

**Testimony before the House Space, Science, and Technology Committee, Subcommittee on Space
Hearing on “Are We Losing the Space Race to China?”**

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Thank you, Chairman Babin, Ranking Member Edwards, and members of the subcommittee, for the opportunity to testify today. While this testimony represents my personal views and not necessarily the judgments of the U.S.-China Economic and Security Review Commission, my comments largely reflect the Commission’s analysis of China’s space activities contained in our *2015 Annual Report to Congress*.

Examining China’s space program, including its “soft power” and military implications, has never been more crucial. Over the next six years, China is projected to take major steps in its manned spaceflight and space exploration programs, drawing significant attention to its efforts in space and potentially setting the stage for a larger leadership role. Beijing specifically plans to collect soil samples from the Moon and return them to Earth in 2017, send a rover to Mars in 2020, and complete a space station in 2022.

To answer the question of how China’s activities in space compare with those of the United States and how they impact U.S. interests, this testimony begins by addressing key characteristics of China’s space program, then examines the contributions provided by a range of its activities in space, including space exploration and international cooperation efforts. It then assesses the implications of these developments in both economic and political terms for the United States, and concludes by providing several recommendations drawn from the Commission’s previous studies of China’s space program. This testimony emphasizes the economic and political aspects of China’s space activities and does not address in any significant detail its “counterspace” programs, which are examined more fully in the Commission’s 2015 annual report.

For the foreseeable future, the United States is prepared to retain scientific and commercial leadership in the space domain. However, China’s more deliberate and comprehensive approach will open up opportunities for Beijing to derive important economic, political, and diplomatic benefits from its space program in the near term. The series of high-profile activities China has planned over the next six years will be particularly influential, as it may appear China is reaching major milestones that the United States has already achieved and is thereby gaining ground, during a time in which the United States is readying for longer-term exploration projects, and observers are cognizant of the planned International Space Station (ISS) deorbit date approaching in 2024. This assessment underscores the importance of U.S. commitment to its objectives in space—specifically, its goals of manned asteroid and Mars missions in the 2020s and 2030s—so that this apparent disparity does not continue after this period.

Characteristics of China’s Space Program

The Commission’s section on “China’s Space and Counterspace Programs” in its 2015 annual report, as well as its 2015 sponsored report on China’s space program by experts at the University of California Institute on Global Conflict and Cooperation, explain the drivers and structure of China’s space program in great detail. For the purposes of this testimony, it is useful to note several key characteristics:

- *Concentrated effort.* China has become one of the top space powers in the world after decades of high prioritization and steady investment from its leaders, indigenous research and development, and a significant effort to buy or otherwise appropriate technologies from foreign sources,

especially the United States. Specifically, China's large-scale, state-sponsored theft of intellectual property and proprietary information through cyber espionage has helped fill knowledge gaps in its space R&D, provide insights into U.S. space plans and capabilities, and identify vulnerabilities in U.S. space systems, enabling future space and counterspace operations.¹ While China does not release budget information for its space activities, its spending on space is likely growing, although still dwarfed by that of the United States. Public reports have estimated that China spends \$2 billion to \$6.1 billion per year on its space program,² in comparison with the OECD's estimates of \$39.3 billion spent by the United States and \$5.3 billion by Russia in 2013.³

- *Methodical approach.* Unlike the swift pace of U.S. missions during the Space Race (achieving manned spaceflight for the first time in 1961 and the Moon landing in 1969), China has opted for a longer-term, more deliberate approach.⁴ Jeffrey Plescia, chairman of NASA's Lunar Exploration Analysis Group, has argued that China "has had a well-developed, focused plan" for lunar exploration and has used incremental steps to carry it out, while the United States "has been floundering around for decades, trying to figure out what to do" in its lunar exploration program.⁵ On the other hand, China is pursuing multiple large-scale efforts at the same time (a space station, a lunar program, and a Mars program) rather than the more sequential approach taken by the United States, making direct pace comparisons difficult.
- *Civil-military integration.* Unlike the United States, China does not have distinctly separate military and civilian space programs. Chinese Communist Party (CCP) leaders provide policy guidance and authorize allocations of resources for the program, and various organizations within the People's Liberation Army (PLA) execute space policy and oversee the space research, development, and acquisition process. China's military also exercises control over the majority of China's space assets and space operations. Thus, even its ostensibly civilian projects, such as human spaceflight, directly support the development of PLA space, counterspace, and conventional capabilities.⁶
- *Lack of transparency.* Related to the predominance of China's military in its space program, Beijing provides little information regarding its intentions in space. It provides limited public strategic guidance beyond short white papers and does not release timetables and technical information when announcing a new program, as is done by NASA and the European Space Agency.⁷

The key actors in China's space activities that provide important economic and political contributions are military and defense industry organizations. While the China National Space Administration is often incorrectly referred to as China's equivalent of NASA and coordinates and executes international agreements, it does not have a direct role in overseeing China's space policy; space research, development, and acquisition process; space assets; or space operations.⁸ The China Aerospace Science and Technology Corporation (CASC) and China Aerospace Science and Industry Corporation (CASIC) are the primary state-owned defense industrial enterprises that support the military in the research, development, and manufacturing of space technologies and systems. The China Great Wall Industry Corporation, a firm subordinate to CASC, is China's sole commercial satellite and launch services provider. A military entity, the China Satellite Launch, Tracking, and Control General (formerly subordinate to the PLA General Armaments Department and likely now situated under the Equipment Development Department⁹) is responsible for managing China's space launches and the telemetry, tracking, and control functions for its spacecraft systems. As such, it is responsible for constructing and operating China's space launch centers and control centers.¹⁰

Economic, Political, and Diplomatic Contributions of China's Space Program

China's space program furthers its leaders' strategic ambitions by adding to the country's "comprehensive national power," a far-reaching term used by sources in China.¹¹ Beyond direct security contributions centered on its key role in China's ongoing military transformation, China's space program provides a wide range of contributions in economic, political, and diplomatic areas. These can be observed primarily in the following categories of space activities: 1) launch services and satellite exports; 2) satellite application technologies; 3) human spaceflight; 4) space exploration; and 5) international space cooperation efforts.

Launch Services and Satellite Exports

Beijing has heavily emphasized both commercial launch services and satellite exports as its space industry has developed. Both activities provide China's space industry with revenues, opportunities to measure the quality of its products and services against international competitors, and industrial development synergies through integration with its military space sector. Furthermore, promoting exports of domestic satellites helps increase demand for Chinese launch services: because U.S. restrictions in place since 1999 prohibit exports of satellites and components to China (including for launch service purposes),¹² China has relied on "delivery in orbit" contracts in which it both builds and launches a satellite for a customer.¹³

Chinese officials frequently stress both the significant impact of U.S. restrictions and the resolve shown by China's space industry in response. Executives at the China Great Wall Industry Corporation noted in a July 2015 briefing to the Commission that although the company's products and practices are "just as good" as those of U.S., European, and Russian providers, it is unable to compete in the "whole [global] market" due to U.S. export controls.¹⁴ Experts also stress the reliability of China's Long March series of launch vehicles: China successfully completed 125 of 128 launches for a 98 percent success rate over the 12-year period from 2001 to 2013, a rate comparable with international competitors.¹⁵ Failures such as the loss of a satellite on September 2, 2016—the same day as the better-publicized explosion of a SpaceX Falcon-9 launch vehicle¹⁶—have been rare exceptions.

China began its return to the international market in 2007 with a satellite launch for Nigeria. It launched a satellite for European satellite communications provider Eutelsat in 2011, its first launch of a foreign-made satellite for a foreign client since 1999 (all foreign satellite launches since 2007 are listed under "international space cooperation efforts" below).¹⁷ China has still struggled in both the launch services and satellite export markets, however. Beijing aimed to capture 15 percent of the global launch services market by 2015, but while it achieved this objective with roughly 19 and 16 percent market share in 2011 and 2012, respectively (not including launches for China's government and state-owned enterprises), it conducted no commercial launches in 2013 and 2014, the last years for which data is available.¹⁸ In the commercial satellite field, China set the goal of capturing 10 percent of the market by 2015 but only achieved 5 percent in 2013 and 4 percent in 2014.¹⁹ In 2015, China announced that it is designing a launch vehicle that could be exported to customers outside China, potentially bypassing U.S. restrictions by selling rockets themselves rather than just launch services.²⁰

Satellite Application Technologies

Chinese analysts emphasize the importance of China's space program in the development of satellite application technologies—supplementary products that build upon the information provided by space technologies to add value for consumers. In their view, China's space program has facilitated the development of these technologies in three primary areas. First, it has led to the development of satellite communications applications such as satellite television and telecommunication services. Second, China

has launched several lines of Earth observation satellites that provide remote sensing data, which many of China's civil government agencies rely on for functions such as agricultural use monitoring, environmental protection, and municipal planning. Many of China's civil-government agencies are dependent on this data. Third, it has helped foster growth associated with the Beidou satellite navigation system.²¹

The Beidou satellite navigation system, which currently provides regional coverage and is projected to achieve global coverage by 2020,²² is the most important of China's space programs associated with satellite application technologies and the one that contributes most clearly in soft power terms. China reportedly spent \$2.57 billion on the program from 1994-2012 and planned (as of 2013) to spend an additional \$6.41-\$8.02 billion from 2013 to 2020, indicating it is one of the largest space programs the country has undertaken.²³ Beidou is also one of China's 16 "megaprojects" under the 2006-2020 Medium and Long-term Plan for Science and Technology Development funded by China's Ministry of Science and Technology, which identifies and coordinates Beijing's top state-directed R&D efforts across government, military, and commercial spheres (three other megaprojects—a high-definition Earth observation system, human spaceflight, and lunar probes—are also space-related).²⁴

Beidou is first and foremost a military system, built to end the Chinese military's reliance on GPS, as Chinese scientists and military officers have advocated since the early 1980s. It has applications in other areas as well. In 2016, China published a white paper announcing for the first time that Beidou (like GPS) would be free to all users worldwide, and calling for a massive push to build a commercial industry compatible with the system.²⁵ China, no doubt, sees an opportunity for significant profits from this effort: the market for downstream global navigation satellite system products in China is projected to reach approximately \$65 billion by 2020,²⁶ and a Chinese academician chairing the 2013 China Satellite Navigation Conference noted the market could be worth "hundreds of billions" in the future.²⁷ China's military could also benefit from civil-military integration in the industry: in August 2015 Alibaba, a private Chinese firm, and China North Industries Corporation, a Chinese state-owned defense conglomerate, formed a joint venture worth roughly \$310 million to "build applications and technology to support and work with the [Beidou] system."²⁸

Beidou may offer China political opportunities as well. As China moves from a regional to a global position, navigation, and timing (PNT) service provider, Beijing could use the Beidou system as leverage to obtain more influence over PNT-related decisions in international and regional organizations such as the International Telecommunications Union, the International Committee on Global Navigation Satellite Systems, the Asia-Pacific Economic Cooperation forum, and the International Civil Aviation Organization.²⁹ China has specifically stated that it plans to expand Beidou coverage to most of the countries covered in its "One Belt, One Road" initiative by 2018 on the way to global coverage in 2020,³⁰ indicating it sees the system as contributing to its economic diplomacy efforts.

Human Spaceflight

Human spaceflight is a clear contributor to China's soft power and international prestige—to date, China is only the third country behind the United States and Russia to have independently launched a human into space. China's human spaceflight program is one of the country's largest and most technologically-advanced projects, involving some 3,000 organizations and several hundred thousand personnel. The program has proceeded methodically along three phases, and is poised to achieve its most significant successes over the next six years. In phase one (1992–2005), China launched several unmanned Shenzhou spacecraft to develop technologies necessary for its first manned spaceflights in 2003 and 2005. In phase two (2005–2013), China conducted both manned and unmanned docking maneuvers between the Shenzhou spacecraft and the Tiangong-1 space lab. In phase three, scheduled for completion by 2022, China plans to launch a permanent manned space station into orbit.³¹ Importantly, news reports in

September 2016 revealed that China has likely lost control of the Tiangong-1 and will not be able to control its descent to Earth in late 2017,³² indicating that Beijing is still catching up technologically as a space power and faces the same obstacles encountered by other nations' programs.

Beijing has specifically planned the following activities for 2016 and the next several years:

- Launch of China's two largest launch vehicles to date—the Long March-7 (LM-7) in June 2016 (completed) and the LM-5 in late 2016 (forthcoming)—required to launch China's 60-ton permanent manned space station*
- Launch of a second space lab, the Tiangong-2, in September 2016 (completed)
- Launch of the Shenzhou-11 spacecraft in October 2016, China's first manned space mission since 2013 and sixth overall, to link with Tiangong-2
- Launch of the Tianzhou-1 cargo-resupply vehicle to resupply Tiangong-2 and Shenzhou-11 in the first half of 2017, China's first such mission, aboard an LM-7 launch vehicle³³
- Launch of the Tianhe-1, the experimental "core module" of the planned space station, in 2018³⁴
- Launch of the remaining two modules in 2020 and 2022³⁵

At 60 tons, China's space station will be closer in size to Skylab, the United States' first space station, than the approximately 450-ton ISS. Should the ISS be deorbited in 2024, however, China will potentially have the world's only active space station.³⁶ China is already engaged in diplomatic efforts involving this project: in June 2016 the director of the China Manned Space Agency signed two agreements with the director of the U.N. Office for Outer Space Affairs, based on which China will solicit, evaluate, select, and finance future experiments from foreign nationals through the UN (although these will also require bilateral agreements with countries involved). China has additionally signed agreements with the Russian Roscosmos space agency and the European Space Agency regarding space station cooperation, and European astronauts are reportedly already learning Chinese in preparation for trips to the station.³⁷

Importantly, manned platforms could also play a role in space warfare, as referenced in several writings by Chinese analysts. Among other activities, manned space platforms can, depending on their type, conduct reconnaissance and surveillance against targets, service military satellites in orbit, and serve as platforms for kinetic and directed energy weapons.³⁸

Space Exploration

China's lunar and Mars missions represent the premier examples of Beijing's pursuit of political and scientific objectives through its space program, and each has seen major developments over the past year.

In April 2016, a senior PLA officer and deputy commander of the China Manned Space Program stated that China plans to send astronauts to the Moon before 2036, the first public reference to this objective by a Chinese space official.³⁹ In its 2011 white paper on space, Beijing acknowledged that it was "researching the critical technologies for manned lunar exploration," and China began a feasibility study that same year for a manned mission to the Moon with a potential launch date of 2020, 2025, or 2030.⁴⁰ The official's 2016 statement noted, however, that it will require 15 to 20 years to land astronauts on the lunar surface, a 2031-2036 timeframe.⁴¹ Given the secrecy surrounding China's space program, it is difficult to confirm exactly when China intends to complete such a mission.⁴²

According to the State Administration of Science, Technology, and Industry for National Defense, China's lunar exploration program was the result of a "major strategic decision by the CCP Central

* The LM-7 can carry 13.5 tons into low Earth orbit, a significant increase from China's LM-2F at 8 tons and the more frequently-used LM-2C and LM-2D at 3.9 tons. The forthcoming LM-5, expected to be launched later this year, will be able to

Committee, State Council, and Central Military Commission” aimed at “promoting [China’s] space enterprise development, promoting [its] S&T advancement and innovation, and improving [its] comprehensive national power.” Although primarily motivated by prestige and scientific objectives, China may also seek to use its lunar program to exploit the Moon’s natural resources. Chinese analysts have noted that the Moon contains large amounts of elements including iron, titanium, and uranium that could be useful for economic development. Helium-3 appears to be of specific interest to these analysts, although utilizing it would require the development of a commercially viable nuclear fusion reactor, a technology not yet demonstrated. China’s lunar exploration program consists of multiple phases involving the Chang’e spacecraft and several lunar landing vehicles:

- In phase one (2004–2007), the Chang’e-1 and the Chang’e-2 spacecraft orbited the Moon to map the lunar surface. The missions also tested China’s ability to control objects in deep space.
- In phase two (2007–2014), the Chang’e-3 spacecraft landed a lunar vehicle on the Moon, making China the third country behind the former Soviet Union and the United States to conduct a soft landing on the Moon, and the first to do so since 1976. The vehicle deployed a rover, designated “Jade Rabbit,” to study the lunar surface and analyze its soil. Later in the second phase, China employed the Chang’e-5 spacecraft to test technologies required to retrieve and return a lunar sample to Earth.
- In phase three, China plans to send a spacecraft to the moon, retrieve samples of the lunar soil, and then return them to Earth. The mission will use the Chang’e-6 spacecraft and is scheduled for 2017.
- In a potential fourth phase, China announced in September 2015 that it would send the Chang’e-4 spacecraft to land on the Moon’s “dark side” before 2020, which would make China the first nation to do so. The stated objective of this mission is to study geological conditions on the dark side, which could eventually lead to the placement of a radio telescope for use by astronomers.⁴³

China announced for the first time in November 2015 that it plans to send a rover to Mars in 2020.⁴⁴ China’s defense industry and the Chinese Academy of Sciences have been conducting studies on the feasibility of such a project.⁴⁵

In other areas related to scientific development, China plans to launch a space telescope described by Chinese officials as akin to the Hubble Space Telescope in the mid-2020s, which will be housed in a separate unit but orbit alongside the space station.⁴⁶ Using a space station as a permanent support base for any type of satellite has not been previously tried.⁴⁷ China reportedly launched the world’s first experimental quantum communications satellite in August 2016, which will test technology that could eventually enable secure digital communication using a virtually unbreakable encryption key.⁴⁸

International Space Cooperation Efforts

China’s space program has opened doors for international cooperation with several countries and international organizations, which in turn has provided benefits to China:

Asia Pacific:

- China led the founding of the **Asia Pacific Space Cooperation Organization (APSCO)** in 2008, its primary vehicle for multilateral cooperation on space. APSCO is a formal, membership-only organization headquartered in Beijing, with seven other member countries (Bangladesh, Iran, Mongolia, Pakistan, Peru, Thailand, and Turkey, with Indonesia as a signatory state but not yet a full member), all of which have less advanced space programs than that of China. APSCO members hold conferences, engage in joint training efforts, and cooperate on multilateral research and development projects. These efforts allow China to position itself as a purveyor of space

technology and expertise to less-developed states. China's leaders also use Beijing's central role in APSCO to promote the export of its space technology and services in order to gain support for its space goals from the Asia Pacific region, as well as to obtain supplementary data and geographic coverage for its space situational awareness efforts.⁴⁹

- Regarding China's **One Belt, One Road** initiative, China has stated that it plans to expand Beidou coverage to most of the countries involved by 2018 on the way to global coverage in 2020.⁵⁰
- China has constructed a telemetry, tracking, and control (TT&C) station in **Pakistan** and leases access to a station in **Australia**. China uses five such overseas stations, in addition to 10-20 in China and seven naval space tracking vessels, to maintain communication with spacecraft that travel beyond the area visible from Chinese territory.⁵¹
- With **Brunei, Laos, Pakistan, and Thailand**, China has signed agreements to provide Beidou-equipped receivers for government and military customers at heavily subsidized costs. These agreements include provisions allowing Beijing to build satellite ground stations in each country. The stations will be used to increase Beidou's range and signal strength.⁵²
- China has provided launch services for Chinese-made satellites to **Laos, Pakistan, and Sri Lanka**. China has also launched a foreign-made satellite for **Indonesia** and launched an experiment for **Japan's** space agency.⁵³

Eurasia:

- With **Russia**, China established a space cooperation subcommittee within the countries' bilateral prime ministers' dialogue in 1997, after a break in cooperation beginning in 1958. This has resulted in the opening of a Chinese space program office in Russia and a corresponding Russian office in China, as well as collaboration on a range of human spaceflight and space exploration activities. Future cooperative activities could include joint rocket engine development, Russia's participation in China's future space station, and a joint Russia-China space station. China likely gains valuable knowledge from cooperating with the world's number-two space power, particularly in the area of launch vehicle technology.⁵⁴
- With **Ukraine**, China implemented three consecutive five-year programs guiding cooperation on large-scale space projects from 2001-2015. These have included cooperation on projects involving remote sensing satellites, space weather satellites, space rocketry, and the Ionosat space system. The two countries have also discussed projects in engine manufacturing and even for exploring the Moon and Mars, but these have not yet seen further action. This collaboration has likely assisted China's development of launch vehicle technology as well.⁵⁵
- With the **European Space Agency**, China's joint space cooperation efforts are thriving, particularly in the areas of space science, space exploration, and human spaceflight. In the mid-to late-2000s, China extracted important gains from the relationship through its early co-development work on Europe's Galileo satellite navigation network. Europe later declined China's continued participation in the project, primarily due to concerns over the dual-use nature of satellite navigation and questions regarding China's plans for its own Beidou satellite navigation system. The project no doubt provided Beijing with essential technology and experience needed for the development of Beidou. Beidou satellites even use frequencies previously allocated to Galileo, for which EU and Chinese diplomats jointly negotiated in the early 2000s. China generally seeks access to Europe's advanced space technology to improve its

own space capabilities, while Europe seeks greater cooperation primarily in order to compensate for the reduced funding of the European Space Agency and to facilitate greater economic ties between China and Europe.⁵⁶

- China has signed a contract to launch a Chinese-made satellite for **Belarus**, launched foreign-made satellites for a **Luxembourg** company and **Turkey**, and launched an experiment for the **European Space Agency**.⁵⁷

Africa:

- With **Nigeria**, China hosted a delegation in April 2016 that reportedly discussed “logistics and investment for a manned space mission,” related to Nigeria’s announcement in 2016 that it intends to send an astronaut to space by 2030.⁵⁸ China reportedly agreed to provide scholarships and training to Nigerian engineers in the space sector to assist this effort.⁵⁹
- China has built a TT&C station in **Namibia** and leases access to a station in **Kenya**.⁶⁰
- China has provided launch services for a Chinese-made satellite to **Nigeria** and signed contracts to launch foreign-made satellites for **Algeria** and the **Democratic Republic of the Congo** in the future.

Americas:

- With the **United States**, China’s space cooperation has been limited since 1999, and official visits have been limited since 2011. However, space officials from the two countries have held meetings, inaugurated the “U.S.-China Civil Space Cooperation Dialogue” in 2015 in an effort to establish regular bilateral consultations, and discussed measures for satellite collision avoidance. In 2015 the two sides determined to undertake a joint project in “space security” within the East Asia Summit, the Association of Southeast Asian Nations (ASEAN) Regional Forum, or another multilateral framework in the Asia Pacific region.⁶¹
- With **Brazil**, China has cooperated on joint satellite development and space launches, most notably the China-Brazil Earth Resources Satellites project, which developed a series of remote sensing satellites from 1988 to 2016. In addition to their scientific mission, these satellites likely benefit PLA satellite coverage, and the project also probably helped Beijing lay the groundwork for its most advanced Earth observation satellite series, which has military applications.⁶²
- With **Venezuela**, China signed a memorandum of understanding on space technology cooperation and established a special joint subcommittee on technology, industry, and space in 2005. Since then China has built and launched two satellites for Venezuela and is helping Venezuela build small satellites, supplying Venezuela’s space industry with Chinese technology, and training Venezuelan engineers.⁶³
- With **Bolivia**, China has trained Bolivian scientists and lent the majority of the funds needed for Bolivia to purchase its first satellite.⁶⁴
- China has built a TT&C station in **Chile**. In **Argentina**, China is constructing its sixth overseas TT&C station at a reported investment of over \$300 million, in exchange for providing Argentina a share of the antenna’s usage time and access to imagery from its surveillance satellites.⁶⁵

- China has provided launch services for Chinese-made satellites to **Bolivia** and **Venezuela**, with a contract signed for a future launch for **Venezuela**. China has launched foreign-made satellites for **Argentina** and **Ecuador**.

Several observations can be made regarding patterns in China's international space cooperation activities: 1) China has sought to work with advanced space powers where possible; 2) it has sought to market commercial space services to developing countries, which are less likely to demand advanced technology subject to U.S. restrictions; 3) these activities often involve practical requirements, such as the placement of TT&C stations around the globe to track spacecraft; and 4) they often appear to relate to China's larger foreign policy efforts in given regions. The fact that China has reportedly subsidized many of its satellite launch and satellite navigation services suggests its motivations are not restricted to commercial interests, although the intention could also be to gain a foothold in these regional markets.⁶⁶

In conclusion, apart from the military imperatives of China's space program, key political, economic, and diplomatic benefits have arisen from Beijing's space activities as well. China's overall achievements in space and its specific plans for a space station, lunar exploration, and potentially the exploration of Mars provide domestic legitimacy and international prestige. Commercial efforts such as space launch services, satellite exports, and satellite application technologies provide revenues and are expected by policymakers to spark wider growth in key economic sectors. Both types of activities supply a product desirable to many international governments and open the door to China's participation in key bilateral and multilateral initiatives. Importantly, these drivers frequently overlap. For example, although Beidou's development was driven by security needs, it is now envisioned to facilitate a widespread downstream commercial industry, and it may provide diplomatic influence as well. Considerations for the United States must thus be assessed along a wide spectrum of possible impacts.

Implications for the United States

Economic Implications

I would like to highlight three areas where China's expanding space program presents economic implications for the United States.

First, China's persistent global marketing of its commercial satellite and space launch services has the potential to cut into U.S. firms' market share, though it has had little effect on established satellite manufacturers or the international launch market thus far. China has been focused on growing its satellite exports to lower-income buyers but will almost certainly seek to expand to higher-end markets in the future. Its launch service costs compare favorably with those of Arianespace, the major European provider, and may be able to compete with those of SpaceX, the low-cost leading U.S. private firm. In addition, according to one former European space executive, China has broken into the launch services market by offering prices as low as three-quarters of the launches' cost, suggesting that heavy government assistance on top of low initial costs could enable China to successfully compete for broader market share in the future. Furthermore, China often packages its satellite exports and launch services together, and also reaps cost and experience benefits from blending its civilian and military space launch infrastructure. An executive for U.S. company SpaceX, which has led a resurgence in U.S. commercial launch market share, stated in 2013 that the company views China as its main competition.⁶⁷

Second, China's designation of the Beidou satellite navigation system—planned to provide global service by 2020—as “national infrastructure,” and introduction of preferential policies to promote its adoption in downstream industries, may affect U.S. firms in these industries in the future. The United States receives no revenue from GPS, and the global downstream PNT industry is moving rapidly towards “multi-constellation” devices built to receive signals from two, three, or all four satellite systems,⁶⁸ meaning U.S.

firms may benefit in the near term by selling Beidou and GPS-equipped products in China's market. However, the long-term outlook for U.S. firms in the industry will likely be negative. A recent Commission-sponsored report notes that ultimately U.S. suppliers will be replaced by local ones for Chinese government and military users seeking "secure and controllable" options, while in the civilian market most financial tax incentives will likely be given to local Chinese companies.⁶⁹ †

Third, U.S. International Trafficking in Arms Regulations (ITAR) were altered by the FY13 National Defense Authorization Act to no longer include exports of many satellites and satellite technologies but are still in force for China. This has prompted many European countries and their industries to pursue "ITAR-free" exports in order to reach the Chinese market—necessitating the exclusion of U.S. technologies from these products. At the Commission's hearing on China's space and counterspace programs last year, one witness explained that this shift has been driven by concerns over U.S. export controls on space-related items, confusion over which items are on the list of banned items for export, and uncertainty over which ones will be on the list in the future. He also suggested that China probably already has access to many ITAR-restricted products from foreign partners, particularly Europe.⁷⁰ In May 2015 General James Cartwright, former vice chairman of the Joint Chiefs of Staff, and Sean O'Keefe, former NASA administrator, reiterated that U.S. ITAR regulations are not currently in line with the pace of technological innovation and are therefore in need of reform in order to protect the U.S. space industry's global competitiveness.⁷¹

Political and Diplomatic Implications

China's space initiatives have important political and diplomatic implications as well, most importantly in their potential to present a future challenge to U.S. leadership in space and to further China's foreign policy objectives.

In terms of "milestones," China will not surpass the United States over the next two decades, if U.S. support for its space program continues as planned. Based on goals outlined in the NASA Authorization Act of 2010 and the U.S. National Space Policy issued in 2010, NASA is working to develop the capabilities needed to send humans to an asteroid by the mid-2020s and to Mars in the 2030s.⁷² These objectives, if achieved, would continue to demonstrate unmistakable U.S. technological leadership in space science and exploration. To place the two countries' programs in perspective, should the U.S. and Chinese space programs both hypothetically achieve their planned objectives, by the late 2030s the United States would have conducted a manned mission to a planet 140 million miles away (based on the average distance from the Earth to Mars), while China would have conducted a manned mission 239,000 miles away to the Moon, 70 years after this was first accomplished. China's achievements should certainly not be minimized, given the steady progress it has demonstrated over time, the milestones it has already achieved, and its success in narrowing the gap with the established space powers, the United States and Russia. But the United States is positioned to remain a leader in pushing the frontier in space exploration.

Despite these considerations, U.S. decisions regarding its space program's direction have incidentally opened up opportunities for China to expand its influence and narrow the gap in perceived achievements.

First, taking a simplistic view, the United States will potentially have a Mars program, but no space station, and no lunar program in the future, while China will have all three.⁷³ The United States may view the latter two programs as extraneous, having already achieved these objectives, but China's engagement in these areas could provide unique leadership opportunities and diplomatic advantages. Nations with

† See the Commission's forthcoming report "China's Alternative to GPS and its Implications for the United States," for more information on the potential security and economic implications of China's efforts to promote Beidou.

developing space programs—particularly those that have already purchased satellite launches or manufactured their own satellites—may view the prestige of achieving manned spaceflight as highly desirable. For example, Nigeria announced plans in 2016 to send an astronaut to space by 2030, and in April 2016 sent a delegation to Beijing to discuss “logistics and investment for a manned space mission.”⁷⁴ China reportedly agreed to provide scholarships and training to Nigerian engineers in the space sector to assist this effort.⁷⁵ Besides being able to offer direct programmatic assistance, China could benefit from its space station serving as a destination for spaceflights and scientific experiments in the coming decades—European Space Agency astronauts are reportedly already being trained for visits to the station.⁷⁶ Should the ISS be deorbited in 2024 as currently planned,⁷⁷ China would be the only supplier in the field to meet such demand.

While China stresses that it is open to its space station hosting non-Chinese experiments, payloads, astronauts, and modules,⁷⁸ Beijing will be able to impose limits regarding participation, launch vehicles used, component sourcing for payloads, and data sharing if it so desires. Given current restrictions, the United States would of course not participate in China’s space station program regardless, barring changes to annual appropriations legislation.⁷⁹ The space station will thus likely serve as a diplomatic tool China can leverage to execute its broader foreign policy goals and as a way to exert leadership in space.

Second, beyond large-scale projects, China may reap geopolitical benefits from its broad-based efforts in space. International cooperation on space activities usually follows progress in countries’ overall relationships and is more of an indicator of the state of a relationship than a critical component.⁸⁰ However, a growing number of governments are desirous of a presence in space and the prestige and domestic political benefits this will bring. Now that China’s space program has reached a high level, cooperation on space projects has become another tool for Beijing to use within its larger foreign policy approach toward the developing world. The space-related agreements China has signed often correlate with the announcement of other investments: China-Pakistan space cooperation was discussed in conjunction with the China-Pakistan Economic Corridor,⁸¹ and the agreement regarding China’s TT&C station in Argentina was made during a state visit that discussed a wide range of military and economic agreements.⁸² The United States should thus anticipate that space will play a role in China’s foreign policy toolbox going forward.

Importantly, China is far from alone in pursuing these international efforts. NASA has longstanding partnerships with an even wider range of countries than China, despite not engaging on the commercial side in the same way China does. Although most of its activities are with developed countries, NASA is also engaging in projects with Argentina, Bermuda, Brazil, India, and Thailand; leading a program that provides satellite-based Earth observation data and science applications to developing countries; and participating in several other international programs geared towards assisting developing countries.⁸³ In its own region, China may face competition from Japan, which had a space budget of roughly \$2.75 billion in 2015,⁸⁴ has launched microsatellites for Vietnam and the Philippines and engaged heavily with Vietnam’s space program,⁸⁵ and has engaged in numerous other international partnerships.⁸⁶ India may be another competitor: it spends roughly \$1 billion annually on its space program,⁸⁷ recently launched a satellite for Indonesia,⁸⁸ and has reportedly been concerned about China’s space cooperation with nearby Sri Lanka.⁸⁹ While China may reap benefits from space-related international cooperation activities, it should not be seen as having a monopoly on such efforts.

Third, China has been able to achieve several small public relations “victories” in Western media related to the question of competition vs. collaboration with the United States in space. As China’s space program continues to develop, this has served to draw attention to ways in which the United States has elected to restrict cooperation with China in space. A few recent examples include the 2016 announcement that China’s space station will be open to all users,⁹⁰ the 2015 CNN documentary on “China in Space” that featured Chinese astronauts discussing their inability to visit the ISS,⁹¹ news

coverage of the ban mistakenly placed on Chinese scientists' participation at an international NASA conference in 2013,⁹² several editorials arguing for greater U.S. cooperation with China,⁹³ and even scenes featuring cooperation in the 2015 movie *The Martian* (highly successful in China), which according to the director of the China National Space Agency showed that "our U.S. counterparts very much hope to cooperate with us."⁹⁴ These narratives have generally downplayed the legitimate concerns underlying U.S. restrictions on space cooperation with China. The scale of this public relations contest has been minor thus far, but does warrant attention due to its potential to grow.

Recommendations

In previous examinations of China's space program, the Commission has made the following recommendations for Congressional action:

- Congress should continue to support the U.S. Department of Defense's efforts to reduce the vulnerability of U.S. space assets through cost-effective solutions, such as the development of smaller and more distributed satellites, hardened satellite communications, and non-space intelligence, surveillance, and reconnaissance assets such as unmanned aerial vehicles.
- Congress should direct the U.S. Department of Defense, U.S. Air Force, and relevant agencies within the U.S. Intelligence Community to jointly prepare a classified report that performs a net assessment of U.S. and Chinese counterspace capabilities. The report should include a strategic plan for deterring, with active and passive systems, strikes against U.S. assets in light of other countries' rapid advancements in kinetic and non-kinetic counterspace technology.
- Congress should direct appropriate jurisdictional entities to undertake a review of (1) the classification of satellites and related articles on the U.S. Munitions List under the International Trafficking in Arms Regulations and (2) the prohibitions on exports of Commerce Control List satellites and related technologies to China under the Export Administration Regulations, in order to determine which systems and technologies China is likely to be able to obtain on the open market regardless of U.S. restrictions and which are critical technologies that merit continued U.S. protection.
- Congress should allocate additional funds to the Director of National Intelligence Open Source Center for the translation and analysis of Chinese-language technical and military writings, in order to deepen U.S. understanding of China's defense strategy, particularly related to space.

On a personal level, I note the value of U.S. leadership in space far exceeds that of achieving technical superiority or a high "medal count" in space exploration for its own sake. Having grown up in the 1960s and early 1970s, I can attest to the powerful impact the Apollo program had on me and on many other Americans, and the sense of patriotism and national purpose it inspired. In addition to the security and commercial reasons for U.S. leadership in this domain—the "ultimate high ground" according to experts in China—a visionary U.S. space exploration program can again strengthen our national purpose, inspire new generations of leading scientists and engineers, and continue to benefit mankind. As I consider this issue from my vantage point at the U.S.-China Commission, examining China's expanding activities in space, the need for continued U.S. leadership becomes even more imperative.

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