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Dr. Phillip C. Saunders

Director, Center for the Study of Chinese Military Affairs
Institute for National Strategic Studies
National Defense University

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 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 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 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 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 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 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 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 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).

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]

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, 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.

[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

[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.

[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."

[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.

[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.

[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."

[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.
[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.
[28] See Gompert and Saunders, *The Paradox of Power*, Chapter 5.
[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.
[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."