SPECIAL REPORT

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China and Strategic Instability in Space: Pathways to Peace in an Era of US-China Strategic Competition

By Bruce W. MacDonald, Carla P. Freeman, and Alison McFarland

A Long March-2F Y12 rocket with a crew of taikonauts lifts off at the Jiuquan Satellite Launch Center in northwestern China on June 17, 2021. (Photo by Ng Han Guan/AP)

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Summary

- US-China competition in space is intensifying against a backdrop of rapid advances in technology, China's commitment to developing its already formidable space capabilities, and the increasingly confrontational nature of US-China relations.
- The space environment is facing unprecedented and destabilizing challenges. Drivers of instability include the entanglement of conventional and nuclear space sensor systems; the testing of kinetic energy direct ascent anti-satellite weapons; and the dramatic growth of constellations of tens and even hundreds of thousands of commercial satellites.
- China is a key factor in all three of these issues, each of which reflects the fact that the infrastructure of space governance has not kept pace with technological change and the burgeoning number of actors in space.
- To mitigate the risk of escalation, the United States and China should do what is necessary to ensure that their nuclear and conventional warning/tracking assets are disentangled.
- Were the United States and China to work together, they might well be able to foster an international commitment to conduct research on the impact of "large" and "very large" constellations on space security and create a coordination mechanism for satellite orbits.

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Making Peace Possible

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CONFLICT ANALYSIS & PREVENTION

ABOUT THE REPORT

Drawing on Chinese government documents and other authoritative sources, as well as Western analyses, this report examines intensifying US-China competition in space, highlighting three key drivers of instability and recommending steps to improve space governance and safeguard the sustainable and safe use of the space domain. The report's findings have been shaped by insights from a group of senior experts from the academic, think tank, policymaking, and technical communities who participated in a scoping discussion and several dialogues.

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Photographers follow the lift off of a United Launch Alliance Delta 4 rocket, carrying a Wideband Global SATCOM military communications satellite into space, at Cape Canaveral Air Force Station in Florida on July 23, 2015. (Photo by John Raoux/AP)

Introduction

Strategic competition between the United States and China is intensifying in the domain of outer space. Two recent Chinese defense white papers—one issued in 2015, the other in 2019—contend that outer space has become the "commanding heights" in international strategic competition.[1] The 2019 paper specifically addresses perceived threats from the United States and NATO, singling out the United States as having intensified competition among major powers and "pushed for additional capacity" in space, among other domains. The United States has likewise identified China as a source of competition in space, asserting that both China and Russia are seeking to "challenge the US position in the space domain"; other assessments, including the 2018 National Defense Strategy, have concluded that China is pursuing "maximum leverage."[2]

While this US-China rivalry is heating up, space is also becoming ever more crowded. Governments from many advanced and emerging economies, as well as some developing low-income countries, have space programs designed to pursue a wide range of economic and security objectives.[3] Amid a dramatic reduction in the cost of many space technologies, space is no longer exclusively the province of superpowers. In addition, private corporations are increasingly active in space. Due largely to commercial activity, the number of satellites in orbit is growing almost exponentially. More than a hundred million pieces of debris, including the tens of thousands of pieces of "space junk" tracked by the US Department of Defense's global Space Surveillance Network sensors, interact with charged particles, magnetic fields, and natural space objects, such as asteroids.[4] This congestion and competition intensifies the potential for strategic instability in space, including elevating the risk of conflict when an unplanned collision is misconstrued as a hostile act.

China's exceptional technological competencies and ambitions, along with those of other emerging players, have brought an end to the era of unquestioned US dominance in space. Moreover, space is no longer an arena for competition only among states; it is now a competitive arena for commercial actors engaged in a range of civil, commercial, and national security activities. These changes in the context of intensifying strategic rivalries, particularly between the United States and China, have put the past several decades of relative stability in space in jeopardy. There is an urgent need for new approaches to ensure stability in space to benefit US and larger global security interests and to head off potential sources of instability with ominous implications over the next two decades.

This report spotlights three sources of instability in space that merit immediate attention because of the growing risks they pose to space security specifically and to global security more broadly:

- The first of these sources is potential nuclear entanglement between strategic nuclear-supporting space infrastructure and purely conventional nonnuclear forces.
- The second is the existence of ongoing kinetic energy direct ascent anti-satellite (DA-ASAT) testing, which creates debris that puts satellites and space missions at risk, and which if used in actual space conflict could greatly increase the likelihood of orbital collisions with the resultant satellite debris produced.
- A lesser but still important source of instability is the absence of ways to manage the deployment of constellations of tens and even hundreds of thousands of commercial satellites (referred to as "large" and "very large" constellations or megaconstellations).[5]

Each of these issues is not only urgent but also actionable through a sustained commitment to diplomacy to forge agreements and even formal institutional arrangements at the global level to improve the prospects for a more stable and peaceful space environment. Furthermore, these are issues in which China, through its actions, technological development, and vision for the role of space as an element of its national power, plays a critical role. Amid the current strains in the US-China relationship and the emphasis in both Washington and Beijing on competing in the areas of advanced technology, economic influence, and international security, getting traction on these issues may not be easy to achieve, but it is not impossible.

Research for this report draws on both English-language analyses of China's space activities and role in space governance and Chinese-language materials and official translations of government documents, focusing on those that can be considered authoritative sources, namely, Chinese government documents and other official statements.[6] The evolution of this report and of the project on which it is based has been significantly shaped by the insights and feedback of a group of senior experts drawn from the United States' academic, think tank, policymaking, and technical communities. (These experts are listed in the acknowledgments at the end of the report.) A scoping session and several dialogues brought these experts together to discuss the issues covered in this report.

The report is organized as follows: It begins with a discussion of how the space environment is changing and the ways in which global space governance has failed to keep pace with those changes. It then considers China's activities in this evolving environment and key dimensions of US-China competition in space, along with the risks that attendant dynamics pose to global stability. The report looks in turn at each of the three drivers of instability in this context. The report concludes with recommendations geared toward US policymakers for actions that can be taken unilaterally, as well as in cooperation with other space powers, to strengthen space governance and mitigate the risks of a congested, debris-strewn, or entangled space environment.

A Rapidly Changing but Inadequately Regulated Space Environment

Space is no longer the exclusive domain of powerful states. Technological advances have substantially lowered the costs of space activity while human activities on Earth have become heavily dependent on space-based capabilities. This has made space appealing and accessible to an array of new actors, ranging from low-income developing countries to large private and state-owned corporations to entrepreneurial investors.

A burgeoning if still embryonic space economy is already valued in the hundreds of billions of dollars and projected to be worth more than a trillion dollars within the next two decades.[7] Public investments continue to drive the lion's share of space activities, but private commercial activity is also expanding quickly and fueling profit-oriented activities in space. These include not only communications but also resource extraction and tourism, with investments even laying the groundwork for future interplanetary travel and settlement.[8]

International private capital, including from sources in the United States and China, is flowing into the development of a range of commercial sectors in space. Since the dawn of the 21st century, a few wealthy US-based investors have supported commercial space entities that have attracted a growing share of NASA and Department of Defense investment in space missions.[9] An increasing number of Chinese companies are also among the more than 10,000 space-focused private firms in existence globally. Because of policies favorable to private investment in commercial space activities that the Chinese government introduced in 2014, more than 100 commercial space companies now operate in China alongside the country's two major state-owned enterprises involved in space operations: the China Aerospace Science and Industry Corporation Limited and the China Aerospace Science and Technology Corporation.[10]

At the same time, space is also increasingly perceived by countries as a domain where conflict can occur. The United States has explicitly identified space as a warfighting domain. For US defense planners, the importance of space for civilian and military life on Earth makes it a key military advantage in peacetime.[11] China is among a small group of countries developing counterspace technologies such as DA-ASATs, as well as nondestructive physical, electronic, Existing legal frameworks and regulatory institutions have not been updated to account for the impact of new technologies, new governmental space actors (such as China), the array of commercial actors, or expanding international interest in space as a security domain for both surveillance and warfighting.

and cyber technologies.[12] Key military space missions are increasingly relying for essential functions not on a single satellite, but on multiple satellites in order to become more resilient to adversary attacks.

These developments are among those that have added exponentially to the human impact on the space environment, making it increasingly congested, contested, and competitive in ways that pose unprecedented potential challenges to the sustained use of space by the United States and its allies and partners.[13] The absence of adequate global regimes, codes of conduct, and other measures and agreements that could help reduce the risk of disagreements, disputes, and misunderstandings escalating into armed conflict make these challenges even more acute.

During the Cold War, the United States and the Soviet Union, as the two countries with extensive space capabilities, supported the crafting of legally binding global agreements on the use of space.[14] The five international treaties that ultimately resulted—the Outer Space Treaty (1967), Rescue Agreement (1968), Liability Convention (1972), Registration Convention (1975), and the Moon Agreement (1979)—focused on prohibiting the appropriation of outer space by any one country, the weaponization of the Moon and other celestial bodies, and the placing of weapons of mass destruction in outer space.[15] As the economic importance of space grew and other problems involving space arose, additional international mechanisms were developed in response. Orbital slots for telecommunications satellites and liability for satellite and rocket body reentry into the atmosphere and crashing onto the surface of a country underneath are among the areas where institutionalized arrangements exist with broad international legitimacy and support today.

However, existing legal frameworks and regulatory institutions have not been updated to account for the impact of new technologies, new governmental space actors (such as China), the array of commercial actors, or expanding international interest in space as a security domain for both surveillance and warfighting. Nor is it clear whether the established norms, codes of conduct, procedures, or other measures are well understood by these new actors or even sufficient to handle the changing space domain. Moreover, some long-standing space powers are also disregarding not only established norms but also the concerns of their peers. For example, India in 2019 and Russia in late 2021 tested DA-ASAT weapons despite ample prior public discussion of the stability challenges such weapons pose.

In some instances, existing global agreements with the potential to serve as the foundation for governance mechanisms for some of these emerging issues lack the international backing needed to serve that purpose. The governance of lunar resources offers several examples. The Moon has become an increasingly appealing target of opportunity for both governments and private firms for various purposes, including the extraction of valuable resources. The 1979 Moon Agreement allows for expansive human activities while committing ratifying states to establish an international regime to govern the exploitation of resources before any such exploitation may commence.[16] However, the three major space powers—China, Russia, and the United

States—are not party to the agreement, which only 17 of the world's countries have ratified. Notably, Saudi Arabia, which had acceded to the agreement in 2012, announced its withdrawal from it in 2023.[17]

In 2020, in response to a US initiative to return humans to the Moon, representatives of the space agencies of eight countries (Australia, Canada, Italy, Japan, Luxembourg, the United Arab Emirates, the United Kingdom, and the United States) proposed a new approach to governing future space activities—the Artemis Principles for a Safe, Peaceful, and Prosperous Future ("Artemis Accords"). The Artemis Accords are a political commitment to a set of nonbinding principles that signatories view as reinforcing the 1967 Outer Space Treaty (OST). The goal of the principles is to reduce uncertainties associated with space resource extraction and utilization, including by stating that space resource extraction does not in and of itself constitute national appropriation, consistent with the OST. On the Moon, it is possible that disagreements could arise from mineral and other substance extraction just as on Earth, not to mention disputes over desirable locations for bases or orbital slots between nations. The accords also detail how buffer areas ("safety zones") might be created around lunar installations.[18] Although 23 countries and the Isle of Man have become party to the accords, China and Russia have not signed on. In 2021, China and Russia put forward a Moon base proposal, which includes plans for a crewed base from which to engage in Moon observation, exploration, and technology testing; it also seeks multilateral participation but does not appear to require any substantive legal affirmations.[19]

In the absence of broad international agreement over how to manage the ownership of lunar and other non-Earth resources, disagreements and even conflicts would not be surprising as space technology accelerates into the future.[20]

China's Achievements and Ambitions in Space

China has pursued space capabilities as a hallmark of national power since it watched Moscow and Washington race for advantage in outer space beginning in the 1950s.[21] By 1964, China had leaped forward in its own space program, sending an experimental biological rocket into space. In 1970, it launched its first satellite. With the emphasis on science and technology development that was a key dimension of China's post-1978 economic reforms, China pushed ahead in building its indigenous space capabilities. Beijing's priority for much of the first decade of reform was developing or acquiring satellites for practical applications that could help spur national economic development. Many military aerospace projects were moved toward commercial production.

China's efforts to develop space capabilities for military purposes began in earnest in the 1990s. The US-led Operation Desert Shield/Desert Storm against Iraq made clear the pivotal role of space in the command, control, communications, and intelligence (C3I) of modern high-technology warfare. By 2002, the People's Liberation Army (PLA) had come to regard the "space battlefield" (太空战场) as a crucial component of warfare and was incorporating it into China's plans for military operations. During the next decade and a half, the PLA broadened its mission to encompass safeguarding access to space and overseeing an expansion in the civilian uses of space through new satellite technologies and an ambitious human space program. With its 2007 ASAT test, China demonstrated its space warfare capabilities.[22] China's military strategy changed to include, first, "winning local wars under the conditions of informatization" (打赢信息化条件下的局部战争) and, later, "winning informationized local wars" (打赢信息化局部战争).[23] This refers to China's emphasis on a cybercentric force utilizing network linkages among PLA platforms.

China's ambitions extend beyond leadership in space to primacy in that domain. In October 2016, the Chinese Communist Party leadership of the State Administration of Science, Technology, and Industry for National Defense suggested that China could become a "space power" by 2030 and asserted that by 2050 China would "surpass and lead" in multiple aspects of space-related activity.[24] This 2050 goal was repeated by a China National Space Administration (CNSA) spokesperson in 2018, although it has not appeared in major documents from top leadership, such as the space white papers.[25]

In some respects, China's prowess in space already rivals that of the foremost global space power, the United States, given China's own global navigation system, crewed spaceflight capabilities, and growing counterspace capabilities. Its expanding commercial space sector with access to state financing is beginning to emerge as an important source of a variety of space technologies and services.[26] In several areas—among them quantum communication satellites, some types of space launch technology, and potentially space solar power—China's technological advances may already be second to none.[27]

According to a State Council white paper issued in January 2022, "China's Space Program: A 2021 Perspective," China's principal goals for outer space are multidimensional. The white paper states that China seeks

> to enhance its capacity to better understand, freely access, efficiently use, and effectively manage space; to defend national security, lead self-reliance and self-improvement efforts in science and technology, and promote high-quality economic and social development; to advocate sound and efficient governance of outer space, and pioneer human progress; and to make a positive contribution to China's socialist modernization and to peace and progress for all humanity.[28]

In practice, China has prioritized several concrete programs to develop its space capabilities. In 2020, it completed its BeiDou Navigation Satellite System (北斗卫星导航系统), giving China global navigational autonomy, essential in a global conflict.[29] BeiDou has also enabled China to include, as a dimension of its Belt and Road Initiative diplomacy, access to a "Space Silk Road" through the BeiDou satellite network.[30]

China has also invested substantially in a human space program, known as "Project 921." China sent its first crewed spacecraft into space in 2003, making it the third country after the United States and Russia to send humans into space. China's civilian space exploration goals are ambitious, as developments in this area show. In November 2022, it sent three *taikonauts* to its recently completed Tiangong space station and, as mentioned, it plans to build a lunar research station in partnership with Russia by 2035.[31] In 2020, China launched a probe bound for Mars that

Chinese taikonauts Liu Boming (left), Nie Haisheng (center), and Tang Hongbo wave as they prepare to board for liftoff at the Jiuquan Satellite Launch Center in northwestern China on June 17, 2021. (Photo by Ng Han Guan/AP)

successfully landed and delivered a robot that was able to explore its nearby environs—a remarkable engineering achievement. China also has its eye on interplanetary human travel, with plans to send a crewed mission to Mars in 2033.[32]

China's development of space infrastructure, such as constructing new launchpads and growing space-based telemetry, tracking, and command communications that will have an interplanetary reach, reflect its commitment to developing space capabilities. These moves evidence China's investment in space development beyond the bounds of purely Earth-centric satellite activity.

As noted, China is not only encouraging commercial space developments, principally through state-owned enterprises, but also opening the door to private investment in the space sector. China's 2014 State Council "Document 60," or "Guiding Opinions of the State Council on Innovating the Investment and Financing Mechanisms in Key Areas and Encouraging Social Investment" (国务院关于创新重点领域投融资机制鼓励社会投资的指导意见), called for greater private capital to be invested in the development of civil space infrastructure, including the provision of commercial launch services.[33]

Among Beijing's priorities is the development of space technologies that will enable it to exploit space-based mineral resources. Included among its technological goals toward this end is developing fully reusable launch vehicles, nuclear-powered space shuttles, and solar power stations to enable mining operations and manufacturing in space.[34]

Complementing these activities and goals, President Xi Jinping and officials leading China's space programs have made clear that China seeks to set rules and norms in space. While this would not necessarily threaten US interests (China has not directly opposed or supported US efforts on space norms), it behooves the United States to play a leading role in the norm-setting process. This is particularly true as it remains unclear what the rules and norms proposed by China might look like. According to some Chinese interpretations, one important objective for Beijing is to ensure that space remains the "common heritage of mankind"—though this seems to be at variance with its refusal to sign the Moon Agreement, which provides that the Moon and its resources are the common heritage of mankind.[35] Notably, China's January 2022 white paper on space speaks more directly, and largely approvingly, than previous white papers of the importance of space environmental governance with language heavily focused on what China is doing on issues such as space traffic control, space debris monitoring and mitigation, and near-Earth object defense. The white paper, however, says relatively little about international cooperation and coordination of efforts to address these issues, though it does call on all countries to "carry out in-depth exchanges and to cooperate in outer space."[36]

With Russia, China has jointly proposed the Treaty on the Prevention of the Placement of Weapons in Space. It has been on the table since 2008 and still suffers from the same loopholes it contained when first proposed. It ignores the threat of ASAT weapons based on the ground, of which China deploys many, and provides no viable means of certification of compliance. Some US observers see the proposal as a move in China's strategic competition with the United States aimed at blocking the United States from deploying missile defense interceptors in space, which has worried both China and Russia for many years, even though the concept suffers from major deficiencies. In late 2020, China and Russia jointly sponsored a resolution in the UN General Assembly First Committee calling for "no first placement of weapons in outer space"; the United States did not support the resolution on a number of grounds, but it was nonetheless adopted by the committee. Advertising its provenance, the resolution refers to a "community of shared future for humankind," a concept promoted by China in international fora.[37]

Although China is encouraging the development of privately capitalized space companies, China's space activities are principally conducted by its military through state-owned enterprises focused on defense. Its space administration, the CNSA, falls under the State Administration for Science, Technology, and Industry for National Defense.[38] Beijing seeks to integrate relevant advances in its technological and operational capacity in the civilian arena into its military capabilities through what it currently calls "military civil fusion" (MCF, 军民融合). The goals of MCF in technological development and innovation are to produce advanced technologies that have both military and commercial applications and to increase interactions between commercial firms and the Chinese military.[39] The State Council's 2017 document laying out its "opinions" on the development of MCF highlighted space as a key area for accelerated development.[40] The document calls for strengthening coordination in space, including accelerating the construction of "space infrastructure" to meet military and civilian needs. Among the specific programs the document lays out are heavy-lift launch vehicles, nuclear-powered space equipment, deep-space exploration, and in-orbit service and maintenance systems for space vehicles.

A 2019 defense white paper notes that the PLA Air Force is "accelerating the transition of its tasks from territorial air defense to both offensive and defensive operations, and improving its capabilities for strategic early warning, air strikes, air and missile defense, information countermeasures, airborne operations, strategic projection, and integrated support."[41] China is developing a variety of offensive counterspace capabilities. In addition to kinetic energy DA-ASAT weapons, these include electronic warfare through a variety of jamming techniques, offensive cyberspace capabilities, directed energy weapons, and direct engagement of adversary satellites through capabilities to execute grappling and remote proximity operations (using extendable arms to physically interact with a target satellite to repair or refuel the satellite for peaceful purposes or, as a weapon, to damage or destroy it—a true dual-use capability).[42] In recent years, Beijing has been cooperating more closely with Moscow, which brings its own expertise in a number of these areas to the table.[43]

FIGURE 1.

Highlights of US-China space diplomacy

1992
NASA signs an agreement with the Chinese Academy of Sciences for Earth Science Research; the agreement was amended in 1996 and renewed in 2002 and 2005.

November 2004
NASA sponsors an “international exploration workshop”; China National Space Administration representatives attend and make a courtesy call on NASA Administrator Sean O’Keefe.

September 2006
NASA Administrator Michael Griffin visits China, the first visit by a serving NASA administrator.

May 2014
The China Satellite Navigation Office and the State Department’s Office of Space and Advanced Technology establish the US-China Civil GNSS (Global Navigation Satellite Systems) Cooperation Dialogue.

September 2015
The first US-China Civil Space Dialogue is held in Beijing.

November 2015
The United States and China establish a “hotline” between the US Joint Space Operations Center and the Beijing Institute for Telecommunications and Tracking.

May 2016
The first US-China Space Security Exchange is held in Washington, DC.

September 2016
Presidents Barack Obama and Xi Jinping discuss space cooperation at a bilateral meeting held on the side of the G20 Leaders’ Summit in Hangzhou, China.

October 2016
The second US-China Civil Space Dialogue is held in Washington, DC.

December 2016
The second US-China Space Security Exchange takes place in Beijing.

November 2017
The third US-China Civil Space Dialogue is held in Beijing.

December 2017
The China Satellite Navigation Office and the Office of Space and Advanced Technology sign a joint statement on civil signal compatibility and interoperability between the BeiDou Navigation Satellite System and the Global Positioning System (GPS).

June 2019
US Deputy Assistant Secretary of State Thomas DiNanno travels to Beijing for meetings focused on outer space security, international security, and arms control.

US-China Relations in Space

Chinese scholars who work for state-affiliated think tanks and universities view space as a critical arena for US-China strategic competition. One scholar characterizes interactions between China and the United States in space as a "game" (博弈) that is an extension of US-China competition on the ground.[44] Others have described the US-China space relationship as playing an important role in the two countries' security dilemma, contending that key drivers of Chinese insecurity are what they view as US quests to achieve space dominance and to develop an effective space-based missile defense system—two concerns echoed in official Chinese statements.[45] While acknowledging that Chinese developments in space capabilities have given rise to concerns in the United States, other Chinese experts contend that China's activities are primarily a response to perceived threats posed by the United States and a key step toward ensuring China's national security.[46] One common perspective among university and think tank experts who advocate the expansion and resumption of dialogues on space issues between the two countries is that mutual mistrust and suspicion are key barriers to the relationship.[47]

Many of the same concerns are echoed by US scholars and analysts, albeit generally with a view that China, not the United States, is the source of instability in space and thus a threat to US national security. US analysts point to Chinese actions that imply a counterspace strategy that seeks to deny the United States its current space superiority and targets the critical role of space in US military capabilities. For example, with multiple treaty commitments and partnership agreements in Asia, the United States is highly dependent on a broad array of satellite systems to support its defense commitments in the region. China has developed a space force structure to take advantage of this dependence and potentially weaken the United States' ability to defend its allies in the Indo-Pacific should war break out there. US observers assess China's growing capacity to degrade and destroy the space capabilities of its adversaries and the rising likelihood that China will achieve "disruptive breakthroughs in space technology" as critical risks to US security.[48]

US-China relations in space have been complicated ever since the "father of Chinese rocketry," Qian Xuesen, was deported to China from the United States in 1955 during the McCarthy era. This action undoubtedly accelerated China's development of advanced rocket technology (see page 13).

The United States and China have never cooperated closely on issues relating to outer space, and China has developed space capabilities largely without interaction with the United States. One exception to this rule was a 1992 agreement between NASA and China's Academy of Sciences to engage on a limited set of project activities, which was renewed several times.[49] Since 2011, however, bilateral interaction on space technology has been sternly discouraged by the United States. A law passed that year championed by Congressman Frank Wolf, then chairman of a key House appropriations subcommittee, prohibits NASA and the White House Office of Science and Technology Policy from engaging in direct bilateral cooperation with China or China-affiliated organizations without explicit authorization from Congress and the FBI. The

The US Roots of Chinese Rocketry

A Chinese national who came to the United States as a graduate student in 1935, Qian Xuesen co-founded the world-famous Jet Propulsion Laboratory (JPL) at the California Institute of Technology. He was recruited into the US Army and made a full colonel so that he and his mentor and JPL co-founder, Theodore von Karman, could be sent to Germany in the closing days of World War II to debrief Werner von Braun and his top rocket scientists and to recruit German scientists for the US missile program.[a]

Starting in the late 1940s, at the beginning of the McCarthy era, the US government and the Ku Klux Klan alleged Qian harbored Communist sympathies, even though his father-in-law was a general in the Nationalist Army, which fought against the Communists in China's civil war, and his mentor, von Karman, was a staunch anti-Communist. Stripped of his security clearances and held under house arrest for five years, Qian was ultimately deported to China in 1955.

While the evidence on Qian's alleged Communist sympathies remains unclear, there is no doubt that his deportation gave a huge boost to China's missile design and development capabilities. The then undersecretary (and later secretary) of the Navy, Dan Kimball, who had defended Qian and had tried for several years to keep him in the United States, commented on Qian's treatment: "It was the stupidest thing this country ever did. He was no more a communist than I was, and we forced him to go."[b]

After Qian's return to China, he was put to work on China's atomic bomb project and eventually became the father of the Chinese missile program, which constructed the Dongfeng family of ballistic missiles and the Long March family of space launchers. Qian's deportation likely made it possible for China to deploy its CSS-4 intercontinental ballistic missile years sooner than it otherwise would have been able to. Perhaps of even greater significance, Qian helped train the next generation of top Chinese rocket scientists, which continues to benefit China to this day. He died in Beijing in 2009.

Notes:

a. Rebecca Grant, "Our German Scientists," *Air Force Magazine*, November 22, 2016, www.airforcemag.com/article/our-german-scientists.

b. Iris Chang, *Thread of the Silkworm* (New York: Basic Books, 1996), 200. Chang's book provides a detailed account of Qian's life.

"Wolf Amendment" was inspired in part by a report that had suggested that technical information provided by US commercial satellite manufacturers in China in the late 1990s could have been used to improve Chinese missile technology.[50] Significant improvements in China's launch reliability since the 1990s (from 70 percent to 95 percent today) have been attributed to the alleged improper transfer of technology.[51]

However, the space policy and technical environment today is far different than that of the 1990s: US-China strategic tensions are far higher, with limited opportunities for interaction on space issues; and China's space technology prowess is far greater than it was then. Those changes—and the ones highlighted in the following section—underscore the pressing need for more, not less, communication and cooperative effort. This task is made more difficult by the domestic policies in both countries.

Nevertheless, there is recognition in Beijing and Washington that there are potential advantages to closer communication. This is illustrated by the fact that there have been ongoing efforts to engage in bilateral dialogues on space, especially in the last decade (see figure 1 on page 11). That this has occurred when the US-China relationship has become increasingly strained illustrates the recognition in both Beijing and Washington of the potential advantages of communication. The Obama administration, for example, began efforts to improve bilateral communications on civil space issues and established a "space hotline" in November 2015 to avert potential satellite collisions and to exchange information on approaches or tests.[52] It also presided over the initiation of both civil and security space exchanges. The civil space dialogue continued under the Trump administration, albeit with only one additional meeting taking place despite attempts by the State Department to hold another.[53]

Such dialogues have not resumed under the Biden administration. China, in a February 2022 Foreign Ministry press briefing, claimed that it is ready to establish "a long-term communication mechanism" with the United States.[54] However, this assertion stems from a point of controversy between the United States and China that began with China submitting a note verbale to the United Nations stating that its space station had to conduct evasive maneuvers to avoid collision with American-owned SpaceX Starlink satellites in July and October 2021.[55] According to the Foreign Ministry, after these incidents, Chinese authorities attempted to contact the United States via email multiple times but did not receive a response.[56] A note verbale submitted by the United States stated that it was "unaware of any contact or attempted contact" from China and did not find that the Starlink satellites' activities met the threshold requiring emergency notification to China.[57] US industry experts and government officials have also commented on the difficulty of getting in touch with the Chinese side.[58] Such challenges illustrate the high level of mistrust and the low level of contact between the two sides and further emphasize the need to address barriers to communication to prevent potential accidents and related escalation.

US-China Relations and Priority Issues for Space Stability

Among the many space-related issues that would benefit from more interaction between the United States and China and between other spacefaring countries, three stand out:

1. Entangled conventional and nuclear space sensor systems
2. The risk of debris from DA-ASAT testing
3. The rapid growth in large and very large constellations of satellites

Each is a driver of instability in space carrying risks for global security—and each requires urgent action. The following section explores these challenges and risks, followed by a discussion of immediate actions that may be taken to address them.

ENTANGLED CONVENTIONAL AND NUCLEAR SPACE SENSOR SYSTEMS

Nuclear entanglement is a critical but largely unnoticed challenge to strategic nuclear stability. It occurs when the nuclear capabilities of a state become deeply intertwined, or "entangled," with the state's nonnuclear capabilities. One specific space-related danger is posed by the entanglement of US strategic nuclear warning and intelligence support to conventional warfighting missions using the same satellites. This could lead to an inadvertent escalation of a US-China conventional conflict into the nuclear domain were China, as part of its conventional military response or deterrence, to attack this key part of the United States' nuclear infrastructure. The United States may interpret such action as a prelude to a nuclear attack, and respond with a nuclear strike of its own.

Before 2007, this sort of entanglement was not a matter of much concern for the US and allied militaries when it came to China. That was principally because China had not yet demonstrated its ASAT capability. PLA counterparts have offered little in the way of reassurance regarding US concerns conveyed to China about the implications of targeting these vital components of America's strategic nuclear architecture. Their message has been that systems used to support conventional military conflict cannot be considered off-limits for targeting.

The Chinese 2007 ASAT test showed that China could, at some point in the future, conduct close approach missions to satellites in geosynchronous orbit (GEO). The test further demonstrated that China could attack US early warning missile launch detection satellites. In a purely nonnuclear conflict, China would normally not want to attack the US nuclear infrastructure. That said, if part of that infrastructure was being used to enable the United States to shoot down conventionally armed Chinese missiles, China could well choose to attack those infrastructure elements.

China's position has been that a US use of strategic nuclear satellite assets in a purely nonnuclear role would make them legitimate targets of Chinese anti-satellite actions. This suggests that, in the event of a conventional conflict between the two nations, the United States must be prepared for potential Chinese attacks on an essential part of the US strategic nuclear infrastructure. The 2018 Department of Defense Nuclear Posture Review explicitly stated that the United States could employ nuclear weapons in response to "attacks on US or allied nuclear forces . . . [or] warning and attack assessment capabilities."[59] This implied that an adversary attack on overhead persistent infrared assets (early warning) could trigger a US nuclear retaliation if the US adhered strictly to its policy. The Biden administration's 2022 Nuclear Posture Review is not as explicit on this point and emphasizes "risk reduction to strengthen stability," but does not eliminate a potential entanglement scenario.[60]

Likely future developments posit even more alarming scenarios. A case can be made that the infrared remote sensing constellation is the most entangled nonnuclear military capability linked to the US strategic nuclear triad. With the goal of enhancing the resilience of US strategic early warning capabilities in the event of possible attack, the Defense Department is seriously considering constellations of disaggregated launch detection satellites (LDS) in low Earth orbit (LEO). Although this overall architecture would be more resilient and less vulnerable, an attack on these satellites could still risk triggering a US nuclear retaliation.

THE RISK OF DEBRIS FROM DA-ASAT TESTING

There are now four countries with tested DA-ASAT capabilities: China, India, Russia, and the United States. Testing such ASAT capabilities has been a significant source of space debris. China's January 2007 test was estimated as responsible for one-sixth of trackable space debris even nine years later; that debris will endanger satellites for decades to come.[61]

In an actual conflict, many satellites could be attacked by DA-ASAT weapons, which would lead to a vast increase in orbital debris. As a consequence, important orbital regimes, particularly at low- and mid-level orbits, could be rendered functionally unusable.

To date, China has adopted a defensive posture with respect to its ASAT test and to DA-ASAT testing and space debris in general. Some experts have sought to justify the 2007 ASAT test on the grounds that the current space regime lacks clear regulations on space debris and what constitutes "harmful contamination."[62] In the aftermath of the launch, many Chinese analysts contended that a key motive for the test was "peaceful," aimed at encouraging the United States to undertake space arms control.[63]

THE RAPID GROWTH IN LARGE AND VERY LARGE CONSTELLATIONS OF SATELLITES

In the commercial arena, with numerous space companies proposing to put into orbit large and very large satellite constellations, there is broad understanding that their size would heighten the risk of collisions between satellites, which in turn risks considerable debris. State-owned and privately owned Chinese space companies have plans to put large and very large constellations in space and have filed applications with the International Telecommunications Union (ITU), which allocates orbital slots in GEO and makes sure the operation of satellites in low Earth orbit does not interfere with satellites operating in GEO. For example, Chinese company SatNet has signed an agreement with the Shanghai local government to provide broadband satellite coverage using 13,000 LEO satellites.[64] But Chinese companies are just a few among myriad others with plans for large satellite constellations.

Perhaps the best known of these filings with the ITU was made in 2021 by the government of Rwanda, which proposed orbiting two constellations with a total of 327,230 satellites (with additional plans increasing the number to 337,323 satellites as of January 2023).[65] The Canadian company Kepler filed a proposal for a constellation of almost 115,000 satellites, a much smaller total than the Rwanda filing but one that greatly exceeds all operational satellites in orbit today.[66] There are reports that Starlink may construct constellations comprising as many as 42,000 satellites, with current plans laid out for 34,396 satellites.[67] Figure 2 shows these and other significant proposals, which together would put more than half a million satellites in orbit; these numbers are frequently changing as commercial interest expands.[68]

An analysis by Aerospace Corporation, a research and development center funded by the US government, of the implications on the global debris environment suggests that if just two or three of the plans for large and very large constellations are realized by the late 2020s, the number of collisions will increase tenfold or more, and the number of "close-approach warnings" issued each day will exceed 25,000.[69]

A critical problem [of a rapid increase in the number of satellites in Earth orbit] is that there is no international entity responsible for assessing the impact the constellations will have on a functional space environment.

A critical problem is that there is no international entity responsible for assessing the impact the constellations will have on a functional space environment, much less an entity that can perform a clearinghouse role to help coordinate orbit selection. The ITU's primary function is to manage radio-frequency spectrum interference and it has no regulations (or expertise) that address orbital congestion. The ITU is also a coordination body and does not have strong inherent regulatory powers (those are reserved by national administrations).

Some US agencies, including the Federal Communications Commission, have started addressing the orbital debris and congestion challenges from large constellations, but their work is still nascent, while thousands of satellites have already been launched. A September 2022 report by the Government Accountability Office highlights the need for more research to mitigate the environmental impact of large constellations of satellites.[70] Moreover, a broader interagency examination of the problem has also been hindered by lack of concrete authority as to which agency provides this type of oversight. Some industry leaders are calling for international efforts to craft rules to mitigate this looming risk while urging all actors to take greater responsibility for the impending crisis.

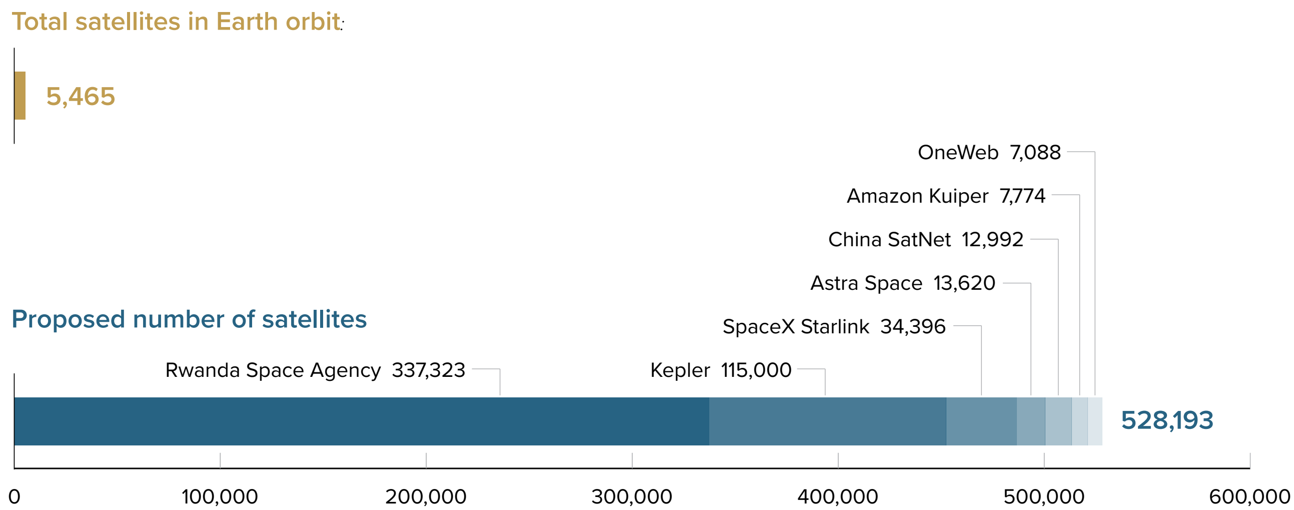
The problem of congestion in the near-Earth orbital environment is not limited to the advent of large and very large constellations of satellites; other contributing factors include on-orbit servicing and refueling, increased maneuvering, and the prospect of a boom in space tourism.[71] The concept of a space traffic management (STM) regime has long been discussed, but no agreed-upon template for a regime has yet to emerge.[72]

The subject of STM has prompted a variety of opinions from Chinese experts. Some observe that the growth in space actors and activities has increased the complexity of space governance around issues including STM.[73] Others also note that the international STM discussion remains focused on principles and has not included substantive questions of law or institution building.[74] In terms of promoting international dialogue, some Chinese commentators take a more passive perspective, adopting the view that the rapid development of large and very large constellations in low Earth orbit will inevitably accelerate the international community's discussion on space traffic coordination and rules of governance.[75] Yet other Chinese experts point to the United States as the main obstacle to the international community building multilateral governance mechanisms, given that the United States has opposed agreements that have reached consensus in multilateral platforms such as the United Nations.[76] Still others criticize US efforts on STM as seeking to shape international STM with American standards and promoting US security exceptionalism.[77] The Chinese government itself, in its January 2022 white paper, for example, has expressed interest in participating in dialogues and in the development of mechanisms on international issues such as STM.[78]

Related to the formulation of an STM regime is the regulation of rendezvous and proximity operations (RPOs), which provide key services such as on-orbit servicing and debris mitigation but also have military and intelligence capabilities. The issue of noncooperative RPOs also needs to be addressed. The UN's Committee on the Peaceful Uses of Outer Space (COPUOS) first attempted to establish guidelines on proximity operations in 2018, but Russia blocked

FIGURE 2.

Partial list of announced satellite constellations



Source: Union of Concerned Scientists Satellite Database, www.ucsusa.org/resources/satellite-database (satellites in orbit as of April 30, 2022); Jonathan's Space Report, "Enormous ('Mega') Satellite Constellations," www.planet4589.org/space/con/conlist.html (proposed satellite constellations of 7,000 or more satellites as of January 16, 2023); and Jeff Foust, "Satellite Operators Criticize 'Extreme' Megaconstellation Filings," SpaceNews, December 14, 2021, www.spacenews.com/satellite-operators-criticize-extreme-megaconstellation-filings.

their inclusion in the Guidelines for the Long-term Sustainability of Outer Space Activities that COPUOS issued in 2018.[79] Still, RPOs continue to be brought up in UN discussions on space sustainability. For example, in a May 2022 submission to the open-ended working group (OEWG) on reducing space threats through norms, rules, and principles of responsible behavior, China called for the suspension of RPOs that endanger other countries' spacecrafts and criticized US operations.[80] China's RPOs have focused on its own satellites rather than those of other nations.[81] Nevertheless, US experts have expressed concern over China's RPOs and Beijing's lack of willingness to establish proximity guidelines.[82] Notably, China voted against the UN resolution in December 2021 establishing the OEWG on responsible behaviors in space.[83]

It should be noted that the growing number of satellites may not only threaten space operations but also has implications for US-China strategic competition. A paper published in April 2022 by Chinese military researchers argued that Beijing needs to develop anti-satellite capabilities to monitor Starlink satellites and be able to "disable or destroy" them if they threaten China's national security. Rising US-China tensions and concerns over the military applications of satellite systems may provide additional impetus for China to advance construction of its own internet satellite networks, such as StarNet, which the United States might deem a military target in a conventional conflict, prompting China to take countermeasures and thus initiating a spiraling threat to space stability.[84]

Conclusion and Recommendations

The evolution in space capabilities is ushering in an extraordinarily dynamic but uncertain era in which both domestic and international policymaking is hard pressed to keep up with technical advances in the field.

Spacefaring powers and space stakeholder countries must take urgent action to address the implications of this surge in space technology before major problems ensue in the economic and military dimensions of the space domain. Dialogue and efforts to address issues of joint concern among space powers have never been more needed.

As two of the world's three most formidable space powers, the United States and China have both incentives and opportunities to promote this sort of communication and collaboration. Currently, however, the two countries are locked in a mistrustful relationship, exemplified by the 2011 US law placing limits on dialogue with China on technological issues in space. It would appear worthwhile for US policymakers to review whether national security concerns about restricting the transfer of space-related technologies to China might be better served by focused restrictions than by a broad prohibition on dialogue with China on important space issues. For instance, the United States could work on some aspects of space technology and policy with China where there are opportunities for mutual benefit while consciously avoiding sensitive areas and reinforcing US national security interests. Interactions with China could also provide important insights into the directions Chinese space planning is taking. The US-Soviet Apollo-Soyuz project that led to a joint mission between the United States and Soviet Union in 1975—the first international crewed space mission—showed it is possible to cooperate in space with a sophisticated adversary without losing vital secrets to that rival.

Although China poses a challenge to US and allied interests in space, overlapping interests still exist, despite differences in perspective. For example, space debris is indiscriminate about whose satellite it crashes into. Both sides have an interest in more efficient space traffic management in an ever more congested environment. And neither side wants to witness the inadvertent escalation of conventional conflict into a nuclear war.

Unilateral, bilateral, and multilateral action to tackle these three drivers of instability should take various forms and encompass not only dialogue but also concrete steps that build on unilateral measures and on one another.

DISENTANGLING CONVENTIONAL AND NUCLEAR THREAT DETECTION SYSTEMS

The entanglement of US conventional and strategic nuclear warfighting launch detection missions has the potential, especially in the absence of US-Chinese strategic stability talks, for inadvertent escalation of a US-China conventional conflict into the nuclear domain.

The United States should develop space architectural options to disentangle its strategic nuclear launch detection mission architecture from its conventional mission architecture. The United States and China should also discuss this issue as one part of a strategic stability dialogue, although China has been reluctant to engage in such talks to date.

A first step is to recognize the implications of the LDS modernization architecture for larger strategic stability issues and for such issues to be accorded a proper role in the design of tomorrow's launch detection/early warning architecture. Any architecture that has the inadvertent effect of increasing the likelihood of adversary attacks against that strategic LDS would have to be looked upon as seriously deficient. A US president must not be placed in the excruciating position of needing to back up the credibility of US nuclear deterrence by initiating escalation into nuclear conflict or damaging that credibility by not doing so. There are other dimensions of nuclear entanglement that should be addressed as well, but this nuclear command control dimension is especially problematic and cannot safely be ignored.

It would be useful for the Department of Defense to describe what steps are available to reduce the level of entanglement of US strategic nuclear C3I assets in nonnuclear missions so as not to risk inadvertent escalation of a nonnuclear conflict with China to the nuclear level. Such a move would make an important contribution to reducing space strategic instability between the United States and China and avoiding an unnecessary threat to the credibility of the United States' extended deterrence pledge to its allies.[85]

CREATING A MORATORIUM ON DA-ASAT TESTING

A second concern addressed in this report is the widespread use of DA-ASAT weapons, which are operational in the PLA's arsenal of ASAT weapons, in a possible conflict between China and the United States. Use of these weapons has the potential to make important swaths of orbital space unusable—with devastating consequences for the future of the space domain.

China should take rapid steps to phase out its arsenal of DA-ASAT weapons if it wants concerns expressed in its white papers about space debris to be taken seriously. There is an opportunity to build on the United States' April 2022 announcement of a unilateral, voluntary moratorium on destructive testing of DA-ASAT weapons.[86] Although the United States has not tested DA-ASAT weapons since 2008, the moratorium is a bold step aimed at winning new international supporters of the policy. The US moratorium does not forswear testing of all ASAT weapons; electromagnetic- and laser-based ASATs, among other types, are not affected by this moratorium, and the announcement says nothing about wartime use of DA-ASATs or any ASAT weapons. Yet it is a noteworthy first step in what could be an important series of steps toward a more sustainable space environment. Nine other countries have committed to their own self-imposed bans.[87] A next phase of steps would be to encourage these same countries to accept a moratorium on deployment of DA-ASAT weapons, again with the theme of maintaining a sustainable space environment. Formal negotiations on an agreement would further continue this process.

The United States' DA-ASAT moratorium also opens the door to discussion of, and perhaps negotiation and introduction of, other space sustainability–enhancing measures and best practices, such as managing congested space traffic.

In October 2022, the United States on behalf of itself and 10 other states, brought a draft resolution titled "Destructive Direct-Ascent Anti-satellite Missile Testing," to the United Nations.[88] The resolution was adopted by the First Committee on November 1 (154 in favor, with 8 against and 10 abstentions) and then by the General Assembly on December 7 (155 in favor, with 9 against and 9 abstentions).[89] China was among the countries that opposed the resolution. According to China's representative to the First Committee, China voted against the resolution on the grounds that it failed to place adequate constraints on the US-led space strategy, raising questions about Washington's motives for pursuing it.[90] The resolution calls for continued discussion in relevant bodies and the development of "further practical steps."[91]

REGULATING LARGE AND VERY LARGE CONSTELLATIONS

This report also examined the threat that the rapid and largely unregulated growth in the projected number of satellites poses to space security. Although benign in origin, the growing number of satellites in orbit could be destructive to the future of commercial and other forms of space applications and operations if mismanaged.

The US government should direct the National Academy of Sciences to conduct a study of the implications of large and very large constellation satellite growth. The government should also launch an interagency study of options to address this problem on a priority basis.

Both China and the United States should undertake urgent steps to regulate the numbers of satellites at various orbital altitudes that agencies and organizations of their respective countries approve or license, ensuring those steps are consistent with the best scientific and engineering knowledge available.

The United States should pursue a multi-stakeholder dialogue with China and other space actors to encourage the development of a regime to avert uncontrolled competition that could disrupt the space orbital environment and threaten to render it unusable. Space actors should strive to create a coordination mechanism that ensures that the continued viability of Earth orbital regimes is not endangered by satellite constellations, potentially modeled on the success of the ITU's allocation of satellite orbital slots in GEO.

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Action on these three issues is urgently needed. A growing number of countries have joined the United States in announcing they will not test DA-ASAT weapons. China has given no hint that it will follow suit; moreover, the UN resolution on destructive DA-ASAT testing is not binding, calling only for countries to commit to not conduct destructive tests. With the United States planning to upgrade its satellite early warning architecture, it has the opportunity to ameliorate the challenge of nuclear entanglement, a step it would be wise to seize to strengthen strategic stability in space. Perhaps the best prospects for immediate progress lie with the need to develop guidelines and regulations for large and very large constellations of satellites. Even commercial satellite companies are concerned about this problem, and in the near term it would appear to have the most impact on US companies. Moreover, given the acknowledgment by Chinese actors of the need for international cooperation on space traffic management, this could be a potential area for fruitful cooperation. Exploratory discussions among spacefaring nations would reveal whether this problem could be addressed relatively quickly, or whether extensive negotiations would be required.

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