it makes sense that China would directly or indirectly assist their future space ISR requirements. In a scene that could be repeated elsewhere, today China is pushing to help rearm Argentina, which has already agreed to lease a critical space tracking and control facility to China. A Chinese-armed Argentina with access to Chinese space ISR may be able to better threaten war to take the Falkland Islands. Even if Britain settles for a negotiated transfer, China will gain regional prestige for having "defeated" a Western power, further reducing U.S. influence in Latin America.

By the 2020s and the 2030s, the PLA's development of space projection and combat capabilities could become the leading element of the next phase of PLA modernization. Networks of larger more capable/survivable surveillance satellites, combined with networks of smaller more survivable satellites, will provide more secure navigation, communication, and targeting for larger numbers of power projection platforms such as nuclear powered aircraft carriers, large amphibious projection ships, very large military transport aircraft, and a next generation of export weapon systems. These could include a new generation of "Prompt Global Strike" systems, enabled by high data rate optical data-relay satellites. These could be joined by more ground-based or air-launched ASAT systems, new LEO-based laser or kinetic armed space combat platforms, and Space-to-Earth combat platforms.

China's political-diplomatic and military space power will be increased by the completion of a dual-use manned space station in the early 2020s and perhaps new small and large reusable dual-use unmanned and manned space planes. If the ISS winds down in the early 2020s it is increasingly apparent that Russia may seek significant space cooperation with China, replacing its space relationship with Washington. By the early 2030s, the new date for the completion of its 100-ton-plus payload heavy SLV, China may be taking its first steps on the Moon and building toward permanent bases by the 2050s or 2060s. China's push for the Moon is prompted by a quest for prestige and to control areas that may yield potential economic/resource benefits. The PLA can also be expected to seek military benefits from its Moon presence. Should China's emerging space and terrestrial power increasingly constrain U.S. power, then Europe and India may be tempted to increasingly "bandwagon" with China, especially in space.

Question 1: Provide a net assessment of U.S. and Chinese space capabilities in a 2015 conflict scenario. How does this assessment change, if at all, for a 2030 scenario?

While it is possible to better assess near term Chinese military-space capabilities due to an accumulation of Western and Chinese disclosures, assessing potential capabilities in the next fifteen years requires making estimates that could over- or under-estimate Chinese capabilities. As the PLA does not reveal its military-space intentions in public documents it is necessary to

consider a body of "grey" data that offers indications of potential capability intent. This estimate projects from current indicators but does not review potential major technology breakthroughs that might accelerate development projections.

2015 Conflict Scenario: The main difference in assessments of U.S. and Chinese military space capabilities in the near-term is that China has a gathering "active" space combat potential and is beginning to build "passive" mil-space capabilities, whereas it is not possible to determine whether the U.S.is developing the former, though it is interested in the latter. The U.S. is credited with over 500 military and civil satellites. While China has about 120 satellites, about 75 are used exclusively or largely by the PLA, and the PLA has access to more of China's "civil" communication satellites. In 2015 China may be capable of strikes against scores of U.S. satellites in LEO, Geostationary Earth Orbits (GEO, 35,000km), or Medium Earth Orbits (MEO, 2,000-35,000km). In 2015 the U.S. may only be capable of limited retaliation against Chinese satellites in LEO, and would be stressed to repopulate critical U.S. satellite networks.

Space ISR: By 2015 the PLA's surveillance satellite network could comprise about 40 optical surveillance satellites, 10 radar satellites, 8 possible early warning satellites, and about 21 electronic intelligence (ELINT) counter-naval satellites. In addition there may be 4 weather satellites that assist global missile targeting. All of these use LEO polar orbits so they are more vulnerable to ground or air-launched ASATs. However, there are indications that the PLA may be developing much larger surveillance satellites, with the potential they may be placed in much higher orbits.

By 2015 the PLA may have four to five dedicated communication satellites in GEO, and 16 to 20 navigation satellites in GEO or MEO. The Beidou/Compass navigation satellite system has a secondary global communication capability at a text-message level. In addition the PLA will control three *TianLan* data-relay satellites in GEO, intended primarily to support tracking and command of manned platforms, but could also support global military operations. Earth-based global tracking and control networks crucial to maintaining China's space architecture include four large *Yuan Wang* tracking and control ships. In China there are eight tracking and control facilities and it has or will gain access to facilities in Argentina, Chile, French Guiana, Kenya, Namibia and Pakistan.

In September 2013 and November 2014 China launched its *Kuaizhou*, a China Aerospace Science and Industry Corporation (CASIC) solid-fueled mobile SLV based on the DF-21 medium range ballistic missile (MRBM) or a larger intermediate range ballistic missile (IRBM). The model of a potential export version of this missile was displayed at the November 2014 Zhuhai Airshow. Also revealed were six new microsatellites for surveillance and communication missions for this SLV. This could be the beginning of China's "Operationally Responsive Space" initiative to be able to repopulate satellite networks. The China Aerospace Science and Technology Corporation's (CASC) liquid fueled small Long March-6 SLV may also be slated for this mission.

Since the mid-1990s China has also invested heavily in micro and nanosatellites, detailing development work mainly to Chinese aerospace universities including the Harbin Institute of Technology, Tsinghua University, Nanjing University of Aeronautics and Aerospace, and the

National University of Defense Technology. China has the capability today to rapidly develop constellations of micro and nanosats that can be used to replace attacked satellites, or to succeed them with more secure but distributed satellite networks. A recent Chinese report notes that the Province of Jilin plans to loft China's first "civil" network of four imaging microsatellites.

In contrast, the more varied U.S. surveillance satellite network makes extensive use of larger systems placed in higher orbit systems in order to reduce their vulnerability. But this is now changing as the PLA develops ASATs able to attack higher orbits. Attempts to build a larger number of smaller surveillance satellites like the SBIRS series faltered due to complexity and expense. As a consequence, the U.S. has shown greater interest in even less expensive and smaller satellites like the U.S. Air Force's TacSat or Operationally Responsive Space-1 (ORS-1).

Ground Based Lasers: On 28 September 2006, the U.S. publication *Defense News* first reported that China had fired a "high power laser at a U.S. spy satellite" as a "test of the Chinese ability to blind the spacecraft." While U.S. officials tried to downplay the test, China's intent to military "blind" enemy satellites was confirmed in the December 2013 issue of *Chinese Optics* in an article "Development of Space Based Laser Weapons" written by three engineers from the Changchun Institute of Optics, Fine Mechanics and Physics. They stated, "In 2005, we have successfully conducted a satellite blinding experiment using a 50-100 KW capacity mounted laser gun in Xinjiang province. The target was a low orbit satellite with a tilt distance of 600 km. Over the following eight years it is likely that China has improved its ground-based ASAT lasers.

In 1997 the U.S. Mid-Infrared Advanced Chemical Laser (MIRCL) demonstrated its ability to "dazzle" a LEO satellite but the U.S. is not known to have developed ground-based lasers capable of conducting ASAT missions. As far as is known publicly, the U.S. Air Force YAL-1 chemical airborne laser was not tested against LEO targets during its 2007 to 2011 testing program.

Ground-Launched ASAT: The PLA's combined ASAT and ABM program that gained momentum in the early 1990s has resulted in at least two known ground-launched ASAT systems. Derived from the CASIC KT-1 mobile solid/liquid fuel SLV, the SC-19 ASAT began a test program in 2005 that resulted in its first successful destruction of a FY-1C weather satellite at 864km in January 2007. Subsequent SC-19 tests on 11 January 2010 and 23 July 2014 were judged as ASAT tests even though they destroyed lower altitude missiles. It is possible that the PLA may now have an inventory of scores of SC-19 ASAT/ABM missiles.

On 13 May 2013, China tested its larger DN-2 ASAT. Chinese sources claim it reached an altitude of 10,000km, while U.S. sources noted it nearly reached GEO. It is possible that both the SC-19 and DN-2 have been put into production although this cannot be confirmed. The DN-2 could be based on a version of the CASC DF-31 ICBM or the CASIC *Kuaizhou* mobile SLV. Mobility for the SC-19 and DN-2 means it can be moved to multiple locations to facilitate surprise ASAT strikes.

On 20 February 2008, a U.S. Navy modified SM-3 surface-to-air missile destroyed a decaying U.S. reconnaissance satellite at an altitude of 247km. Believed to have been a counter-

demonstration for China, the U.S. is not known to have put into production a ground launched ASAT. The SM-3 or U.S. Army THAAD could form the basis for a LEO ASAT but no such program has been reported.

Air Launched ASAT: The April 2009 issue of the journal of the Shenyang Aircraft Design and Research Institute, or 601 Institute, contained an article titled, "The Technologies of the Fighter Platform Launching Trajectory Missile Attack Satellite." This article concludes that it is "feasible and reasonable" that an aircraft be used to attack a satellite "in the present stage." This suggests that SAC has already adapted, or may be in the process of adapting its J-11 fighter, a clone of the Russian Sukhoi Su-27, to perform ASAT missions to attack LEO satellites. An ASAT-capable J-11 fighter would offer greater tactical flexibility and could be concealed at numerous PLA Air Force airbases. While there are no open reports of a Chinese airborne ASAT test, it is conceivable that China has developed such a system over the last six years.

The Reagan Administration in 1988 cancelled the ASM-135, the second U.S. air-launched ASAT program, due to cost, technical and Congressional opposition challenges. It was tested successfully once against a satellite target in September 1985. In 2015 the Defense Advanced Research Program Agency (DARPA) reportedly will start testing its Airborne Launch Assist Space Access (ALASA) F-15 fighter-launched small SLV, which could form the basis for an air-launched ASAT.

Co-Orbital Interceptors: China apparently has developed satellites capable of co-orbital interceptions of other satellites for benign or hostile missions. On 19 July 2013, China launched three satellites, two of which, the Shiyan-7 (SY-7, Experiment-7) and Chuangxin-3 (CX-3), interacted with the Shijian-7 (SJ-7, Practice-7) launched in 2005. The SY-7 is believed to have manipulator arm that could perform maintenance or intelligence missions, or attack missions which disable without creating a debris cloud. While classified as an "experimental" system, this satellite could also be developed into a more capable co-orbital close-up surveillance or interceptor platform.

In late 2010 or early 2011, China is believed to have conducted a sub orbital test of its *Shenlong* small space plane, a technology test bed which could also be developed into a multi-mission dual use platform similar to the U.S. Boeing X-37B small space plane. A Russian source confirmed to this analyst that the *Shenlong* was tested, but there is no open reporting that an operational version has been produced. Larger manned and unmanned Chinese space planes are very likely under development.

U.S. experience with co-orbital inspection capabilities may extend to the *Prowler* satellite launched in 1990, and more recently to two XXS and two MITx satellites launched in the last decade. However, it is not known publicly whether these have been developed into operational system; most likely not. The U.S. Air Force has also built three 5-ton Boeing X-37A/B small reusable space planes which are capable of deploying micro or nanosatellites, or carrying passive or active military payloads. They have conducted three lengthy but classified missions. While small, the X-37B would be vulnerable to ground-based PLA interception systems.

Dual Use Manned Platforms: While the U.S. never launched a manned military space platform, the Soviets lofted military Salyut small space stations in the 1970s, and in the late 1980s tried to launch an unmanned space combat platform and were considering turning their *Mir* space station into a base for space bombers. Perhaps influenced by this Soviet example, China could be planning for a range of military uses for its manned space platforms.

The September 2008 *Shenzhou 7* mission, remembered most for China's first manned spacewalk, also saw its launching of a micro-satellite shortly before passing about 45km from the International Space Station. As far as can be determined, China provided no warning of its intention. Also, despite the potential for an accident which may have threatened the lives of two Russian and one U.S. astronaut onboard, there has been no public response to this incident from U.S. or Russian officials. Was this an early Chinese attempt to simulate space docking, or was it a simulated co-orbital attack against the ISS? Does this incident, and the previous use of the *Shenzhou* to carry military payloads, mean that China's manned space platforms will be equipped to perform "active" military missions? If the PLA could equip the *Shenzhou* orbital module to launch the BX-1 micosatellite, could it also modify the orbital module to carry intercept sensors and kinetic kill vehicles (KKVs)? The larger *Tiangong* has payload bays which have used Earth observation cameras. Might China consider modifying *Tiangong* to be perform ASAT or orbital Earth bombing missions?

U.S. programs to develop manned military-mission space platforms like the *Dyna Soar* space plane and the Manned Orbiting Laboratory (MOL) were cancelled by the end of the 1960s in favor of unmanned satellites for military-space missions. While both the Soviet Union and China feared that the U.S. Space Shuttle would be modified for combat missions, there is no open reporting this was done. However, the Shuttle was used on numerous occasions to deploy military payloads but was retired in July 2011. The U.S. National Air and Space Administration's (NASA) Boeing *Orion* manned capsule made its first unmanned test on 5 December 2014 but may not make a manned test until 2021. The private SpaceX Corporation *Dragon* manned capsule may not fly until 2017 or 2018. There is no reported consideration that either may be modified for active military missions

2030 Conflict Scenarios: China's Potential Capabilities

Provided the CCP survives to expand its power, by 2030 China will require increasing space power in order to support its expanding global projection forces on Earth, and because military competition in space will have become more intense, largely due to China's continued development of space combat capabilities. It is likely that an expansion in the number of space combat programs by individual services will have prompted the PLA to create a unique "Space Force." While China's first manned forays to the Moon may not occur until soon after 2030, plans will have advanced significantly toward the creation of a permanent Moon Base by 2050 or sooner. A proliferation of its space combat systems around the Earth will push China to seek increasing advantage, setting the stage for its strategic-military development of the Moon.

As mentioned earlier, absent a fundamental change in the character of the CCP or its evolution in a pluralistic direction, China is unlikely to accept negotiated limits on its expanding space power. Furthermore, Russia, provided its authoritarian anti-Western character increases, may have to

seek a far more deeper military relationship with China, assuming Beijing's hunger for Russian resources can be satisfied short of taking its territory.

Space technology may become Russia strong suit in its military relationship with China, provided it can sustain Chinese funds to insure its space sector remains competitive. Since early in the last decade Russia has been considering its post-ISS future in space, considering alternate space station designs, Moon and initial Mars missions, manned architectures and next generation spaceships, perhaps to include nuclear propulsion. While China's preference may be to develop its national space capabilities, as it has done repeatedly regarding weapons technology it could begin broad space technology cooperation with Russia to accelerate next generation capabilities.

China's Future Close-to-Earth Mil-Space Capabilities

If current trends discernable today continue, it is likely that China will have multiple options to distribute its critical satellite service requirements to larger and deeper space platforms as well as to clouds of micro and nanosats. As it does so, it should be expected that China will develop means to both attack and defend its evolving satellite networks.

Large satellites may include 5-ton and 10-ton systems able to reside in deeper space which may active and passive defenses. Chinese academic engineering literature shows some familiarity with large membrane space mirrors, for example as used by the U.S. Defense Advanced Research Projects Agency's (DARPA) Membrane Optical Imager for Realtime Exploitation (MOIRE). Membrane mirrors can be expected to enable large deep space surveillance satellites, as envisioned by MOIRE, or to make micro and nano-surveillance satellites even more powerful.

Future Chinese micro and nanosats might be able to "cleave" or double or quadruple in the event of an attack. A previously mentioned Chinese report notes that the Province of Jilin plans to have a constellation of 137 small satellites by 2030, noting this may enable a revisit time of 10 minutes. The PLA or "civil" authorities in China could be hosting scores of satellite "cloud" constellations by 2030. The potential for China to develop counters to small satellites should also be considered. Already, China is testing and considering other novel concepts for capturing/disabling small UAVs with airborne nets. Conceivably, large nets could be used to co-orbitally intercept small satellite clouds.

A potential Chinese leap-frog technology advance was briefed at the 2014 International Astronautical Congress (IAC) in Toronto attended by this analyst. A Chinese engineer briefed a paper proposing that China's next generation data relay satellites use optical or laser data links, which could phenomenally increase data transfer rates. The major technological obstacle was to develop an optical/laser data transfer to Earth receivers that could overcome atmospheric distortion. If successful, such data transfer rates could go far to enable an intimate level streaming tactical imagery of targets for very distant hypersonic Prompt Global Strike systems, space bombing platforms, perhaps in multiple simultaneous combat theaters. The kicker: the engineer noted this satellite could begin development to construction in 2016 or 2021. China may be the only country investing in this capability.

Occasional statements from Chinese military academics and academic engineering articles point to China's interest in developing a range of future space combat capabilities. Asian military sources told this analyst in 2008 that an initial PLA ABM system could emerge in the early 2020s. This might happen even sooner. Chinese-developed ABM/ASAT capable missiles may become smaller and deployable on aircraft, ship and submarine platforms. In a December 2013 journal article, engineers from the Changchun Institute of Optics, Fine Mechanics and Physics, a leading Chinese laser weapon research body, proposed it would be possible by the mid-2020s for China to loft a 5-ton laser-armed space combat platform. A key enabling technology would be large membrane mirrors. It should be considered that by the mid-2030s might China be able to halve the size of possible laser space combat platforms so as to launch more in a single SLV.

At the 2006 IAC in Valencia, engineers from the China Academy of Launch Vehicle Technology (CALT) briefed a paper on two reusable space plane concepts under consideration: a 130-ton or so manned space plane for LEO operations, and a 100-ton unmanned suborbital space plane for launching payloads on an expendable second stage. Both concepts, which could appear in the early 2020s, apparently are dependent on using the first stage of the Long March-5 heavylift SLV slated to begin testing in 2015 or 2016. The manned space plane concept carries most of its weight in fuel as a "second stage" to reach orbit. However, more reserve fuel may enable greater capability for maneuver than U.S. or Soviet space shuttle concepts, which could increase its military utility.

Chinese military academics and academic engineering articles have addressed the idea of using platforms in LEO to bomb targets on Earth. This could be done with a relatively simple platform derived from the *Tiangong*, a manned or unmanned space plane, or a hypersonic cross air vehicle (CAV), for which there may be some interest as seen in Chinese academic engineering literature.

It also has to be considered that China's interest in manned space combat platforms may extend to its future space stations. The first 120-plus ton space station that may be completed by 2023 is based on the replaceable module concept developed in the 1970s by the Russian Energia Company. There is some reason to conclude that under the guise of goodwill, Russia was unwise enough to allow a significant Chinese espionage exercise within its space companies in the late 1990s and that Energia's space station technology may have fallen victim. The first Chinese space station may have two experimental modules, one of which will have large imaging systems pointed out to space and at the Earth—which could be dual-use. If needed, such modules could be replaced with others equipped for combat, more capable military surveillance or command-control needed to compensate for the loss of Earth control facilities. At the 2014 IAC in Toronto, a Chinese academic told an audience that China was likely planning a larger second generation space station. Given that the first may have a life span of 10 years, the second may be ready by the early 2030s.

Before the 2020s it can be expected that the PLA will also make real progress in creating "Near Space" capabilities that can compensate for the loss of LEO assets. Large UAVs or stratospheric airships capable of performing radar, optical, communication and navigation satellite functions could emerge soon. A next more capable generation of these systems may emerge in the mid-to-late 2020s.

Potential Deep Space Ambitions

As it controls the rest of China's space program, the PLA also controls China's Moon program. As it has done throughout its space program, the PLA can be expected to seek dual use benefits from China's presence on the Moon. Over a decade ago, Chinese Moon program leader Dr. Ouyang Ziyuan, highlighted the Moons military value and the need for China to be able to secure vital resources, perhaps Helium-3 to power future fusion energy reactors. Writing on 31 January 2015 on the website of the CCP Central Committee's journal *Quishi* (Seeking Truth), the Chairman and CCP Party Secretary of the China Aerospace Science and Technology Corporation (CASC), Lei Fanpei, stressed that "We will adhere to the path of developing military-civil integration in our coming demonstration of deep space exploration, manned moon landing, heavy launch vehicle and other major programs, and are of major significance both to the nation's long-term development and to the task of building the nation into a strong space power." This is a strong indicator that the PLA will use its Moon and Deep Space program for military gain. While some Western analysts may scoff at the idea of the Moon having military value, perhaps PLA planners have decided otherwise.

While from the perspective of current technology it may be better to invest in ISR and military capabilities closer to Earth that can dominate LEO and GEO, perhaps as ISR assets move well beyond MEO it may then become useful to have Moon capabilities to find or interfere with such assets. Early in the *Change* unmanned Moon probe program there was mention that the stationary Moon lander might include an experimental payload using a laser to measure distance to the Earth. While recent reporting on the December 2013 *Change-3* Moon landing mission has not included mention of a laser package, at the 2014 IAC a Chinese space company official did mention that it could be included in a future landing mission. A low-power laser on the Moon could become militarily useful were it able to vibrate and thus interfere with the very thin membrane mirror of a potential MOIRE like surveillance satellite.

What if, in about 100 years, breakthroughs in space propulsion make it possible to reach Mars in weeks, versus months or years? Should the Earth's economy come to be dominated increasingly by access to resources on Mars, then the Moon and the Langrangian Points become the nearest "parking garages" to support that commerce. So from a very long term perspective it may be attractive to the PLA to secure a dominant position on the Moon in order to have the option to secure access to other potentially strategic positions in the Earth-Moon system.

Question 2: Given China's emerging counter-space capabilities, which defensive or offensive capabilities should the United States prioritize to maintain its strategic advantage in space? Assess the implications, if any, for U.S. defense budget requirements in these areas.

The degree to which China, with possible Russian help, obtains "space control" will most likely be determined by the degree to which the United States rises to defend access to space by the democracies and deters attacks by China and Russia. From the perspective of the 2015 policy balance in Washington, this will require a fundamental political shift to emphasize a commitment to sustaining a broad rebuilding of U.S. power to include space power. It will also require a constant investment in the futures technologies. There must be a deep search for what will

succeed the systems viewed as the next wave of space power: micro and nanosat constellations; mega membrane-based deep-space surveillance satellites; hypersonic cross-air and glide vehicles; liquid-fueled 100-plus ton payload SLVs; solid state lasers; $1 -$20 million space launch services; and, strategic position on the Moon.

Suggested Military-Space Priorities

Retaliation: After nearly 25 years of continuous development of its current ASAT systems, China shows little inclination to consider constraints on its space combat system development. So far China has demonstrated four, possibly five, ASAT systems; ground based lasers, two ground launched ASATs; and both an unmanned and a possible manned co-orbital interceptor. It is reasonable for the United States to conclude that it needs to develop appropriate capabilities to deter the CCP/PLA from starting a shooting war in space. This should include capabilities that produce rapid symmetrical effects following Chinese attacks against U.S. space assets. It may not be necessary for the U.S. to match every Chinese space combat development, but the U.S. may require its own variety of space combat capabilities.

To reduce costs it is suggested that initial ASAT systems exploit existing long-range surface-to-air missiles, to include the U.S. Navy's SM-3 or the U.S. Army's Terminal High Altitude Area Defense (THAAD) and Ground Based Midcourse Defense (GMD), which in some instances may only need appropriate software. This should be succeeded by a common ASAT which is able to use ground, ship, and submarine launch platforms and to reach targets in MEO. It will also be necessary to develop an air-launched ASAT for use from strike fighters or bombers, which would offer fastest response to a PLA space attack. DARPA's ALASA fighter-launched small SLV may offer an early path to an air-launched ASAT but the U.S. should also develop a heavier multi-stage air-launched ASAT that can reach GEO.

Responding to the possible PLA use of unmanned orbital Earth attack platforms may require consideration of multiple responses. Should the PLA launch continuously orbited space combat or Earth attack platforms, perhaps something similar to the Soviet unmanned *Polyus* system, then the U.S. should consider an appropriate in-orbit system to immediately respond to its use. Should the PLA instead launch space combat/Earth-attack platforms in concert with larger military campaigns, then it may be necessary to develop near-space hypersonic platforms able to intercept the PLA space attack platform.

Responding to potential PLA use of manned platforms for military operations, or its placement of military assets on the Moon, also requires serious consideration. One possible conclusion from the 2008 *Shenzhou 7* mission is that China has signaled that it will show no hesitation to attack manned space craft from the United States or other countries that it deems threatening. It is perhaps appropriate now for the U.S. to consider, as a matter of policy, whether it reserves the right of defensive response to China's use of manned space craft for military missions and then to make public that decision.

A key enabling technology for future U.S. space combat platforms or, for providing naval or ground forces a defense against space-launched weapons, will be energy weapons. It is crucial to proceed more rapidly with programs that can increase the strength and reduce the size and

energy requirements for solid state lasers. In addition, there should be greatly accelerated development of large and smaller railguns, which have the potential to launch steel pellet clouds to shred PLA anti-ship ballistic missiles (ASBMs), hypersonic glide vehicles (HGVs), and perhaps, space-launched ground attack munitions.

Resilience: The other side of the coin to deterring PLA attacks in space is to demonstrate that any space assets that are attacked can rapidly be either replaced or have its function effectively reconstituted. DARPA is now pursuing a number of programs which are intended to strengthen U.S. space resilience; these are deserving of increased support. In addition to the ALASA air-launched SLV, there is the *Galileo* program, intended to take parts off of older satellites in GEO and reconstitute them in space. DARPA's associated *Phoenix* program would develop a robotic builder satellite, in addition to its "Spacecraft Morphology" project that would use common Lego-like "Satlets" to build satellites for different missions.

In addition to such government-led programs, the U.S. should encourage many private corporate or university based initiatives to loft small sat clouds with the goal of succeeding the functions of larger more costly single satellites. In Japan, the Next Generation Space Systems Technology Research Association (NESTRA) is working on a 30-40 constellation of small sats with a 1 meter resolution. U.S. companies like Skybox, Planet Labs, and Black Sky are also developing constellations of small sats to provide commercial imagery with cheaper-smaller platforms.

If a satellite constellation cannot be replaced, such as the MEO Global Positioning Satellites (GPS), then there should be a greater investment in terrestrial alternatives. For example, growing jamming threats and China's DN-2 ASAT should provide ample justification for the U.S. to invest in E-LORAN to compliment and provide backup for GPS. E-LORAN will at least help provide vital navigation signals for aircraft and ships, aid ground vehicle navigation, and provide time synchronization services. In addition, the U.S. should invest in airborne platforms such as very long-endurance UAVs and near-space airships which can also replicate the functions of many satellite types.

Position: As it seeks to deter via retaliation and resilience, the U.S. must also be investing in strategic-positional deterrence, or simply put, make sure it can contest the "high ground"--which for the near term means the Moon. For the U.S. to bypass the Moon and simply invest in a Mars program that many take many decades to materialize, and leave China to build dominance over the Moon, would constitute strategic myopia for the United States. Under national policies of "civil-military integration" China likely seek military benefits from its presence on the Moon, perhaps to include developing options to block U.S. access to Mars.

Essential to exercising the option to build a Moon or Cis-Lunar presence would be the development of the heavy lift Space Launch System (SLS), and encouraging private companies to develop more efficient medium-heavy lift SLVs. While the U.S. government may not necessarily require a program to physically return to the Moon, it should retain the means to get there if required, and it should actively encourage multinational government-private initiatives to build an unmanned or manned Moon presence.

This could offer a "new" broad international program to succeed the ISS. It has the advantage of allowing space-faring nations with interests in deep space, like India and Japan, to "own" this project from the beginning and to leverage their participation to develop respective national capabilities such as heavy SLVs. A large multinational Moon program could create positive pressures for Russia and China "play nice" and, depending upon relations on Earth, advance an opportunity for peaceful cooperation that may offer a better chance to challenge China's space-nationalist policies. If this does not work, then the West will have secured a presence on the Moon that can at least offer options to respond to possible Chinese or Russian military exploitation.

Question 3: Discuss China's approach to space diplomacy and cooperation, particularly with the United States. Assess the risks and benefits of U.S.-China space cooperation.

China's space diplomacy approach toward the United States, as with Russia, has been to try to use all doors — the front and the back and sides. Despite occasional opportunities for discussions between space officials, largely due to post-Tiananmen sanctions, China and the U.S. did not engage in space-technical cooperation as China and Russia did starting in the early 1990s. The U.S. was not selling, but Russia was, so China was able to import significant Russian space technology to accelerate its 921 Program manned effort.

China has repeatedly expressed its willingness to consider space cooperation with the United States, as it stands ready to cooperate with many others. But instead of responding to over two decades of variously sourced U.S. concerns about its behavior on Earth, or in space, China's basic space-diplomacy strategy is to wait out the Americans. They are relying on China's accumulation of space power to convince enough U.S. power centers to carry the rest that cooperation with China must proceed despite real risks. It is a strategy that has worked well for Beijing in both economic and military realms.

A 29 September 2014 editorial in the prestigious *Aviation Week and Space Technology* noted, "It is absurd that the U.S. Navy can conduct joint exercises with the Chinese navy but Congress bars NASA from working directly with Chinese engineers and scientists." Well, to the shock of the U.S. Navy and its allies, when China accepted its first invitation to participate in the 2014 multilateral RIMPAC exercises, it brought along its own ELINT ship to record everybody's electronic emissions — a threatening response demonstrating essential hostility to the intent of inviting China's participation. This simply does not bode well for cooperation in space either.

To boot, the U.S., Russia and Europe all have had their sad experiences with Chinese espionage targeting their respective space sectors. According to the testimony of a Chinese solid fuel rocket motor engineer interviewed by this analyst, what they learned from the Martin Marietta solid satellite kick motor used on a Chinese SLV in the early 1990s has enabled all of their solid rocket motors for their new ballistic missiles now targeting the United States and its allies with nuclear weapons. Europe's Galileo navigation satellite program wanted China to be a partner, but when China obtained the technology it needed, it left and built its Compass system. At the 2007 Moscow Airshow, Russian space officials explained their attempt circa 1998 to promote business and cooperation by selling "internships" or access, to some 200 Chinese engineers, to

Russian space companies. The Russians did not sell space station tech to China, but they now know why the Chinese space station looks like theirs.

A simple reality for U.S. policy makers to keep in mind is that cooperation in space with China cannot be separated from China's ambitions on Earth or out into space. Likewise, for the United States to "wall off" space cooperation with China and to treat it as a "special" realm only plays into China's game. As long as it is ruled by the CCP, China is not likely to alter its ambitions to end the democracy on Taiwan, militarily consolidate the South China Sea, ensure that Iran and North Korea, like Pakistan, become nuclear missile states, or facilitate wars which challenge U.S. and Western security interests, merely to advance cooperation in space. It is imperative for U.S. leaders to accept that each of these challenges -- and countering China's expanding military ambitions in space --, are more important to U.S. security than is space cooperation with China.

Question 4: The Commission is mandated to make policy recommendations to Congress based on its hearings and other research. What are your recommendations for Congressional action related to the topic of your testimony?

1. Congress should request detailed information from U.S. sources about China's ambitions and activities in space. It is also crucial that the Congressionally-mandated annual Department of Defense report on the PLA contain a detailed section explaining China's space activities that bear on its military capabilities, and the related security concerns for the U.S. and its allies.
2. Congress should request that the Administration clarify with Chinese officials the recent disclosures that Chinese President Xi Jinping has personally ordered services of the PLA to prepare for space combat.
3. Congress should ask the Administration at what point in China's accumulation of active military space power does the United States respond with its own active military space capabilities to deter Chinese attack in space and to defend the space security interests of the United States.
4. Congress should ask the Administration to explain what are the security, political, and economic dangers to the United States of a Chinese military projection to the Moon and deep space.

OPENING STATEMENT OF DR. ROGER HANDBERG
PROFESSOR, DEPARTMENT OF POLITICAL SCIENCE, UNIVERSITY OF CENTRAL FLORIDA

DR. HANDBERG: My testimony today is going to first provide a net assessment of U.S. and Chinese civil space programs, discuss possible cooperation, which I see as a minimalist option but possible, and assess the impact of the Chinese space program on the U.S. and the global community.

First, both the United States and China operate full-scale space programs although the U.S. generally is much more active in the space sciences, astronomy and planetary science. The U.S. space program is clearly in a state of flux. What we are doing is we are privatizing significant segments of it, which makes the government sector in a sense less relevant.

The government--NASA--is now out of the business of going to low earth orbit. It's not going to return. What we have is SpaceX, Orbital Sciences for cargo, and several options for taking crews to the International Space Station.

That all appears very depressing, but from a broader perspective, the United States space program is not lagging behind the Chinese. In fact, if you objectively analyze it, the Chinese are catching up to what the original space pioneers, the Soviet Union, now Russia, and the United States did in the '60s and '70s. You know, it's kind of like "back to the future."

But the point is they're doing their space activity in a period where most of the people on earth are younger. They don't remember the earlier era. You know, they weren't here when astronauts came back from the moon and went on parades like prize bulls being taken out to be exhibited. So what happens is their program appears new, fresh, et cetera, but I would point out that their program has not suffered the ultimate crisis: loss of crew during space flight.

We went through Challenger; we went through Columbia; the Soviets went through their version. The Chinese space program works very cautiously, but it's likely over the long haul, over the next five to ten years, something is going to happen, and that will dissipate some of the public momentum and make people a little more realistic about what the Chinese are doing.

In terms of cooperation, China sees its space program as part of its charm offensive, to acquire allies, or at least influence neutrals to support their positions in various particular areas, and they've been very successful because we have certain restrictions, ITAR and others, that make it more difficult for us.

In the case of China, they don't give away their technology. People come to them; they launch them. We don't do as much of that as we used to. Back in the '60s, we had a very strong relationship with India, and then we got into nuclear proliferation questions, and that went away.

China is also working, as has been noted--I was sitting through some of the earlier panels--with the Europeans. The Europeans are trying to decide where they put their eggs in the next race. You know, the United States appears disorganized, in flux, unable to decide where it's going to go with the space launch system, and their case is the International Space Station can go down around 2020, probably 2024--it may last longer than that. Mir lasted long past its due date. But the point is the Chinese space satellite space station is going to be the next option for them as far as they see it because they don't see the Americans moving to ISS-2, and so that gets to be a real issue.

But the Europeans have discovered that they have competition and complications. There is Galileo Program. They invited the Chinese in and then suddenly they shut the door. Why did they shut the door? Because they began to realize despite what they talked about, Galileo was a

military capable system, and they were not going to--the Chinese wanted to get in on their encoded signals, not the public signal, so the Europeans backed off.

So Chinese cooperation may not be quite as important as you may think because I think there is an inherent limitation on what they want, especially with the developed countries. They want it to be a one-way street from the developed countries to China, and that makes it a little more complicated for the cooperative activities.

One of the questions we were asked, whether there's a space race between China and the United States, and the answer is simply no. The United States has never acknowledged the race because we have been there and done that. Now that's a little bit of complacency, but it also reflects a political judgment. We're not going to race to the moon again; we've been there. Will we go to the moon? That will probably be decided by the next administration because a space launch system will become available. It will be then in a situation where you can realistically start talking about where you want to go with it.

Going to an asteroid or moving an asteroid here is not necessarily the most glamorous, but it may be a useful exercise--could get long duration space missions.

The U.S. space program also appears less capable because we privatize things. SpaceX is on the rise. SpaceX is changing the international space launch market. The Europeans are desperate because they see their Ariane System, which was the opposite, the competition for the Americans. The American launch vehicles, Atlas and Delta, are basically out of the game.

Now, the biggest competition between the U.S. and China is in GPS. I think that is where you're going to see the greatest impact. The Chinese have put up their Compass/Beidou-2 system. It is now regionally operational. By 2020, it will be global. But here's what becomes the key. Right now the GPS is the standard for measurement so when you see international companies building space navigation things, GPS locators, they have GPS first, and then they have something else, usually right now GLONASS, it could be Galileo, it could be Compass/Beidou.

The literature I've been reading most recently says Compass/Beidou-2 will be the second one. But here's the problem. The Europeans are already talking about, and the U.S. has protested, Europeans requiring that their nationals use their Galileo system. So for the United States, that is the biggest technological and economic threat to space, is if the Chinese do that--they don't have to say anything to their people. They just say it will be there. The Chinese and Russians in January signed an agreement establishing a coalition between the GLONASS and the Beidou system, Compass/Beidou, and what they are trying to do is exclude the United States GPS system.

Now, on one level that's not a big deal, but economically it has an enormous consequences going forward.

Thank you

PREPARED STATEMENT OF DR. ROGER HANDBERG
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U.S.-China Economic and Security Review Commission
Hearing on *"China's Space and Counterspace Programs"*
"Implications for the United States"
Submission by Roger Handberg
February 18, 2015

I would like to thank the members of the U.S.-China Economic and Security Review Commission for inviting me to participate in today's hearing on "Implications for the United States." Daily, I am engaged in the study of American space policy generally but with particular focus on military space and international space policy including China and Europe.

My testimony today provides a net assessment of the U.S. and Chinese civilian space programs, discuss possible cooperation and assess the impact of China's space program upon the U.S. and the global community presently and into the future.

>Both China and the United States operate full scale space programs although the U.S. generally is much more active in space science including different forms of astronomy, Earth science and planetary science. The US civilian space program arose in an atmosphere of competition with the Soviet Union with a strong sense of national security driving the effort, space "firsts" were the priority but that ran down across the 1970s after the U.S. made successful landings on the lunar surface. The United States became engaged in a strong space science and astronomy effort once Apollo ended in 1972 with a continued focus on human space exploration. The international competitive tone of the American space program continues despite some setbacks.

The U.S. space program is in a state of flux. The commercial aspect is entering an era of opportunity with the rise of independent commercial launch options and expanded uses of space based applications especially navigation, remote sensing and communications. These resulted from the gradual removal of Cold War era security restrictions on nonmilitary space operations. The government side of the program is presently in a situation where budget realities are severely impacting future operations even though in areas such as planetary science and astronomy ongoing exploration is occurring at the edge of the solar system, on Mars, and in the galaxy beyond as new worlds are discovered.

In terms of public perceptions, China's space program appears to be moving ahead of the United States. But, upon closer examination, while the Chinese space program is making great strides across the spectrum of space activities but essentially China is still catching up to the original space pioneers, the United States and the Soviet Union, now Russia. Psychologically, momentum appears to be moving in China's favor with the possibility of actually moving ahead of the United States over the next two decades. The U.S. technological advantage is being challenged but has not been over taken up to this point. The strongest challenge actually appears to be relative to the U.S. GPS system which is the dominant navigation system at this time.

So, any net assessment has to specify a time line involved with the obvious reality that the farther out you go the less accurate the judgment. Over the next decade, despite some U.S. issues, China is still running behind but can rapidly catch up over the next two decades as the U.S. space program runs down unless some major changes occur or a new sense of urgency enters the equation. Americans assume continued U.S. superiority but that is a thin margin that will require reinvigoration. One must note however China's program has not (at least publicly) suffered a major setback in terms of a flight loss with crew deaths, that will not change the technological aspect but may change the psychological and public momentum.

>China, since the 1970s after the departure of Mao Zedong, has envisioned their space program as a tool through which other states can be engaged, circumventing any U.S. objections. At first, their cooperative activities were with members of the Soviet bloc rather than globally. More recently, China's space program is part of their "charm offensive" in order to acquire allies or at least influence neutrals globally. States otherwise excluded from outer space activities can partner with China to acquire access in the form of useful space applications. The joint China Brazil Earth Resources Satellite program initiated in the 1980s represents one example of those efforts where China consciously uses its space assets especially launch vehicles, the Long March family, to engage in cooperative activities with other economically advancing and challenged states. Chinese Long March vehicles have carried satellites to orbit for Venezuela and Nigeria, both influential states in their regions. With more developed space states, China have linked up especially with the Europeans. For example, China invested in the early Galileo navigation system and more recently just agreed to a robotic program with the European Space Agency. More recently, China has become visibly active in joint programs with the European Space Agency and individual states such as France. Examples include a robotic mission with ESA and several efforts in astronomy with France, the latter having encountered problems with U.S. International Traffic in Arms Regulations (ITAR) policies which prohibit or limit use of U.S. technology with certain states without formal U.S. consent.

The United States and China do not directly cooperate due to U.S. congressional actions banning such cooperation. Restrictions were originally driven by events after World War 2 and further hardened by the Korean War. After President Richard Nixon's opening to China in 1972, subsequent establishment of formal diplomatic relations in 1979, cooperative activities came slowly or not at all. U.S. policy has consistently placed severe restrictions on transfer of militarily relevant space technologies. In addition, the U.S. and other states agreed upon the Missile Technology Control Regime which expanded the restrictions further and brought other states (now 34) to agree on limits on what missile technologies could be sold or transferred to nonmembers. ITAR restrictions were somewhat loosened in the late 1980s-early 1990s in the context of allowing launch of U.S. comsats on Chinese vehicles but generally remained in force.

By 1998, concerns were raised about satellite technology transfers occurring during post-accident investigations involving Chinese launch vehicles carrying U.S. comsats. In response, ITAR restrictions were further tightened, shutting out launches on Chinese vehicles. Further restrictions occurred after 9-11 and only now are those restrictions being loosened but not removed. Congress explicitly banned cooperation between NASA and China. The pressures for an easing of ITAR restrictions came from industry.

With reference to China, the concern was that the Chinese were surreptitiously accessing U.S. technologies for their military and economic advantage. Given the technological disparities existing earlier, that was not an unreasonable fear. Concern about cyber-attacks keeps one vigilant and skeptical but circumstances have changed at least partially. Over the past decade, China has consistently demonstrated the independent capabilities for conducting space operations in LEO and at the Moon. This work appears to have been indigenous rather than imported from elsewhere. Concerns about industrial espionage especially through cyberattacks are realistic and not inconsequential but the circumstances may be changing with regards to civil space activities.

Therefore, I would suggest opening the possibility for cooperative space activities between NASA and China on at least a limited basis. This would be particularly fruitful in conducting space station operations since the ISS is projected to terminate around 2024 with no follow on program in sight. Commercial options may arise but are still problematic at this point in time. China is proposing to complete its next space station around 2022 although slippage is always possible and likely. China has publicly said the Chinese Space Station would have international partners, mirroring the ISS as it presently exists. The United States has consistently argued that China must become an integral part of the international order; cooperative space activities are one facet of such outreach and in fact is least threatening to U.S. security and economic wellbeing. China is demonstrating the ability to operate its program in outer space without others participating which is the criterion for joining the space club as a major member, one of three who have sent humans into outer space.

>Assessing whether there exists a “space race” between the US and China is simple: no. A space race implies there are at least two parties involved in the competition. The United States does not directly responded to the Chinese space program’s expanding activities especially human space activities. Instead, the US posture has been of isolating China in terms of participation in the International Space Station (ISS). For the United States, domestic considerations dominate the development of our space program. Budget concerns for example come in two forms: one is a concern with the federal deficit which leads to a statist position as demonstrated by the NASA budget over the past decades (see attached Table 1); and two, a continuing political-technical disagreement over where the next NASA human launch vehicle, the Space Launch System, should go. The disagreement boils down to the Moon first position and the “flexible path” as embodied in some variant in a crewed mission to an asteroid. These factors reduce any competitive response to China’s space program with the recognition that there appears little political interest in engaging in such a competition. Furthermore, the U.S. is committed to a significant commercial engagement in outer space initially in Low Earth Orbit (LEO) and eventually farther out. So, the U.S. space program may look less capable than China’s program in certain aspects because some has been farmed out to the private sector.

China’s space program is an instrument for achieving and sustaining international prestige, as a symbol of military power, and an instrument for economic development. International prestige is critical for China as it strives to assume what they perceive as their proper role in world affairs as one of the dominant powers. Regionally, space activities become an instrument for signaling their superiority to Japan, its major regional rival. The result from China’s perspective is a twofer: equality with the United States and superiority in the Asia-Pacific realm. All of this

creates tensions with others both globally and especially regionally but for domestic political reasons that is an acceptable cost.

Launching satellites, space stations, and crewed vehicles to space are important symbols of Chinese military and economic power. In a manner similar to the Soviet Union in the earliest days after Sputnik, launching peaceful space payloads symbolically is the equivalent to launching ballistic missiles. Its signals that China possesses significant military capabilities. So, for China, a "space race" is underway – one in which China races to accomplish the same "space firsts" achieved by the Soviet Union and United States in the first decade and a half of the space age. The race is to acquire international attention and respect, the military aspect remains more muted but present in the background. One should point out that China's race to space is much more leisurely than occurred across the 1960s. In one sense, their margins for failure are much narrower, for China "failure is not an option" unlike the early space age when failure was expected as new technologies came on line. Prestige wise, China benefits from its successes but that is always fragile given the possibilities that a flight failure may occur especially in human spaceflight.

For the United States, by 2030, the question of where to go in terms of human space exploration will be decided and the exploration process under way or else the U.S. will have withdrawn from any significant role in conducting exploration of outer space by focusing its energies on robotic missions. The reality is that the U.S. and Chinese human space exploration programs may both confront the reality that space may prove too harsh an environment given existing technologies. Remember NASA is only now sending an astronaut to the ISS for a year and then will evaluate that individual with their twin to assess the amount of damage inflicted by the space environment. If China lands on the Moon, the question will be what are their long term plans for that location?

>The 2007 destruction of an obsolete Chinese weather satellite drew much world attention because the Chinese military appeared to be unaware or indifferent to the proliferation of orbital debris and its consequences. A subsequent U.S. shooting down of a descending satellite produced much less debris which reentered the atmosphere quickly. Recent estimates show that China despite the relative newness of its accessing Earth orbit has become the leader in creating orbital debris, reflecting their lack of systematic programs for disposal of obsolete satellites and space craft. NASA for example has deorbited various satellites when their missions ended and before the vehicle ran out of fuel to allow for a partially controlled descent. For example, when the ISS ends its effective lifespan, it will be deorbited into the Southern Pacific under hopefully controlled conditions. One estimate by the Russians was that China has contributed 40 percent of the debris in orbit with the U.S. and Russia around 25 percent each despite much longer space histories in terms of launches and satellites in orbit. Explosions of Long March vehicles after their payloads were orbited have occurred at least 4 times leading to the spread of debris as a result. China established mitigation policies but implementation has been slow, reflecting a relative lack of priority.

For all space states especially the United States with its large array of satellites, orbital debris is a major concern both commercially and militarily while the ISS has routinely been moved in orbit to avoid large pieces of orbital debris including entering the Soyuz vehicle on station as a

lifeboat. If China does not become more conscious of orbital debris impact on space operations, the reality could be a significant decline in the ability of states to operate in space especially in low Earth orbit. Economically, the U.S. GPS system could be disabled and efforts at exploring space could be severely damaged. Ironically, China pushes for international agreements against weaponization of outer space with the argument in part about the debris catastrophe such a conflict would generate. That same effect could be accomplished just by lack of care in disposing of obsolete or otherwise useless space hardware. UN efforts to limit debris proliferation have the usual problem of being obsolete but the U.S. and others have already demonstrated that mitigation can be achieved in absence of removal.

>China since the 1980s has pursued commercial activities initially through their China Great Wall Industry Corporation. Their Long March launchers represent a potentially strong competitor internationally. Earlier, they failed due to several launch accidents resulting in deaths among the local population. Those accidents combined with U.S. ITAR restrictions reduced their role in the global marketplace given American dominance in comsats at that time. In reality, their domestic launch manifest was growing, providing a means by which to reestablish Long March reliability. They launch a few non-Chinese payloads but the potential is growing because of the cooperative activities mentioned earlier. Their move in this sector may be adversely impacted by changes in the launch marketplace if SpaceX proves as successful and cost efficient as appears to be happening. Chinese technologies are improving such as in satellite construction but competition is also rising. For example, India and Japan are as their new launch systems and satellites are becoming available.

The most significant immediate Chinese commercial challenge to the United States is emerging in their Compass/BeiDou-2 navigation satellite system. This satnav system has achieved regional coverage and is building toward global coverage. The U.S. GPS system is the benchmark against which all other potential competitors are measured. The Russian GLONASS and European Galileo systems were both constructed as alternatives to the U.S. system, the latter as a direct commercial competitor while the Russian system is a carry forward from the Cold War. Both have encountered some turbulence but are both either on line (GLONASS) or coming into service (Galileo). Regardless, the Chinese system is rapidly growing in impact. Both Galileo and Compass/BeiDou-2 should be globally operational in 2020. A growing number of Global Navigation Satellite System (GNSS) commercial applications are built in multi-GNSS configurations, meaning presently GPS plus one of the others, GLONASS, Galileo or Compass/BeiDou-2. However, there is mounting evidence that different states involved in supporting a GNSS system are requiring their nationals to use their system. The Europeans are already being challenged on that requirement but the reality is China does not have to officially require its operators to do so since most operate at the sufferance of the government. The alliance between Russia and China (driven in part by the Ukrainian situation) will probably end with GLONASS and Compass/BeiDou-2 being their preferred arrangement especially after the latter becomes global. GNSS applications are a major economic driver in the global market as the uses proliferate well beyond the dreams of the original builders. The major U.S. advantage is that U.S. GPS satellites have proven extraordinarily reliable over the years while the GLONASS has had recurrent gaps in coverage.

>The impact of China’s civil space programs and activities on U.S. space programs and

industries comes mostly at the level of cooperative projects when China is willing to subsidize participation by economically challenged or neutral states. The U.S. further hampers its international cooperation efforts through the ITAR process but that has been a burden the nation has agreed to bear. China is excluded completely from space relevant exports under ITAR as it is applied. Otherwise, the U.S. relies on private vendors to make sales in other states that can qualify. That means that economic benefits are lost due to technology transfer restrictions tied to national security concerns. Such losses occur across the spectrum of U.S. space technologies and activities which means solutions will be sector by sector or else sale by sale. That may be a bearable cost but one must insure the review process is both timely and relevant.

> Recommendations are few given the ongoing international situation between China and the United States as rivals:

1. As suggested above, the ban on NASA interacting with China should be addressed so that more nuanced decisions can be made regarding what cooperation with China is deemed possible given security and economic concerns. The reality is that the United States may find itself outside many future civil space programs which will likely be cooperative rather than standalone by the United States. China is actively working to pull others into their orbit, a competition the United States is in effect ignoring or saying that nothing can be done. Also, the United States cooperated with the Soviets earlier, indicating that security concerns can be addressed successfully.
2. A more general but relevant recommendation is that the U.S. needs to decide what it plans on doing regarding our civil space program, the commercial aspect is well underway and moving to the next level of international competitiveness. NASA and other government programs need a stronger sense of direction supported by actual budgets moving forward in time. Understanding that Congress wishes to retain power of the purse, the necessity is that we as a nation generate a path to the future (with the possibility of detours) regarding our space program. Otherwise, we will continually meander forward and waste scarce fiscal resources and professional talent in a continual trip to nowhere. Supposedly, reaching orbit meant the entire solar system and universe was open to us that has not happened.
3. More broadly, the United States must systematically review its ITAR policy in order to maximize trade options while maintaining necessary security restrictions. The major changes involve improving the capacity to review and decide on requests more quickly. The international space marketplace is evolving quickly and the United States must work to remain competitive. Markets once lost are difficult to recover especially given the quickness with which change is occurring globally.

Table 1*[1]
NASA Budget Historical Current Dollars FY 1959-2010

Fiscal Year	NASA Budget (current dollars, millions)	Percent Change	Percentage Federal Government Outlays
1959	145	-	0.1
1960	401	177%	0.5
1961	744	85.5	0.9
1962	1,257	69	1.2
1963	2,552	103	2.3
1964	4,171	63.4	3.5
1965	5,092	22.1	4.3
1966	5,933	16.5	4.4
1967	5,425	-8.6	3.4
1968	4,722	-13.0	2.7
1969	4,251	-10.0	2.3
1970	3,752	-11.7	1.9
1971	3,382	-9.9	1.6
1972	3,423	1.2	1.5
1973	3,312	-3.2	1.3
1974	3,255	-1.7	1.2
1975	3,269	0.4	1.0
1976	3,671	12.3	1.0
1977	4,002	9.0	1.0
1978	4,164	4.0	0.9
1979	4,380	5.2	0.9
1980	4,959	13.2	0.8
1981	5,537	11.7	0.8
1982	6,155	11.1	0.8
1983	6,853	11.3	0.8
1984	7,055	2.9	0.8
1985	7,251	2.8	0.8
1986	7,403	2.1	0.7
1987	7,591	2.5	0.8
1988	9,092	19.8	0.9
1989	11,036	21.4	1.0
1990	12,429	13.6	1.0
1991	13,878	11.7	1.0
1992	13,961	6.0	1.0
1993	14,305	2.5	1.0
1994	13,694	-4.3	0.9
1995	13,378	-2.3	0.9
1996	13,881	3.8	0.9
1997	14,360	3.5	0.9
1998	14,194	-1.2	0.9

1999	13,636	-3.9	0.8
2000	13,428	-1.5	0.8
2001	14,092	4.9	0.8
2002	14,405	2.3	0.7
2003	14,610	1.4	0.7
2004	15,152	3.7	0.7
2005	15,602	3.0	0.6
2006	15,125	-3.1	0.6
2007	15,861	4.9	0.6
2008	17,833	12.4	0.6
2009	19,168	7.5	0.5
2010	18,906	-0.2	0.5
2011	17,618	-6.8	0.5
2012	17,190	-2.4	0.5
2013	16,865	-1.9	0.5
2014	17,646	4.6	0.5
2015	18,010	3.11	0.5

*"Historical Tables, Budget of the U.S. Government, Fiscal Year 2015" (Washington: Office of Management and Budget, White House, 2015), Tables 5.2 and Table 5.3. Fiscal Years 1959-1961 come from Jane Van Nimmen and Leonard C. Bruno with Robert L. Rosholt, "NASA Historical Data Book, 1958-1968, Vol. I, NASA Resources," (Washington: NASA SP-4102, 1976), Table 4.4, page 118. Updated January 30, 2015.

[1] Chart originally reported in Roger Handberg, "Human Spaceflight and Presidential Agendas: Niche Policies and NASA, Opportunity and Failure," *Technology in Society* 39 (2014), 31-43.

OPENING STATEMENT OF DR. PHILLIP SAUNDERS
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DR. SAUNDERS: Thank you.

It's a pleasure to be here today and an honor to be here to address the Commission. I have to remind people that these are my personal views, not those of the National Defense University, Department of Defense, or the administration.

Now that I've got that out of the way, I'm going to focus my time and oral remarks mostly on the first and most important question you asked, which is what actions the U.S. should take to mitigate risks and maintain its strategic advantage in space in light of changing Chinese space and counterspace capabilities?

Since previous speakers have talked about the details of China's increasing military and civil use of space and the range of counterspace systems it's pursuing, I'm going to focus on the implications and responses in my remarks. I will, however, note that there are a lot of motives behind the Chinese space program including economic, scientific, technology and military motives. It's also driven partly by prestige, both domestically and internationally, and profit.

PLA strategists see the U.S. military dependence on space as a critical vulnerability that they can exploit by counterspace assets, but they also intend to take full advantage of the contributions that space assets can make to their military operations, emulating what the U.S. military has done to improve their capability to fight and win in informationized war.

As the PLA becomes more dependent on its space assets to conduct operations, the current asymmetrical situation where the U.S. is much more dependent on space and hence more vulnerable will become more symmetrical, especially in operations farther from the Chinese mainland where the PLA can't rely on land-line communications and ground-based aviation assets.

The January 2011 U.S. National Security Space Strategy talks about a four-layered approach, which includes: developing norms of responsible behavior; building coalitions to enhance collective capabilities; denying the benefits of aggression, both by enhancing the resilience of the U.S. space architecture, and ensuring that the joint force can operate effectively when capabilities are degraded; and then finally being prepared to respond to an attack on U.S. or allied space systems proportionally but not necessarily symmetrically and not necessarily in space.

In my view, all four of the legs of this strategy have some merit. There's been a lot of talk about a space code of conduct, and I think that could have value for supporting development of norms of responsible behavior, but I'm skeptical about the prospects for arms control to produce meaningful, verifiable restrictions on development, testing, and deployment of counterspace weapons.

Dave Gompert and I wrote in The Paradox of Power that traditional approaches to arms control seem unlikely to limit U.S. and Chinese ASAT weapons both because both sides see a lot of military return and there are so many different approaches to anti-satellite technology. You can't find, verify, and control them all.

If you can't ban ASAT weapons via arms control, the next best solution is to create a strategic environment that deters their use against U.S. space assets. I think the National Security Space Strategy focuses on two sides of this:the first is denying an adversary the

potential gains from using ASAT weapons, what we call deterrence by denial; and the second is being prepared to respond to an attack in ways that generate unacceptable damage, either to an adversary's space assets or to other high value assets, deterrence by punishment. We have to think about both sides of that equation.

There's a variety of things the U.S. could do to make space assets less attractive targets. These include rapid replenishment of damaged satellites, also known as "operationally responsive space"; making satellites harder to find and harder to hit by making them smaller and stealthier; building constellations of small satellites that disperse capability and are less vulnerable to attack; hardening communication systems; making better use of non-space tactical reconnaissance systems; using foreign satellites to help increase the political costs of attacks; considering direct attacks against Chinese ASAT systems, some of which are land-based; and finally, space-based weapons to attack Chinese ASAT systems or space assets.

I think the problem, or the challenge, is that many of these solutions are very, very expensive to implement, especially considering the relatively low cost of ASAT weapons that can destroy expensive satellites or degrade their functionality. So it would be nice to have a full set of off-the-shelf replacements and ample launch capability to surge if space assets are damaged, but that's going to require a huge investment whose positive impact could be overcome by adding more and cheaper ASAT weapons.

So I think when you consider the options, DoD should pursue those that have the greatest return on investment, especially when considering adversary responses. To me, some of those seem to be hardening satellite communications, making greater use of tactical reconnaissance systems, and exploring constellations of small satellites.

But it's not enough just to invest in space assets. We also have to make efforts to conduct military exercises that simulate degraded access to space and cyber and explore and practice workarounds if space systems are not available.

Actions such as kinetic attacks on Chinese counterspace systems or extensive use of space-based weapons have the potential to be both strategically destabilizing in a crisis and to stimulate an expensive arms race.

Given that I don't think we can buy our way out of this vulnerability, I think we also need to make investments in counterspace systems to hold Chinese space assets at risk. As the official strategy quoted above states, this need not only involve kinetic ASAT or symmetrical approaches. I think generally speaking, we should prioritize non-kinetic ASAT systems that do not generate significant amounts of space debris, soft kill over hard kill, and ways of temporarily limiting the ability of adversary satellites to support their military operations.

Such counterspace systems are more usable in a conflict and thus more credible in deterring Chinese attack.

As I mentioned at the start, the Chinese military will become more dependent over time on their own fragile and vulnerable space systems, especially when operating farther from China's coast. If they do decide to deploy missile defenses, which they are testing now, they will also need to deploy early warning radars and launch detection satellites to provide cueing data.

Over time, I see the Chinese military becoming more and more dependent on space assets both for warfighting and for strategic stability, which will reduce the current asymmetrical vulnerability in the space domain. Eventually, I can see the PLA joining the U.S. military in thinking it's better for both sides to fight each other with their space assets rather than without them.

I think this may produce more common interests in making space a sanctuary even if

there is a military conflict. Dave Gompert and I articulated in The Paradox of Power what such strategic restraint might look like, focusing on mutual agreement not to interfere with the operations of each other's civilian or military satellites.

We argued that such agreements built on a foundation of deterrence can reinforce deterrence and damp down some of the potential arms race dynamics in U.S. and Chinese space and counterspace development. This will not only make our access to space more secure but will also contribute to more stable bilateral relations.

I have in my written testimony addressed the questions on space cooperation, debris, and Chinese motives, but I am out of time so I will stop here.

Thank you.

PREPARED STATEMENT OF DR. PHILLIP SAUNDERS
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Testimony before the U.S.-China Economic and Security Review Commission

Hearing on "China's Space and Counterspace Programs"

February 18, 2015

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Dr. Saunders is speaking in his own personal capacity as a member of the academic community. This statement represents his views based on his research. It should not be implied to represent the views of the Department of Defense or the Administration.

I am grateful for the opportunity to address the commission as part of this important hearing on China's Space and Counterspace Programs. In trying to address the many questions posed by the committee, I have focused on the first and most important question, what actions the United States should take to mitigate risks and maintain its strategic advantage in space in light of changing Chinese space and counterspace capabilities.[1]

Chinese thinking has been heavily influenced by the study of U.S. space doctrine and how the U.S. military has used space assets in modern military conflicts, beginning with the Persian Gulf War in 1991. This has sparked Chinese efforts to develop their own space capabilities to support their own military modernization, with space systems being a key element of efforts to "informationize" the People's Liberation Army (PLA) to improve its combat power and ability to conduct joint operations. At the same time, China has also invested in a range of counter-space capabilities intended to exploit U.S. military dependence on space, which the Chinese see as a critical U.S. vulnerability.

Over the medium-term, Chinese investments in space assets are likely to produce a more symmetrical situation in which both the U.S. and Chinese militaries are heavily dependent on access to vulnerable space assets in order to conduct both routine peacetime and combat operations. Moreover, the governments, companies, and citizens in both countries will benefit increasingly from space-based technologies in areas including weather forecasting, access to global-positioning system (GPS) navigation data, satellite television, and use of satellite data to

[1] For a useful overview of the strategic role of spacepower, see Charles D. Lutes and Peter Hays with Vincent A. Manzo, Lisa M. Yambrick, and M. Elaine Bunn, Toward a Theory of Spacepower: Selected Essays (Washington, DC: NDU Press, 2011), http://ndupress.ndu.edu/Portals/68/Documents/Books/spacepower.pdf

improve crop yields and reduce vulnerability to natural disasters. This more parallel situation will not eliminate U.S. concerns about Chinese counterspace systems or make it possible to eliminate such systems through arms control agreements. However, it may allow both governments to pursue strategic restraint in space, based on a foundation of mutual deterrence, in ways that limit the high costs of unrestrained military competition in space.

Chinese Thinking about Space

Chinese thinking about space emphasizes its importance across a wide range of economic, scientific, and military applications. The 2011 space white paper lists the aims of China's space activities as:

> to explore outer space and to enhance understanding of the Earth and the cosmos; to utilize outer space for peaceful purposes, promote human civilization and social progress, and to benefit the whole of mankind; to meet the demands of economic development, scientific and technological development, national security and social progress; and to improve the scientific and cultural knowledge of the Chinese people, protect China's national rights and interests, and build up its national comprehensive strength.[2]

The 2011 Space White Paper notes that "China's space industry is subject to and serves the national overall development strategy, and adheres to the principles of scientific, independent, peaceful, innovative, and open development."[3] However, the 2006 space white paper gives a more candid description of the strategic nature of the space program: "China considers the development of its space industry as a strategic way to enhance its economic, scientific, technological and national defense strength, as well as a cohesive force for the unity of the Chinese people, in order to rejuvenate China."[4] These statements have been backed by sustained investments to develop and improve China's space capabilities in both the commercial and military realms.

The Chinese Communist Party (CCP) has derived considerable domestic and international prestige from Chinese accomplishments in space, including its manned space program, scientific exploration activities, and willingness to share space technology and provide launch services and satellite expertise to other developing countries. China's official policy emphasizes the peaceful use of outer space and calls for a ban on the weaponization of space and negotiation of a legally binding treaty on the prevention of an arms race in outer space.[5] China and Russia jointly submitted a draft treaty to the UN Conference on Disarmament in 2008. The text called for a ban on objects carrying weapons in orbit or on celestial bodies along with commitments "not to station such weapons in outer space in any other manner" or to "resort to the threat or use of

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[2] Information Office of the State Council of the People's Republic of China, "China's Space Activities in 2011," December 2011, Beijing.
[3] Information Office of the State Council of the People's Republic of China, "China's Space Activities in 2011," December 2011, Beijing.
[4] Information Office of the State Council of the People's Republic of China, "China's Space Activities in 2006," October 2006, Beijing.
[5] Information Office of the State Council of the People's Republic of China, "China's Space Activities in 2011," December 2011, Beijing.

force against outer space objects." However, the draft treaty contained no verification measures and does not apply to Earth-based weapons that can attack satellites or their terrestrial support infrastructure, making it largely irrelevant to the goal of limiting the danger of ASAT attacks.

PLA Space Capabilities[6]

Although the PLA does not appear to have developed and approved a comprehensive space doctrine, one PLA textbook proposes "unified operations, key point is space dominance" as a guiding concept.[7] "'Unified operations' refers to applying all types of capabilities, terrestrial and space-based, active and passive measures, hard-kill and soft-kill, focused on assuring that the PLA can derive and exploit space at times and places of its choosing, while preventing an opponent from doing so."[8] Space dominance requires the integration of space operations with those of other services and the integration and unification of various types of offensive and defensive space operations.[9]

The Chinese military discusses the use of space assets to support joint military operations in terms of "space support operations," which corresponds to the U.S. terminology of "force enhancement."[10] Space support operations make use of space-based platforms to provide critical information to ground, air, and naval forces, including space-based ISR, communications and data relay services, navigation and positioning, early warning of missile launches, and Earth observation.[11] China has significant capabilities in most of these mission areas and is likely to develop more sophisticated capabilities in the future.

PLA expert Mark Stokes described the military impact of Chinese space capabilities in these terms:

> Increasingly sophisticated space-based systems expand PLA battlespace awareness and support extended range conventional precision strike systems. Space assets enable the monitoring of naval activities in surrounding waters and the tracking of air force deployments into the region. The PLA is investing in a diverse set of increasingly sophisticated electro-optical (EO), synthetic aperture radar (SAR), and electronic reconnaissance assets. Space-based remote sensing systems also provide the imagery necessary for mission planning functions, including automated target recognition technology that correlates preloaded

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[6] The following two sections are adapted from chapter three of David C. Gompert and Phillip C. Saunders, The Paradox of Power: Sino-American Strategic Restraint in an Era of Vulnerability (Washington, DC: NDU Press, 2011), http://ndupress.ndu.edu/Portals/68/Documents/Books/paradox-of-power.pdf

[7] Dean Cheng, "Prospects for China's Military Space Efforts," in Roy Kamphausen, David Lai, and Andrew Scobell, ed., Beyond the Strait: PLA Missions other than Taiwan (Carlisle, PA: U.S. Army War College, Strategic Studies Institute, April 2009), 273–279.

[8] Dean Cheng, "China's Space Program," written testimony submitted to the U.S. China Economic and Security Review Commission, May 11, 2011.

[9] Cheng, "Prospects for China's Military Space Efforts," 218.

[10] Kevin Pollpeter, "The Chinese Vision of Space Military Operations," in James Mulvenon and David Finkelstein, eds., China's Revolution in Doctrinal Affairs: Emerging Trends in the Operational Art of the Chinese People's Liberation Army (Alexandria, VA: CNA Corporation, 2005), 333–334.

[11] Li Dong et al., "Research on Concepts of Space Operations and Command," cited in Cheng, "Prospects for China's Military Space Efforts."

> optical, radar, or infrared images on a missile system's computer with real time images acquired in flight. A constellation of small electronic reconnaissance satellites, operating in tandem with SAR satellites, could provide commanders with precise and timely geo-location data on mobile targets. Satellite communications also offer a survivable means of linking sensors to strike systems, and will become particularly relevant as PLA interests expand further from PRC borders.[12]

Although China currently lacks satellites to provide early warning and tracking of ballistic missile launches, the utility of this capability is discussed in Chinese military writings. If China intends to deploy ballistic missile defense capabilities (it conducted test intercepts in 2010, 2013, and 2014), a space-based launch detection system to provide cueing data would be a requisite capability. China also employs a range of telecommunications and data relay satellites to support both military operations and civilian applications such as satellite television, Internet, and telephony.[13] China is developing its own global positioning system as well, which is already operational and expected to have a complete global constellation by 2020.[14] Navigation and positioning information is critical for a range of military applications, including to provide guidance and targeting information for China's growing array of precision strike weapons.

In addition to more sophisticated payloads, China is improving its launch capabilities. In September 2013, China launched a satellite into orbit using the Kuaizhou ("quick vessel") mobile space launch vehicle; a second launch followed in November 2014.[15] China is also developing a second responsive space launch vehicle, the Long March-11, which is intended to provide "a vehicle to rapidly enter space and meet the emergency launching demand in case of disasters and contingencies."[16] Mobile space launch vehicles reduce China's dependence on a limited number of fixed space launch sites and constitute a step toward "operationally responsive" space capabilities better suited for use in a military conflict.

PLA Counter-Space Capabilities

China is also pursuing efforts to deny an adversary's use of its space assets. February 2015 testimony by DIA Director Lieutenant General Vincent Stewart notes that:

> Chinese and Russian military leaders understand the unique information advantages afforded by space systems and are developing capabilities to deny U.S. use of space in the event of a conflict. Chinese military writings specifically highlight the need to interfere with, damage, and destroy reconnaissance, navigation, and communication satellites. China has satellite jamming capabilities

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[12] Mark A. Stokes, prepared statement for U.S.-China Economic and Security Review Commission hearing on the Implications of China's Military and Civil Space Programs, May 11, 2011.
[13] Office of the Secretary of Defense, "Report to Congress on Chinese Military Power 2010," 36.
[14] Office of the Secretary of Defense, "Military and Security Developments involving the People's Republic of China 2014," 11.
[15] Rui C. Barbosa, "China launches Kuaizhou-2 in second launch within 24 hours," nasaspaceflight.com, November 21, 2014, http://www.nasaspaceflight.com/2014/11/china-launches-kuaizhou-2-second-launch-24-hours/
[16] Office of the Secretary of Defense, "Military and Security Developments involving the People's Republic of China 2014," 10.

> and is pursuing other antisatellite systems. In July 2014, China conducted a non-destructive antisatellite missile test. A previous destructive test with this same system in 2007 created long-lived space debris.[17]

China space expert Dean Cheng notes that PLA authors emphasize the importance of offensive operations to deny a superior adversary the ability to use space, but these efforts are not limited to attacking systems in orbit. Chinese military writings discuss:

> a range of efforts aimed at affecting the range of space-related capabilities, from orbiting satellites, through space-related terrestrial facilities, to the data, communications, and telemetry links that tie all these systems together. . . . Space offensive operations include not only applying hard-kill capabilities against satellites, but also attacking launch bases and tracking, telemetry, and control facilities. They also discuss the use of soft-kill techniques, such as jamming and dazzling, against satellites, in order to minimize the generation of debris, and the attendant physical and diplomatic consequences. And they also will likely involve the application of cyberwarfare methods against the various data and communications links that transfer information and allow satellites to maintain their orbits.[18]

China has developed a wide range of capabilities that can potentially be used to target space assets and support systems. In addition to the direct-ascent ASAT system China successfully tested in January 2007 and 2014, a Pentagon report notes that China has "a multi-dimensional program to limit or prevent the use of space-based assets by potential adversaries during times of crisis or conflict." The report adds that:

> China's nuclear arsenal has long provided Beijing with an inherent ASAT capability, although a nuclear explosion in space would also damage China's rapidly multiplying space assets, along with those of whomever it was trying to target. Foreign and indigenous systems give China the capability to jam common satellite communications bands and GPS receivers. In addition to the direct-ascent ASAT program, China is developing other technologies and concepts for kinetic and directed-energy (e.g., lasers, high-powered microwave, and particle beam) weapons for ASAT missions. Citing the requirements of its manned and lunar space programs, China is improving its ability to track and identify satellites—a prerequisite for effective, precise counter-space operations.[19]

Although some Chinese military experts advocate preemptive attacks on space assets to take advantage of U.S. dependence on them and seize the initiative in the fight for information

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[17] Lieutenant General Vincent R. Stewart, USMC, Director, Defense Intelligence Agency, Statement for the Record, Worldwide Threat Assessment, Armed Services Committee, U.S. House of Representations, February 3, 2015.
[18] Cheng, "China's Space Program."
[19] OSD, Annual Report to Congress on Chinese Military Power 2010, 36. Limited Chinese space tracking and identification capabilities were one reason an earlier study by this author on Chinese interest in ASAT technologies accurately noted that as of 2002 China lacked some capabilities necessary for an operational ASAT system. See Phillip C. Saunders, Jing-dong Yuan, Stephanie Lieggi, and Angela Deters, "China's Space Capabilities and the Strategic Logic of Anti-Satellite Weapons," Center for Nonproliferation Studies Research Story of the Week, July 2002.

dominance,[20] it is not clear that this argument has been fully accepted by the PLA leadership or endorsed by Chinese civilian leaders. Another strand of thinking emphasizes the importance of China having offensive space capabilities as a deterrent measure. This is partly to exploit the inherent vulnerability of costly space assets as a means of deterring conflict in the first place. However, some PLA writings appear to envision an escalation ladder that runs from testing space weapons, to exercising space forces, to reinforcing space capabilities (especially in a crisis), and to actually employing space forces. Demonstrating the capability and will to attack an adversary's space assets is described as the most credible form of deterrence.[21]

Other relevant aspects of PLA writings on space issues highlight a preference for "soft kill" (which temporarily or permanently denies use of space assets by means such as jamming, blinding, or cyber attack) over "hard kill" (kinetic attacks with the potential to generate significant amounts of space debris that might affect China's own satellites). Soft-kill attacks are seen as potentially more deniable and having fewer diplomatic consequences than hard-kill attacks, which may generate debris or involve kinetic attacks on facilities in third countries. Some writings by PLA authors also stress the importance of centralized authorization of attacks due to diplomatic costs and the potential for escalation.

PLA authors discuss a range of "space defensive operations" to protect space assets and defend against attacks from space. These include the use of camouflage and stealth measures to disguise a spacecraft's functions, deployment of small and microsatellite constellations rather than single large satellites, maneuverability, capability for autonomous operation, and deploying false targets and decoys to overload an adversary's tracking capability. They also envision offensive operations by both space-based and terrestrial assets to protect space assets.[22] Deployment of mobile launchers would also help the PLA surge additional space assets into low-earth orbit to augment capabilities or to replace satellites that are damaged. These tactics might have some value in protecting military space assets but would probably do little to protect civilian satellites. PLA space experts write that space dominance will be a critical and contested objective throughout a military conflict, with the PLA seeking to preserve the operational use of its own space assets in the face of attacks by an adversary's ASAT capabilities and to deny an adversary's use of its space assets.[23]

Implications

- **Given China's emerging counterspace capabilities, what actions should the United States take to mitigate risks and maintain its strategic advantage in space? Identify which defensive or offensive capabilities, if any, the United States should prioritize and assess the implications for U.S. defense budget requirements in these areas**.

PLA strategists see U.S. military dependence on space as a critical vulnerability that can be exploited by use of counterspace assets. However, the PLA also intends to take full advantage of the contributions space assets can make to its military operations, emulating U.S. military efforts

[20] See Pollpeter, "The Chinese View of Military Space Operations," 355–362.
[21] Cheng, "Prospects for China's Military Space Efforts," 234–240.
[22] Ibid., 231–234.
[23] Pollpeter, "The Chinese View of Military Space Operations," 355–362; Cheng, "Prospects for China's Military Space Efforts."

to improve their capacity to fight and win an "informationized war." This will necessarily increase PLA dependence on its own vulnerable space assets. As the PLA becomes more dependent on space assets to conduct routine military operations, the current asymmetry (with the U.S. military much more dependent on space, and thus more vulnerable) will become more symmetrical, especially for operations further from the Chinese mainland where the PLA cannot rely on landline communication and ground-based aviation assets to supplement the capabilities of its space systems.

The January 2011 National Security Space Strategy describes a four layered DoD approach to deterring attacks on space capabilities:[24]

1) Support the development of international norms of responsible behavior that enhance safety, security, and stability in space.

2) Build coalitions to enhance collective security capabilities.

3) Deny the benefit of aggression by enhancing the resilience of space architectures and ensuring that the Joint Force can operate effectively when space capabilities are degraded.

4) Be prepared to respond to an attack on U.S. or allied space systems proportionally, but not necessarily symmetrically and not necessarily in space, using any or all elements of national power.

With respect to the possibility for deterrence failure, the strategy calls for the United States to "be in a position to respond in self-defense and defeat such aggression. Such a response will include proportional, but possibly asymmetrical responses, using any or all elements of national power. They may not be limited to the space domain, but rather will occur at the time and place of our choosing."[25] In my view, all four elements of this strategy have merit.

While a space code of conduct could have value in supporting development of norms of responsible behavior, I am skeptical about the prospects for arms control to produce meaningful, verifiable restrictions on the development, testing, and deployment of counter-space weapons. David Gompert and I wrote in 2011 that traditional approaches to arms control (such as efforts to limit development, testing, and deployment of ASAT weapons through legally binding treaties) are unlikely to succeed in limiting U.S. and Chinese ASAT weapons:

> While both sides are dependent on space, both see sufficient military utility in ASAT weapons that they will be reluctant to forego such capabilities even if the other were willing to do so. Moreover, there are too many ways to degrade satellite and satellite mission performance, and too little possibility of effectively controlling them, to make traditional ASAT arms control promising. For instance, neither side is going to give up direct-ascent rocketry or directed energy systems

[24] Department of Defense and Office of the Director of National Intelligence, "National Security Space Strategy: Unclassified Summary," January 2011.
[25] Department of Defense and Office of the Director of National Intelligence, "National Security Space Strategy: Unclassified Summary," January 2011.

> of the sort that could be used as ASAT weapons but have plausible alternative uses (for example, BMD). Limitations of soft-kill capabilities would be even harder to formulate, much less achieve agreement about. Verification of compliance with limitations on capabilities is virtually impossible. Moreover, because development of ASAT weapons could not be retarded even if systems were not operationally deployed, there would be huge breakout potential in any ASAT arms control agreement.[26]

If it is impossible to ban ASAT weapons via arms control, then the next best solution is to create a strategic environment that deters their use against U.S. space assets. The U.S. national security space strategy focuses on two sides of the deterrence calculus: denying an adversary the potential gains from using ASAT weapons (deterrence by denial) and being prepared to respond to an attack in ways that generate unacceptable damage, either to an adversary's space assets or other high value assets (deterrence by punishment). It makes sense to pursue both avenues.

A variety of potential means exist for making U.S. space assets less attractive targets:[27]

- **Rapid replenishment of damaged satellites**. Also known as "operationally responsive space," the ability to quickly launch replacement satellites into Low Earth Orbit (LEO) could limit the military advantages from ASAT attacks against such systems. This capability is likely to be expensive and might be negated by increased Chinese deployment of ASAT weapons that are much less-expensive than the satellites they threaten. It would also require investment in ground launch sites to increase their launch rate.
- **Make satellites harder to find and harder to hit**. Smaller satellites that incorporate stealth technology, employ countermeasures, or have the ability to maneuver would be harder for China to target and attack.
- **Constellations of small satellites**. Dispersing capabilities among a number of small satellites would reduce the vulnerability to the loss of any single satellite and complicate adversary efforts to target U.S. space capabilities. It would also increase robustness by creating redundancies. This would require a shift in design philosophy, and might not be applicable to all military space capabilities.
- **Harden satellite communications systems**. Given extensive Chinese investments in jamming technologies that can interfere with satellite control signals and degrade their ability to transmit data to ground stations and military users, it makes sense to design satellite communications and control systems for better performance in a complex electromagnetic environment that includes jamming of satellite data.
- **Make greater use of non-space tactical reconnaissance systems**. Aircraft and unmanned aerial vehicles (UAVs) can substitute for some space-based assets, and would potentially be harder to target. However, they may not be able to loiter in critical or contested airspace, rendering them ineffective in some combat environments.
- **Use foreign satellites to increase the political costs of attacks**. Some space experts have suggested the United States could make greater use of European, Japanese, or other

[26] Gompert and Saunders, The Paradox of Power.
[27] This section is adapted from Charles D. Lutes and Phillip C. Saunders, "China's ASAT Test: Motivations and Implications," Joint Force Quarterly 46, 39-45.

commercial communications or imagery satellites to take advantage of Chinese reluctance to attack commercial or foreign space assets.

- **Direct attacks against Chinese ASAT systems**. Attacking ground-based ASAT systems or components prior to launch or use might be effective against known high-powered lasers, critical radars, and optical tracking systems, but would have only limited utility against mobile ASAT systems that would likely be dispersed, hard to find, and located deep in China's interior. Kinetic attacks inside Chinese territory would significantly escalate any conflict.
- **Space-based weapons to attack Chinese ASAT systems or space assets**. Space-based weapons could potentially help protect U.S. satellites by attacking some types of Chinese ASAT weapons (specifically co-orbital or direct-ascent ASAT systems). However, they also have the potential to accelerate strategic competition in space. Such systems would take years to develop and deploy, and could cause the United States to embark on a costly path (both economically and politically). Some space experts suggested that China might hope to divert U.S. military modernization down this path.

Unfortunately, many of these potential solutions are very expensive to implement, especially considering the relative low costs of many ASAT systems that can destroy satellites or degrade their functionality in a wartime setting. Having on-the-shelf replacements for vulnerable satellites and a surge crisis launch capability would require huge investments whose positive impact might be overcome by relatively modest adversary investments in different types of ASAT capabilities.

Options exist to reduce the vulnerability of U.S. space assets, and DOD should pursue those that promise the greatest return on investment when likely adversary reactions are figured in. Hardening satellite communications, making greater use of tactical reconnaissance systems, and exploring constellations of small satellites appear to be particularly promising areas. This should also include efforts to conduct military exercises with degraded access to space and cyber capabilities so that U.S. forces can explore and practice work arounds if critical space systems are not available.

On the other hand, actions such as kinetic attacks on Chinese counterspace systems or extensive use of space-based weapons have the potential to be both strategically destabilizing in a crisis or conflict and to stimulate expensive arms races between space and counterspace systems.

Given that the United States will not be able to buy its way out of vulnerability to adversary counterspace systems, it will need to make investments in counterspace systems of its own to hold the space assets of potential adversaries at risk. As the official strategy cited above suggests, this need not involve only kinetic ASAT systems or symmetrical approaches to deterrence. The United States should prioritize non-kinetic ASAT systems that do not generate significant amounts of space debris, soft kill over hard kill, and ways of temporarily limiting the ability of adversary satellites to support military operations. Some of these approaches may involve attacks in other domains that achieve effects in the space domain. Such counterspace systems are potentially more useable in a conflict, and thus more credible and more capable in deterring Chinese attacks on U.S. space assets.

As the PLA routinely employs space assets in pursuit of its mandate to be able to fight and win "informationized wars," the Chinese military will also become more dependent on fragile and vulnerable space systems, especially when operating further from China's borders. If China decides to deploy ballistic missile defenses of its own in order to protect its nuclear forces, it will need to deploy early-warning radars and launch detection satellites in order to provide cueing data for ballistic missile defenses. Over time, this will increase China's dependence on space assets for both strategic stability and operational warfighting and reduce the current asymmetry in vulnerability in the space domain. Eventually, the PLA may join the U.S. military in preferring that both sides fight *with* their space assets rather than fighting *without* them.

Moreover, the Chinese state and Chinese society are becoming more dependent on space assets for a variety of purposes ranging from weather forecasting, to GPS navigation, to satellite communications with overseas commercial operations. In a 2007 visit to a small village in Sichuan, I was struck by the widespread use of inexpensive satellite television receivers, a crucial means for the Chinese Communist Party to get its message out to the population in rural areas. Many of these commercial and civil applications could be put at risk in the event of a major military conflict in space.

Over time, more symmetrical U.S. and Chinese military and civil dependence on space assets may produce more common interests in making space a sanctuary in the event of a conflict. David Gompert and I have articulated what such strategic restraint in space might look like, focusing on mutual agreement not to interfere with the operations of each other's civilian or military satellites.[28] We argue that such agreements have the potential to reinforce deterrence and to damp down some of the arms race dynamics in the U.S. and Chinese space/counter-space development and deployment, thus contributing to more stable bilateral relations.

In the remaining space, I will try to respond briefly to the other questions raised for this hearing where I can speak at an unclassified level based on my expertise.

- **Discuss China's approach to space diplomacy and cooperation, particularly with the United States. Assess the risks and benefits of U.S.-China space cooperation**

China views space diplomacy and international cooperation as means of learning from countries with more advanced space capabilities (including from the United States), demonstrating China's technological prowess to both domestic and international audiences, using technology sharing and space cooperation to strengthen its ties with other countries (especially developing countries), and earning revenue from its investments in military and civil space technology. Given the dual-use nature of much space technology and the fact that even China's civil and manned space programs have heavy military involvement, there is reason to be cautious about space cooperation with China. That said, a complete prohibition on official and commercial space cooperation with China would have heavy costs in terms of its negative economic impact on the U.S. space industry (especially on secondary and tertiary suppliers), on U.S. allies (if the U.S. pressures them not to engage in space cooperation with China), and on the U.S. global image (if U.S. unwillingness to cooperate with China on even innocuous space issues is viewed as a sign of unwarranted hostility and a loss of U.S. self-confidence).

[28] See Gompert and Saunders, The Paradox of Power, Chapter 5.

Accordingly, the U.S. government should identify areas where space cooperation with China could contribute significantly to Chinese military space and counterspace capabilities and limit cooperation in these areas. Some of this analysis has already been done in the recent process of revising U.S. export controls governing space technology. In some cases, such as space situational awareness, the United States should limit cooperation that might enhance China's ability to locate and target U.S. satellites, even if it is willing to cooperate with other allies and partners.[29]

However, there are other areas such as many scientific applications and manned space flight where the United States can share information and experiences without compromising national security and can benefit from growing Chinese investments in space capabilities and China's potential contributions to international space cooperation. The U.S. government needs a process to make such case-by-case evaluations in a manner that reflects legitimate Congressional concerns about the potential risks of space cooperation with China.

- **Identify the extent to which China's activities in space may contribute to increasing debris fields and what steps, if any, China is taking to address this issue. Assess the economic and security implications for the United States of increasing space debris.**

China's 2007 direct-ascent ASAT test generated more than 3,000 pieces of trackable debris, generating international outrage about the increased threat of collision with other satellites in orbit.[30] Although Hu Jintao appears to have been briefed in advance that the test would generate a significant amount of space debris, this information was presented in a way that minimized the potential negative international reaction to the debris. The fact that China was slow to issue a public statement acknowledging the test further increased the public relations damage.[31]

Chinese officials appear to have learned from their mistakes in both the conduct of the test and how the information was presented publicly. Subsequent 2010 and 2013 tests, which China characterized as ballistic missile defense tests, were conducted against sub-orbital targets and did not create any long-lived space debris.[32] In both cases, China quickly issued public statements acknowledging the tests, stating that they were not aimed against any other parties, and highlighting that they did not generate space debris.

China's 2011 Space White Paper included several references to Chinese efforts to mitigate space debris, noting that "China will continue to strengthen its work on space debris monitoring and mitigation and its work on spacecraft protection." These efforts include developing technologies for monitoring space debris and warning of potential collisions. The White Paper also cites specific actions China has taken to mitigate risks of space debris, including "fully inactivating Long March rockets and moving a few aging GEO satellites out of orbit."[33]

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[29] See Statement of Mr. Douglas L. Loverro, Deputy Assistant Secretary of Defense for Space Policy, Before the Senate Committee on Armed Services, Subcommittee on Strategic Forces, April 24, 2013.

[30] Department of Defense and Office of the Director of National Intelligence, "National Security Space Strategy: Unclassified Summary," 1-2.

[31] Lutes and Saunders, "China's ASAT Test."

[32] Brian Weeden, "Through a Glass, Darkly: Chinese, American, and Russian Anti-Satellite Testing in Space," Secure World Foundation, March 17, 2014, 1.

[33] Information Office of the State Council of the People's Republic of China, "China's Space Activities in 2011," December 2011, Beijing.

These examples highlight increased Chinese awareness of the potential negative impact of space debris on China's own space assets and on China's image as a responsible spacefaring nation. Whether concerns about generating space debris would affect China's willingness to employ its direct-ascent ASAT system or other kinetic ASAT capabilities in a conflict is speculative. However, Chinese military writings cited above suggest a preference for "soft kill" systems that do not generate debris, partly because there would be less political blowback from other space-faring nations not involved in a conflict.

- **Describe the political drivers behind China's space programs that can be identified from official statements, activities, and resource allocation decisions. How has Xi Jinping influenced the trajectory of China's space programs? Assess the challenges and opportunities for the United States presented by these political drivers.**

Chinese space policy involves a wide range of actors interacting in a complex policy environment. Key features of the process include top leadership involvement, the influence of elite scientists, coordination by leading small groups, and operational control by the PLA.[34] Even within the PLA, responsibilities are divided, and different organizations are vying for control of Chinese space activities. The China Aerospace Science and Technology Corporation and the China Aerospace Science and Industry Corporation are the two key state-owned research and development and manufacturing organizations, while the State Council's China National Space Administration coordinates and executes international space cooperation agreements.[35]

The sections of China's 2006 and 2011 space white paper cited at the beginning of this testimony provide a good indicator of the official rationales for China's space program. It is clear that Chinese leaders derive significant domestic legitimacy and international prestige from China's manned space program and from space exploration activities such as the Chang'e lunar probes. China has stressed the domestic technology and indigenous origins of China's manned space program, even though it has benefitted significantly from access to Russian designs and technology. This testimony has highlighted the many military applications of space technology and the military's central role in running the space program. The General Staff Department, Air Force, Navy, and Second Artillery Corps are the primary military customers for information derived from space-based assets.[36]

The Chinese government's emphasis on commercialization of space technology is likely to lead to a further expansion of space-related goods and services, with applications centered on navigation and positioning data and on the use of geospatial data for mining and resource management being areas for future growth.[37] Central government agencies, such as the China Meteorological Administration and the China Oceanic Administration, and large state-owned enterprises, including commercial telecommunications providers, are currently the largest civil and commercial users of space-derived data, but local and provincial governments and smaller enterprises are becoming increasingly important. Key applications include telecommunications,

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[34] Alanna Krolikowski, "China's Civil and Commercial Space Activities and their Implications," testimony before the U.S.-China Economic and Security Review Commission Hearing on the Implications of China's Military and Civil Space Programs, May 11, 2011.
[35] Stokes.
[36] Stokes.
[37] Krolikowski, "China's Civil and Commercial Space Activities and Their Implications."

mapping and surveying, natural resource management, satellite navigation, and weather forecasting. This diversification of space uses and space users is broadening the number of Chinese actors with a stake in continued access to space, though not all voices are represented equally in the Chinese political system.

PANEL III QUESTION AND ANSWER

HEARING CO-CHAIR TALENT: Okay. Two questions. Mr. Fisher, you say in your testimony, "But at that juncture, before China has achieved levels of space dominance, it is crucial to link any real cooperation with China to its behavior in space and elsewhere which threatens U.S. security."

We had a discussion in the first panel today about whether and how the United States should cooperate with China in space. So maybe you could elaborate on that a little bit.

And then the second question is Dr. Saunders discussed a lot that, if I understand you properly, one of the reasons you think the Chinese are pursuing this so vigorously is because of its asymmetric value in dealing with the United States.

Are the other two of you in agreement with that? And do you think that as the Chinese become more dependent upon space assets that it might indeed be possible to work out some kind of an arrangement with them? And actually any of you can comment on either one of the questions. I didn't mean to foreclose that.

MR. FISHER: Senator, linking space cooperation to broader national security concerns in the case of any possible future cooperation with China is not something new. We pursued such linkage quite vigorously during the '60s and '70s in the Cold War. We had serious, very serious concerns about Soviet objectives and activities, especially in Europe and around the world, and we constrained our cooperation in space with the Soviet Union to an appropriate level designed to minimize any leakage of technology to give the Soviets an advantage or to make a political point when that was appropriate at the appropriate stage in our relationship.

Today we have real concerns with China's objectives in the Western Pacific, in addition to its potential to build military advantage off of its projection of economic and political power to other regions of critical interest to the United States and the role that space power will play in that projection. At this point, I believe there are far more concerns that we have with China and that before we hop into the ISS together or into the Chinese space station, it's far more important that we reach an appropriate level of understanding regarding their objectives, how they intend to employ space to support their military. We also need to begin a dialogue that could lead to real control of dangerous activities, much as happened with the former Soviet Union over time beginning in the late 1950s and into the 1960s as a balance of nuclear power was built between the two sides.

Now, that leads to your second question, Senator. I'm skeptical that space will become a sanctuary if there is a balance of use, or exploitation, if you will. Space is an attractive combat zone primarily because it offers very high political and psychological impact compared to the cost that you pay for in terms of men and material.

And if the other side does not have the ability to retaliate or repopulate, then the effect could become decisive. Today, especially, the temptation to attack the American superiority is far too great, and I expect it will be used in any near-term conflict, especially should something occur over the South China Sea, the Taiwan Straitor the Senkakus.

My view is that a sanctuary for space is much more possible if there is a fully-armed balance of power in space, if we not only have the ability to repopulate our satellites but also to defend them, that both sides build into their satellites the ability to either use passive or active defenses, that we are very careful about not allowing China or potentially Russia, to gain a specific advantage in manned or unmanned space combat platforms, and that we are very careful to sustain a wide range of options in terms of responding to any potential use of the Moon or

deep space, the Lagrangian Points, for military advantage by China or Russia.

DR. HANDBERG: I published a paper about a year ago that looked at the question of the proliferation of GPS or space navigation systems, and the conclusion I drew was if governments or militaries become dependent on that, which the Chinese are not yet, but as the Chinese reach globally, when they reach out there, I think there's a strong possibility that they will be somewhat constrained.

The sanctuary approach is not loved by the military, but the alternative is chaos and the possibility of turning the low earth orbit into essentially a graveyard. All the commercial satellites will go down once the ones out there because if you get sufficient amount of debris, you're not going to get stuff to be able to move out to the GEO-orbit.

So the sanctuary approach is very controversial in the context of the military in the discussions of space because there are people who see space as logically the next place we're going to fight a war. It may well be, but it cannot be a kinetic war because otherwise you inherit, you know, the graveyard. You won't be able to do anything up there because you will lose most of your assets, and especially as proliferation of small clouds of communication satellites go out, you're going to lose those also.

Commercially, we have become dependent, for example, on our GPS system for a good part of our economy. The atomic clocks are used so you can buy gas anywhere in the country, and it goes to a centralized billing system from a thing that's on the top of the service station.

How is that regulated? That's regulated because it's working off the atomic clocks in the GPS system. So if you go away from sanctuary and say, oh, we're going to fight a war, you better make sure it's nonkinetic because you cannot afford. Go back to 2007. We ran on about what the Chinese did, and the Russians estimate, the Russian group estimated they constitute 40 percent of the debris in the earth orbit. That's an enormous amount of debris from their various things. There's a NASA site that covers all this kind of stuff, and they talk about how the Chinese are very sloppy. Long March boosters blow up in space, creating more debris.

So I'm not so sure if the Chinese reach a certain point. Now the question is what do you do when they reach that point? Are we prepared to, how do we deal with a power that becomes more equivalent to us, you know, and one that we perceive as being hostile to us? That's the bottom line question.

The sanctuary will continue until we have an alternative. We can develop nonkinetic ways of disabling satellites. Fine. Are we able--or we develop means--we cannot remove debris right at presently. There's a lot of research going on on what looks like big fly swatters in space where you collect this stuff and you return it to burn up in the earth orbit. I mean it's an issue.

So I think sanctuary is not likely to go away quickly because the alternative is worse, and I'm--

DR. SAUNDERS: I agree with Rick that you can't get there without the U.S. having both ability to reduce its vulnerability in space and offensive counterspace capabilities to create stable deterrence so you have to have both sides of that deterrence approach to be successful and to be stable.

But the point is don't just have it be a de facto thing. This has to be something we talk to the Chinese and come to an understanding. Now why is that? I dwelled in my testimony on the military applications, which is the area that I work most, but it's also true there's a huge commercial and civilian application for space data in China.

And if you look at GPS, that's a multi-tens of billions dollar commercial market even just inside China. If you look at how the Communist Party gets television signals with propaganda

out to the remote villages, they have satellite receivers, which I've seen even on quite poor villages. They still have cheap satellite television receivers. So the government and Chinese companies are becoming more dependent on space as well as the military.

And their interests may be somewhat different. I If you are a PLA space planner, they're very focused on how do you exploit this vulnerability for military advantages. If you're sitting at the top of the Chinese Communist Party, you have a broader take on what your prestige interests are, what the commercial interests are of your companies, what your economic interests are, how do you talk to your 1.3 billion people, and space factors into all of that. So I think the calculus may change a little bit over time.

MR. FISHER: I would also add that the viability of the sanctuary argument is very much affected by what Mark Stokes referred to as China's, as well as the United States', interest in near-space capabilities, capabilities that take the place of current space assets. A balance in that sphere is going to be necessary for real incentives for arguments for sanctuary to go forward as well.

HEARING CO-CHAIR FIEDLER: Let me just comment and follow-up. It strikes me that if, let's just paint a Taiwan scenario, Chinese decide for whatever reason to take Taiwan, and we do things that make that more difficult or prevent it, then the legitimacy of the Party or its hold on power may evaporate. You're telling me that leaders will be rational in terms of debris in space in the face of loss, that dramatic a loss of power, if they conceive that that's a problem domestically?

In other words, they can't take a loss. And a rising power exercising power, mildly irrationally, which would be this Taiwan scenario, in my view, it's not out of the question. I don't see this sanctuary idea continuing. It's sort of like everybody agreeing to take knives to a gunfight instead of guns. Am I mistaken here about the rational basis that the decision-making world faces here?

MR. FISHER: Well, Commissioner, in my opinion, the 2007 demonstration followed in a long train of abrupt, seemingly irrational Chinese actions that were designed to produce a psychological effect that would inhibit a current target actor or future actors. Such demonstrations would also include China's bolt-out-of-the-blue attack against the Americans in Korea in 1950, its attacks against India and its telegraphed attack against Vietnam. I view the 2007 ASAT exercise as yet another power demonstration for the United States and others dependent on space that, yeah, we can do this to you if you don't do what we want.

HEARING CO-CHAIR FIEDLER: Or just an element of craziness in the equation that throws us off.

MR. FISHER: Yes. I mean you can also imagine, given today's swirl of crises, that the United States could be tied down militarily in one, maybe two, crises, an escalated Ukraine, something in North Africa or the Persian Gulf or the Middle East, and the temptation becomes too great. Let's push the government in Taipei into agreeing to "peace in our time" and scare the Americans away from doing anything about it, and instead become the handmaiden to the peace in our time agreement. Maybe taking out half a dozen satellites would change the balance of calculation in the White House.

HEARING CO-CHAIR FIEDLER: Right. What do you guys think?

DR. SAUNDERS: If I can respond, first, I agree with the logic, but it's good news. Because if they're going to roll the dice on Taiwan, they're potentially putting the regime at stake, and what we've seen is a Chinese leadership that is calculating and I think pretty rational and pretty risk averse. Yes, they're doing a lot of things in the South China Sea, but those are

very calculated and done in a low-risk manner to try to control escalation.

So I think it's good news because I think they are going to be reluctant to roll the dice and hope that good things happen in Taiwan if they think they're putting the regime on the line because that's what they care about most.

Now, your question about can a sanctuary last if you're risk-loving enough to start a conflict anyway, can a sanctuary hold up? Well, I don't think it's like taking a knife to a gunfight. It's like both of you having guns and agreeing to start fighting with knives, and that if you start shooting at each other there's going to be a lot more damage--

HEARING CO-CHAIR FIEDLER: That's like take a knife to a gunfight.

DR. SAUNDERS: Yes. That's not what I'm proposing.

HEARING CO-CHAIR FIEDLER: Because when he decides I'm losing, and I'll use the gun.

DR. SAUNDERS: Well, I think that's a big issue, is how escalation might go in a conflict. That's a concern because that's partly why China is developing counterspace systems. It's saying if a conflict breaks out, we can do a lot of damage.

HEARING CO-CHAIR FIEDLER: And we may use those.

DR. SAUNDERS: Right.

HEARING CO-CHAIR FIEDLER: I had an earlier question. At the last panel, you seemed to be raising your hand and saying you had the answer to the number of satellites that the Chinese have that are devoted purely to littoral defense, and I defined that as the sort of adventurism that may be going on in the farther-reaches of what they define as their littoral area.

MR. FISHER: China's optical and radar satellite population is about 40 satellites of varying resolution. On top of that, there are five sets of three triangulated electronic intelligence satellites that assist in targeting. But all of these are low earth orbit systems, essentially Polar orbit, meaning--

HEARING CO-CHAIR FIEDLER: Meaning they have to go around--

MR. FISHER: Where they have to go around the Earth, and there's only maybe a once a day revisit to the same spot on the Earth, although because they have so many of them, they can revisit that one spot many times, and it's LEO, which makes, which means they're vulnerable.

Now, Commissioner, in my opinion, the Chinese are going to move their ISR architecture out into GEO or MEO. They are working on a much larger satellite bus. Information available from Chinese sources indicates that future surveillance satellites will weighfive ton, maybe more, and that gives you more options for storage of fuel to maintain position, a much larger optical or radar package or ELINT package. So before 2020, I think we'll begin to see the ISR network move out into deeper orbits.

HEARING CO-CHAIR FIEDLER: Thank you very much.

Mr. Wessel.

COMMISSIONER WESSEL: Thank you, gentlemen.

You know I'd hate to say I've left this panel and this day rather concerned about our defense capabilities and would love to have my concerns abated by this group. From what I hear both in terms of Chinese capabilities, some of which have been tested, some of which have not, the continuing development of their assets and where we are in terms of expenditures on our side, that they are catching up, shall we say, that this is an area of significant vulnerability because of our informationized dependence, that sanctuary, I don't know that we're anywhere near a sanctuary, as well as the history of our relations with China over the last ten, 12, back probably 25, years about what norms are and how we understand each other may leave real

questions as to how does one, in fact, reach some kind of agreement, some normative agreement, some controls.

So we have to report to Congress later this year. What would you like Congress to think? What would you like them to be responding to? Do we have to put many more assets into developing our space capabilities? Do we need to call for talks immediately? What two or three steps should we be engaged in right now? And if you're the American people, should you be concerned about this or not?

Mr. Fisher, you want to start?

MR. FISHER: Well, Commissioner, I've outlined my preferred list of capabilities that need to be addressed, and the Congress should be asking questions about how quickly does the United States need deterrent capabilities in low earth orbit? How quickly does the United States need to reorient its space plans to take into account potential strategic exploitation of the Moon or other places?

But I think this Commission can make a significant fundamental contribution by suggesting to the Congress that it not only seek greater information from the Administration about China's ambitions in space, to have these ambitions explained in much greater detail. In addition, I suggest that you ask the Congress to consider how it can best help the U.S. government and the Intelligence Community to revive a much more vigorous and useful translation service that can make the mountains, mountains of Chinese technical literature and military writing accessible to the broad American policy community.

In my opinion, this was fundamental to helping the United States debate evolve in a direction that allowed the U.S. to identify and then seek capabilities that helped to win the Cold War.

We are intellectually disarmed when we do not devote a real effort to reviving a translation service that can make accessible these mountains of journal articles, military writings, and such that would help us understand much more rapidly China's interests, possible objectives, and the progress that it's making it toward its objectives.

Thank you.

COMMISSIONER WESSEL: Dr. Handberg.

DR. HANDBERG: Yeah. I agree with the translation service thing because that's the old service they used to do on the Russian, everything had a Russian return. That was an asset that allowed both the internal government community, the intelligence community, and the external community to do analyses that weren't otherwise possible.

But I want to go back to a more concrete kind of military issue. One of the things that Congress needs to do--it has done it repeatedly, but it has not put much force behind it--the Air Force each year budgetarily wipes out operationally responsive space.

My God, 1991, we fought the first, quote, "space war." I remember the story was the general running the air campaign wanted more space assets. He thought he could order them up like reconnaissance aircraft. There was a satellite that was put up and was used during that war, but that had been scheduled for three years. Right now we do not have the capability, and the Chinese are developing it, to replace what's shot down.

It may not be a full-blown example, you know, you see the giant one that they launched for the NSA or the CIA or somebody like that. But we need the capability within basically weeks. You lose a satellite, you got to be able to replace it. It doesn't have to be high quality. It doesn't necessarily have to go and do all the things that the first one does.

But, for example, we lose, you know, observation, we lose electronic intelligence, we

lose all those things very quickly, and they're not--right now we cannot replace them in a time frame that makes any sense because a war--the scenario was given about Taiwan. That's going to be the first thing that may go down. According to the Chinese, that's what they're going to do.

And they've been very open about it. Our response is to say, oh, that's interesting. I was talking to an Air Force officer who's at Maxwell working in their space department, he said you realize we have fewer space, military space satellites than we used to, even though, quote, "we're a space force now, we are space dependent"?

You know the U.S. military travels with space assets. But what's increasingly happening, which is not bad in a way, is that we buy them commercially.

You know, during 2001, when we did the operations in Afghanistan, the Department of Defense went out and bought every image that was taken of Afghanistan, not to use it, although they did use it, but to prevent other people from having it where someone might access that data because it was commercially available, process it and maybe tell the Taliban we're coming kind of thing.

You know, so I think that from Congress' point of view, that is something that they can make a priority. You don't, you know, they need to make the Air Force understand that worrying about whether they're going to have more F-35s may be irrelevant when those F-35s, which are satellite dependent, can't find a target.

You got pilots moving at supersonic speeds trying to do eyeball attacks. Ain't going to happen. And so you need for all these precision-guided munitions GPS. You can load that in internally, but a lot of them now are such that they can adjust to the GPS signal as they go to the target. But if we don't have a satellite there that can do that, we're out of business.

You know, American military is, quote, the "best in the world." I believe it is. But it's built on a fundamental flaw. We cannot guarantee that we will be number one in the crunch if someone is able--and they don't have to knock them out. All they got to do is, you know, laser them or do something else electronically to knock out the signal. We're out of business.

DR. SAUNDERS: I think the most frustrating question you asked was to perform a net assessment, which I found myself unable to do at the unclassified level. I think the U.S. has demonstrated some counterspace capabilities, notably the 2008 Burnt Frost, when we shot down a satellite using the Aegis system, but I'm just not able to talk about that at a unclassified level.

So this may be an area where Congress, which is authorized to get some of that information, would want a classified assessment because I can't do it at an open source level at this, nor do I have the technical expertise that you really need to do it. One recommendation is I don't think you can do this successfully at open source.

The second is that actually the U.S. military is doing some of these things and it's not doing others. There have been exercises that simulate the loss of space connectivity. We are investing in UAVs and other tactical reconnaissance assets that can both complement and add capability but potentially provide some degree of substitution for space assets that are lost. So there are some things going on in that realm.

Operationally responsive space, I think, is part of the solution, but to have the full package of capabilities that is redundant and on the shelf is a very, very expensive price tag, and it's not free. It comes from loss of capability and funding in other areas.

So I think that's part of the answer, but it's not just a matter of writing a big check and getting it. Because I don't think that will deliver everything that you need.

Are we ready to sit down and talk with the Chinese and work out an agreement on space as a sanctuary today? No, we're not. But what we can do in the interim is make sure that their

civilian leadership recognizes that this is not just a matter that the PLA can inflict damage on the U.S. military and nothing is going to happen to China, that they have their own vulnerability, whether that's because low earth orbit gets populated with debris, and you can't use any of those commercial or civil satellites, or that retaliation causes China to lose access to those things.

So I think a first step is making sure that the Chinese leadership recognizes their own increasing dependence and the vulnerability there, and when the PLA says, well, now we've got to start shooting down satellites, they ask the question, well, what happens next and what happens to our assets?

HEARING CO-CHAIR FIEDLER: Commissioner Tobin.

COMMISSIONER TOBIN: To my colleagues, you've already raised the questions I hoped to explore from the space diplomacy to the recommendations, and--so let me just ask a little more specificity on the translation service. What would that be; how would you see that working for space challenges? Would you see it for space and all our other security needs? So if we're asking Congress to think about that, Mr. Fisher, can you spin it out a little bit more in detail?

MR. FISHER: Yes. A little over 15 years ago, the Foreign Broadcast Information Service, as it was, provided broad translations, not just of Soviet military, economic, cultural literature, but it surveyed the Warsaw Pact as well, and covered China and North Korea.

The old Chinese translation offerings were very useful, selecting important technical as well as political literature for daily translation. So you could track the development of air-to-air missiles or space technology in addition to being able to assess the latest nuance of a general's speech in PLA Daily.

That was not available from the the World News Network that was effectively shut down in either late last year or early this year. So it's not even an option anymore. And this was, in my opinion, a very important tool that allowed people on the inside and people on the outside, people contributing to our public debate, to arrive at a consensus with experts on the inside of a community about what was important, what was, what did we have look out for in the future, and better inform our modernization and technology choices.

That capability is not available, and one of the most important aspects of the old system was that the availability, broad availability, of translations allowed for a debate to take place.

There may be within the intelligence community--I don't know; I don't live there; I don't have clearances--such a broad translation capability, but then the debate over what is selected and then what is consumed takes place within a narrow community. That debate should be taking place outside the intelligence community as well as inside.

We're a democracy. We fail when we restrict ourselves, when we restrict our voices, when we restrict the possibility of multiple opinions and interpretations. We win when we allow for a richer and broader debate.

COMMISSIONER TOBIN: Very eloquent, gentlemen. Dr. Saunders.

DR. SAUNDERS: Thank you for the chance to weigh in on this.

My center does a lot of work with open source analysis, often working with original Chinese sources, sometimes benefiting from the translations that the government does. And Rick is right, that there used to be a lot more of that that was made publicly available through libraries. Some of it was commercially available through the World News Connection which was shut down recently.

That allowed people who don't necessarily have the language skills to work directly with the primary sources to get information and bring their expertise in space or whatever their

broader military or functional expertise was to make use of sources in foreign languages. And I think it's a loss because we do benefit from the ability of academics and graduate students and experts at think tanks to make use of that.

I think it's been a combination of things. An increasing amount of that material is copyrighted, and they find it difficult to make it publicly available because of that. It's technology a little bit, finding ways to translate enough. You know, frankly, I have access to some of it, but I don't see nearly as many things translated as I would like because I can read it a lot faster if somebody has translated it into English than if I'm working with the Chinese.

This is an area where a relatively modest amount of resources probably could make a significant difference, but it's partly having the translators and the ability to pick the right stuff and translate it, and then it's partly solving this legal problem, how do you make copyrighted material available to the public even in translation?

There might be some creative solutions. You might think about this as crowdsourcing where people get paid a nominal amount to produce some analysis and in return get access to this in a way that complies with copyright regulations, but makes the material more widely available to the public. I share Rick's view that there is a lot out there, and Rick is a good digger anyway of information. I benefit from his work a lot.

COMMISSIONER TOBIN: Right. Amplification.

Dr. Handberg, anything further on either the translation service or recommendations?

DR. HANDBERG: No, not at this time.

COMMISSIONER TOBIN: Okay. Thank you.

HEARING CO-CHAIR FIEDLER: Commissioner Shea.

VICE CHAIRMAN SHEA: Just to thank you all. Very interesting. Maybe somewhat disturbing but hopeful in other aspects.

Just a point of clarification. The Chinese military still continues to this day to rely in part on GPS; doesn't it?

DR. SAUNDERS: [Nods affirmatively.]

VICE CHAIRMAN SHEA: And the concept is to transition away from reliance on GPS to their new Beidou--a more built-out Beidou system; is that correct?

MR. FISHER: Yes. The original regional Beidou system is being expanded into a global network, and the exploitation of Beidou by the PLA has been a decade-long enterprise.

VICE CHAIRMAN SHEA: Right.

MR. FISHER: It's advanced; it's getting better. As China develops more commercial spinoffs for the larger Compass, Beidou Compass system, it is being incorporated into PLA systems increasingly, but, yes, by and large, there is the goal to transition from reliance on multiple GPS, Russian GLONASS, to primarily reliance on the Compass Beidou system.I would also add that Compass Beidou from the beginning has had a secondary communication capability.

It has enabled the PLA units to be able to send low-gain messages, basically text messages.If you need a secure way to receive an order about what hill to shell, Compass Beidou is good for that, and now this is going to be replicated in the global system. It will enable global communications as well as for navigation signals.

VICE CHAIRMAN SHEA: Yes.

DR. SAUNDERS: Just add to that, China is making use of all kinds of GPS systems, the U.S. GPS, the Russian GLONASS system, and then its own Beidou, and among other applications for it besides ordinarily positioning, whether it's the GPS in your car or the GPS in

your tank or the GPS on your ship, they also make use of it for precision-guided munitions, and that's partly why they wanted to have their own system.

VICE CHAIRMAN SHEA: Make use of the U.S. GPS? Or?

DR. SAUNDERS: They make use of all three of those, but they were worried that the U.S. in a crisis or a war would start encrypting the signal, and then they would lose access to it so that's partly why--

VICE CHAIRMAN SHEA: So how long a period is this transition going to occur over? I mean are we talking about by 2020 all Chinese, the PLA will be using exclusively Chinese Compass--

DR. SAUNDERS: I don't think they'll necessarily move to an exclusive use because then if they lose access to that, then everything they have is dead.

VICE CHAIRMAN SHEA: I see.

DR. SAUNDERS: So you want to be able to receive signals of whatever type and use whatever is available and gives you the highest--

VICE CHAIRMAN SHEA: But they'll move to a situation where the U.S. will not have leverage over them?

DR. SAUNDERS: That's correct and that's the intent.

VICE CHAIRMAN SHEA: Okay. Now, Dr. Fisher, in your paper, in your testimony, your written testimony, you--Mr. Fisher--you mentioned an incident that I had never heard of, the September 2008 Shenzhou 7 mission which was the Chinese first manned space walk. You said during that mission while the capsule was about 45 kilometers from the International Space Station, it launched a micro-satellite.

MR. FISHER: Yes.

VICE CHAIRMAN SHEA: Do we know what the purpose of that? And this is about a year after the ASAT test. So do we know what the purpose of that?

MR. FISHER: Commissioner, to my knowledge, neither American nor Russian officials have had anything substantive to say about this incident. And I wrote one of the few American academic source articles on this incident about a week after it happened. I was able to confirm through a NASA spokesperson, who spoke with our Air Force's Space Watch folks, who confirmed that there was an ISS fly-by within 45 kilometers with a micro-satellite out in front. I suppose you could interpret this as an attempt at a co-orbital interception, a demonstration of an ability to shoot down the ISS, or a demonstration of an ability to co-orbit with the ISS for docking.

The Chinese have not explained this. The Russians, the Americans have not responded. I think that's deplorable. There were two Russians and an American on the ISS during this incident, and it was something that the Chinese clearly planned because the interception occurred basically between Australia and New Zealand, and at that time the Chinese stationed one of their large space tracking and control ships right under where the interception occurred.

So for the Chinese, this was a very deliberate exercise. They wanted to do this. The optics of launching a projectile in front of the intercepting spacecraft was something that they clearly wanted to convey, and I think it follows on the the strategic tendency of the Chinese to seek instances to shock and amaze their potential opponents.

And I think one of the goals of this exercise was to put firmly in our minds the idea that in space they are ready to use their manned platforms for combat. This issomething that we haven't even considered in terms of policy since the early 1960s.

VICE CHAIRMAN SHEA: Are you aware of the U.S. government requesting a

response from the Chinese about why they--

MR. FISHER: No, I'm not.

VICE CHAIRMAN SHEA: --you're not even aware of the U.S. government raising it?

MR. FISHER: It's possible, but it hasn't been disclosed publicly.

VICE CHAIRMAN SHEA: Are the two other witnesses familiar with this particular incident? Or think it more benign?

DR. SAUNDERS: I haven't looked at it in detail, but I would just make the general comment that trying to use manned space platforms where you have to have all that technology to keep astronauts alive as ASAT weapons is a really inefficient way of doing it.

That doesn't mean the PLA doesn't want to say, hey, we have a manned space program, and, yes, there is a military role for it, too, which is something that they've said, but if you're going to go after counterspace systems, this seems a really expensive and inefficient way to do it.

VICE CHAIRMAN SHEA: Dr. Handberg.

DR. HANDBERG: Yeah, I would agree it's not a very efficient way to do it. Remember, back in the '70s, the Soviets put up a space station with machine guns because they were totally convinced--

VICE CHAIRMAN SHEA: With a machine gun on board?

DR. HANDBERG: On board. That could be rotated and fired because they were firmly convinced the space shuttle was built to seize control of their space station. That was space--because we had no space station. So we were going to seize theirs and all of a sudden we have a space station.

You know, I read the earlier--I saw the earlier report by Dr. Fisher, but I don't have any other way.

VICE CHAIRMAN SHEA: Okay. Thank you.

Yes?

MR. FISHER: I believe it was at the 2003 Moscow air show that I met two former Soviet combat cosmonauts, and I simply asked, w if we had actually attacked the Salyut Space Station, do you think you would have survived? What were you going to do next? One of them was quite effusive in saying, no, that our station was designed to survive for five minutes.

You could hit it. It would survive for five minutes, and that was time enough to get into the escape capsule and leave. So the Soviets had not only developed Salyut, but by the 1990s, they would have unmanned combat satellites, laser-armed satellites in space, and they had plans to turn the Mir Space Station into a docking port for low earth orbit bombers based on their manned space plane Buran.

My opinion, this has informed the Chinese about the realm of possibilities, and thus they are determined to have a compensating capability. As a manned space combat capability is within the realm of possibility by the adversaries so they're going to do it.

And if you consider it, were the Americans able to destroy enough earth-based communication linkages to space assets, then the ability to have a command and control or even a combat capability in low earth orbit then becomes something that could be useful.

Yes, it's vulnerable. It could be shot down as well. We should also consider the Chinese investment in their next generation data relay satellite, which is going to be optically based and capable of vast amounts of data transmission compared to the existing radio frequency based data relay systems used by the Americans and the Chinese.

With throughput of data extending into the megabytes or terabyte ranges, you can begin to consider managing from space multiple prompt global strike campaigns in which missiles or

hypersonic strike vehicles can be launched at multiple places on the globe, supported by ISR, and coordinated and commanded from a dual-use space station.

In my opinion, China's first space station and its subsequent space stations will be dual use.

DR. SAUNDERS: I'm just going to say one of the challenges in assessing stuff, and Rick is as good a digger as there is out there in pulling things together, is the Chinese explore all kinds of concepts and all kinds of possibilities. It's pretty cheap to do that kind of think research and to explore different concepts of operations and things and even to experiment with some of them.

I think the challenge is recognizing that exploration because they typically explore every possible way you can do it. Trying to come to an assessment of are they likely to put the resources to turn it into not just an experiment but a real capability. That's one of the challenges in working in the field of assessing the Chinese military and strategic things. You get interesting bits of writing and say, well, they do seem to be exploring or thinking about it. But is there going to be the investment to turn that into a real capability that really matters?

That's the challenge in this business is noting the interest and being alive to it, but then also asking the question is it going to get the resources to turn it into a real capability. Some of the things will and some of them won't. They don't have infinite resources. They are budget constrained, and those constraints are likely to increase as the Chinese economy slows, at least in my view.

VICE CHAIRMAN SHEA: Thank you.

HEARING CO-CHAIR FIEDLER: A quick technical question. How vulnerable is the U.S. nuclear missile defense system to Chinese space attack? How dependent are we in the operationalizing missile defense on space to make it happen?

DR. SAUNDERS: I can give you an unclassified answer.

HEARING CO-CHAIR FIEDLER: Yeah, the unclassified.

DR. SAUNDERS: I think pretty vulnerable because if you look at how we go about it, one part of it is to use infrared sensors to detect the launch quickly and get a vector on where the missile is headed and that provides cueing data for the interceptors to go after it.

There can be mid-course corrections to an interceptor that tell it the target is here, you're here, and some of that information comes from satellite capability, and then usually there's a terminal homing system that's mounted on the interceptor itself so it doesn't need so much external information. But there's definitely dependence on that, and that's part of the reason for Chinese interest in anti-satellite capabilities. They see this as connected to nuclear deterrence, that if they worry that their limited arsenal is vulnerable, and that the U.S. might contemplate a nuclear first strike, which I don't think we ever would, they then worry that ballistic missile defense could be used to clean up any nuclear missiles that survive.

Counterspace assets are a way of holding parts of that system at risk and making the notion of a nuclear first strike so risky as not to be contemplated. I think that is a dimension in their thinking about their concerns about ballistic missile defense that the U.S. has and their interest in counterspace systems.

The other point I ought to also mention is that in addition to thinking about that as part of a ballistic missile defense system, the U.S. also uses satellites for nuclear command and control of our own weapons systems.

HEARING CO-CHAIR FIEDLER: Well, that was my next question, is our arsenal and its dependence on space?

DR. SAUNDERS: Right. I'm limited in what I can say.

HEARING CO-CHAIR FIEDLER: Yeah, yeah, me too.

DR. SAUNDERS: But that's part of--it is part of the U.S. nuclear command and control system. To me that is a reason to talk to the Chinese--

HEARING CO-CHAIR FIEDLER: About sanctuary.

DR. SAUNDERS: --about counterspace because if you accidentally take out a satellite or deliberately take out a satellite that's part of the nuclear command and control system, we might interpret that as either preparation for or the start of a nuclear attack, and the risks of what happens next after that are pretty high.

HEARING CO-CHAIR FIEDLER: Yes, Richard.

MR. FISHER: I certainly agree with Dr. Saunders regarding increasing vulnerability. ButI would also point out that our deep space observation early warning satellite system also supports our conventional military capabilities, our conventional tactical ballistic missile defense capabilities as well.

So the reasons for China to want to reach out and attack that capability have grown over the last 20 years.China's development of a MEO capable DN-2 ground-launched ASAT is worrying enough, but as the gray literature suggests, China may also be developing laser-armed space, low earth orbit combat platforms or other unmanned platforms armed with kinetic devices. The United States will need to have the near earth or near space capabilities in order to support military operations necessary for our defense.

COMMISSIONER WESSEL: I just have a quick--

HEARING CO-CHAIR FIEDLER: Do you have a question?

COMMISSIONER WESSEL: Just a quick comment. I'd like to commend our staff. You talked about the loss of FBIS, et cetera. Our staff has begun several months ago translating a number of important Chinese documents. They are available to the public on our Web site. We do see, as you do, that severe infirmity and doing a small part to try and fix it, but clearly see that as a problem that needs to be addressed.

HEARING CO-CHAIR FIEDLER: I want to thank our staff for putting this hearing together and working closely with you. I think that you have, all the panelists, they made it very clear that we're in a very unpredictable environment in space, and I want to thank you again for being here today.

Thank you. We're adjourned. The next hearing March 18 on China and Central Asia. Thank you, again.