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# Chinese Space Strategy and Developments

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## CHINESE SPACE STRATEGY AND DEVELOPMENTS

Competition in space is not a new phenomenon. The Space Race between the Soviet Union and United States was one of the defining aspects of the Cold War era. While astronauts are no longer national celebrities and media coverage has greatly diminished, competition in space remains fierce. The United States, China, Russia, Europe, and numerous others all seek to use outer space in a way that best forwards national interest.

China, in particular, has substantially increased its outer space efforts and capabilities in the post-Cold War era. China's 2015 Defense White Paper refers to space as the "commanding height in international strategic competition",<sup>1</sup> and its commitment to active programs further underlines this strategic development. China already possesses advanced space-based C4ISR capabilities, a growing fleet of modern launch vehicles, the BeiDou satellite navigation program comparable to U.S. GPS, an array of counterspace and ASAT weapons (kinetic-kill, directed-energy, co-orbital, and cyber), and an advanced manned space program.

Developing more advanced programs is a key aspect of China's military modernization efforts. Any assessment of China's goals and program in space must be considered within the broader framework of its other substantial military reforms which all represent a move towards fighting modern "informationized" wars. "Informatization" has been doctrinally enshrined by the PLA since 1993 and arose from PLA strategists after observing what they believed to be paradigm shifting success of U.S. forces during the 1991 Gulf War.<sup>2</sup>

Key aspects of informationized warfare like communications and technological dominance, long-range precision strikes, C4ISR, anti-access anti-denial (A2/AD), and joint force integration are impossible without substantial and varied space capabilities. Thus, China's stated goal of "'major progress' towards informatization by 2020"<sup>3</sup> is reliant on advancing its space capabilities. Consequently, Chinese involvement and subsequent competition in space is unlikely to slow as China moves forward.

Indeed, it has already become a major area of competition between China and the U.S. While outer space has many peaceful uses, the continued competition in space between the United States and China adds a new dimension to their de facto arms race. In fact, some high-level military officials on both sides have stated that the militarization of space is inevitable.<sup>4</sup>

It is also a competition with many uncertainties and risks of further escalation. The relationship between the Soviet Union and the United States during the Cold War Space Race may have been more unstable, but current competition between the U.S. and China has broader military and civil implications. Global space infrastructure has been consistently built up over a long period of time, and substantial destruction would not be quickly repaired. Both the civilian and military world rely substantially more on space assets than during the Cold War. The debris created by even minimal kinetic space conflict has the potential to be devastating—not only for military capabilities like ISR, missile guidance, and operational communication—but also for staples of

modern daily life like telecommunications, television, weather tracking, the Internet, GPS, and scientific research.<sup>5</sup>

Additionally, the impact of space militarization and warfare remain a strategic question mark. While space competition is still often seen in terms of nuclear deterrence and strategic stability, space capabilities have gained such outsized importance to modern militaries, that a successful first strike in space is likely to disproportionately favor the weaker party, particularly if it comes without warning. Furthermore, a first strike could severely inhibit the attacked party's ability to react to any form of asymmetric, conventional, or nuclear attack.

In the case of nuclear forces, deterrence is not the sole reason for the avoidance of nuclear warfighting, but it is a critical one. As long as a war in space can affect the outcome of a major nuclear exchange, and the space capabilities of each side do not have a matching level of deterrence, conflict becomes more likely. Moreover, the lack of an accepted code of international law regarding space conduct further fuels uncertainty for states involved in spacefaring.

As a result, finding ways to mitigate the advantages of a first strike in space and maintain the ability to respond have become key tenets of 21st century deterrence and strategic stability.<sup>6</sup> Many of the future aspects of space competition, conflict, and warfare remain uncertain. However, China has made developing an advanced space program a key priority and space capabilities are a key part of the strategy and function of all branches of the PLA. Consequently, analyzing the organization and capabilities of China's space program, and seeking to assess Chinese motivations and strategy, have become critical aspects to understanding and assessing China's military.

## *Chinese Space Strategy*

In November 2009, the current Vice Chairman of the CMC, General Xu Qiliang, said that space is the "new commanding height for international strategic competition...[and] means having control of the ground, oceans, and the electromagnetic space, which also means having the strategic initiative in one's hands."<sup>7</sup> Once again, China views the space program as paramount in fighting "informationized" wars.

"Informatization" has become somewhat of a catch-all term in Chinese discussions of modern warfare. It is clear, however, that China's defense strategists have drawn on the advanced American military battle management; intelligence, surveillance, and reconnaissance (ISR), stealth, and precision strike capabilities that emerged in the 1990's in the First Gulf War and in the conflict in the Balkans, to develop their own concepts and strategy.

While understanding "informatization" as a key organizing principle of the People's Liberation Army (PLA) is valuable, this makes a more targeted definition important. James Mulvenon provides the following explanation of what the Chinese mean when they talk about information warfare:<sup>8</sup>

Chinese writings clearly suggest that information warfare (IW) is a solely military subject, and as such, they draw inspiration primarily from U.S. military writings. The net result of this "borrowing" is that many PLA authors' definitions of IW and IW concepts sound eerily familiar. For our purposes, therefore, we

shall use the definition of information warfare found in Joint Pub 3-13, *Joint Doctrine for Information Operations (IO)*:

Information operations conducted during time of crisis or conflict to achieve or promote specific objectives over a specific adversary or adversaries.

“Information operations” are defined in Joint Pub 3-13.1, *Joint Doctrine for Command and Control Warfare (C2W)* as:

actions taken to achieve information superiority by affecting adversary information, information-based processes, information systems, and computer-based networks, while defending one’s own information, information-based processes, information systems, and computer-based networks.

More concretely, the Army in FM-100-6 *Information Operations* defines “information operations” as

continuous military operations within the military environment that enable, enhance, and protect the friendly force’s ability to collect, process, and act on information to achieve an advantage across the full range of military operations; information operations include interacting with the global information environment and exploiting or denying an adversary’s information and decision capabilities.

The goal of these operations is “information dominance,” or

The degree of information superiority that allows the possessor to use information systems and capabilities to achieve an operational advantage in a conflict or to control the situation in operations short of war, while denying those capabilities to the adversary.

By introducing these definitions, I am not precluding that the Chinese may eventually develop an indigenous IW strategy, and there is limited evidence of movement in this direction. Instead, these U.S. definitions provide a baseline by which to judge PLA writings.

This belief that space is the new strategic high ground stems from China’s “Space Dream” strategy as explained by President Xi Jinping, when he stated that, “the dream of space flight is an important part of the strong country dream [and] the space dream is an important component of realizing the Chinese people’s mighty dream of national rejuvenation.”<sup>9</sup> It has become a key element of the strategy that seeks to transform the Chinese military toward one of information superiority under the Local Wars concept.

The US-China Economic and Security Review Commission describes the growing importance of space-based programs in the PLA’s strategy as follows:<sup>10</sup>

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

In assessing China’s space strategy, it is important to note that although various civilian entities are involved in China’s the space program, policy is almost entirely controlled by the PLA. China is focusing on expanding its own space-based systems in ways that will enhance its deterrent, missile, and other military capabilities. The Party leadership has also emphasized such

activities as long-range missiles and other aerospace programs in its military modernization push along with its support of a major modern space program.

The November 2015 US-China Economic and Security Review Commission report notes that:<sup>11</sup>

Under this nebulous framework, even China's ostensibly civilian projects, such as human spaceflight, directly support the development of PLA space, counterspace, and conventional capabilities. Moreover, although any country's satellites are capable of contributing to its military operations, the PLA during wartime would probably take direct command over all Chinese satellites.

Consequently, it is important that the decision making process regarding China's space program be assessed with the objectives of the PLA and CCP in mind.

### **Value of Space Program for Global and Internal Legitimacy**

A modern and expansive civil space program remains a totem of international prestige. In many ways the U.S. still draws upon its accomplishments during the Cold War competition in space. However, manned space travel has lost some of its appeal for the United States and Russia. This is reflected in the ongoing five-year U.S. gap in manned spaceflight following the retirement of the Space Shuttle and consistent NASA budget shortages.<sup>12</sup>

However, a manned space program remains a key goal for a rising power like China. On March 15, 2003, China became only the third country to independently launch a manned mission into space when its Shenzhou 5 successfully put taikonaut<sup>13</sup> Yang Liwei into orbit for over 20 hours.<sup>14</sup> China has since continued its manned space program and launched an additional nine taikonauts into space through its Shenzhou program.<sup>15</sup> China has traditionally relied on its manned Shenzhou spacecraft, capsule-based vehicles. It would also appear that China is in the test-flight stages of a new Shenlong space plane, a drone that is similar to, though less capable than, the U.S.' X-37B.<sup>16</sup>

Early in 2012 the PRC achieved its first manned space docking at its space lab Tiangong-1. On September 15, 2016 China successfully launched its second space lab, Tiangong-2, into orbit.<sup>17</sup> Tiangong-2 will operate until China can achieve its stated goal of building a 60-ton space station for future missions by the year 2020. In 2013, China conducted the first "soft landing" on the moon since 1976 when it landed the Yutu rover. Additionally, China has and plans to launch a Mars rover in 2020.<sup>18</sup>

A 2014 report by James A. Lewis of the CSIS notes the importance that China now places on the technological prowess of its space program for the purpose of international prestige:<sup>19</sup>

Manned spaceflight demonstrates to China's neighbors the seriousness of China's claim to regional leadership and makes the point that under the party's leadership, China has arrived as a world leader. The manned space capsule Shenzhou 6 carried seeds from Taiwan in a symbolic assertion of China's sovereignty over the island. China sees its space programs as a strategic activity to gain political and military advantage, but the primary purpose of China's manned space program is political. For China, it is especially important to show that it has reclaimed its place among the leading nations of the world. China's successes in space reinforce its claims to regional dominance by demonstrating that it is the most advanced among Asian nations, with technology and resources that others cannot match.

Furthermore, as with all things related to China, prestige for the state cannot be separated from prestige for the Chinese Communist Party (CCP). The Party views a successful space program as another way in which it can emphasize its legitimacy not only abroad but also domestically. Kevin Pollpeter notes in his March 2015 report that:<sup>20</sup>

The space program's effect on prestige is also directed inward. The Chinese Communist Party (CCP) is now communist in name only, and its continued legitimacy is predicated on delivering economic and nationalistic benefits in an informal social contract with its citizens: the CCP agrees to increase the standard of living and develop China into an internationally respected country, and the people agree not to rebel. By developing a robust space program and participating in high-profile activities such as human space flight and lunar exploration, the CCP can demonstrate that it is the best provider of material benefits to the Chinese people and the best organization to propel China to its rightful place in world affairs.

James A. Lewis further states that:<sup>21</sup>

The manned space program also serves an important domestic political purpose by enhancing the legitimacy of the Communist Party.

China's leaders need and use manned spaceflight in a way that other nations do not, to reinforce the political legitimacy of the party and show the Chinese people the progress the party is making in restoring China's global position. This ensures that China's space program has greater political support by national leaders than is the case in other countries. President Xi's attention to and support of the Chinese manned program is unlikely to diminish because it forms a useful counternarrative for the image of the party, which has been injured by widespread corruption and public policy failures in environment, urban planning, and transportation.

Utilizing space — or any technological achievement — for international prestige is far from unique to China. Indeed, the U.S.-Soviet Union Space Race was tied closely to the broader race for prestige and influence that shaped the Cold War. However, the fashion in which the CCP now relies on technology and modernization for both strategic influence and domestic legitimacy has made it more important to China than other spacefaring nations like the United States, Japan or India.

### **Regional Power Projection**

Space also plays an important role in Chinese regional power projection, and Chinese power projection would be severely limited without the advances in its space program. Walter C. Ladwig of King's College London identifies nine elements of national power projection, splitting them between soft and hard power. On the soft power side, he includes securing sea lanes of communication, non-combatant evacuation operations, humanitarian relief, and peacekeeping. For hard power projection Ladwig adds showing the flag, compellence and deterrence, punishment, armed intervention, and conquest.<sup>22</sup>

While these are not all perfectly applicable to China, many fit well and are augmented by China's strong space capabilities. In terms of soft power, China has utilized its space-based capabilities often to project power. China has repeatedly deployed its various satellites to handle evacuations and disaster and humanitarian relief. The November 2015 US-China Economic and Security Review Commission report notes:<sup>23</sup>

According to Beijing, the Gaofen-1 "has been used in land resource investigation, mineral resource management, atmospheric and water environment quality monitoring, and natural disaster emergency response and monitoring," and its imagery has supported "tens of national ministries and agencies, local governments, research institutions, universities, enterprises and organizations in China." China also employed the Gaofen-1 to assist in the search for missing Malaysian airliner MH370 in 2014, demonstrating its ability to conduct broad maritime surveillance that could be useful for the PLA.

Furthermore, China has worked hard to secure sea lanes of communications not only in its backyard but abroad—as exemplified by its involvement in counter-piracy efforts in the Gulf of Aden. Monitoring and coordinating maritime operations is increasingly reliant on space-based

C4ISR. In the contested areas of South and East China Seas, Beijing has greatly increased satellite involvement.

Kevin Pollpeter notes:<sup>24</sup>

“Although Haiyang satellites are ostensibly used to monitor the ocean environment, a Chinese official has stated that the satellites can be used to monitor the disputed Senkaku/Diaoyu islands and Scarborough Shoal/Huangyan Island.”

China’s increased use of space-based capabilities on disputed maritime territories is an exhibition of its use of hard power in showing the flag. The technologically advanced PLAN continues to sail through Japanese waters near the Senkaku islands and blockade the Philippines from Scarborough Shoal, with the goal of projecting Chinese power.<sup>25</sup>

China has also used its array of space-based C4ISR capabilities to support its maritime militia made up of fisherman. China relies on this maritime militia to aggressively assert and protect its maritime claims. Simon Denyer notes an example of the space-dependent technology that the Chinese government has provided this militia in an April 2016 *Washington Post* article:<sup>26</sup>

Here, in the fishing port of Tanmen in the southern island of Hainan, 50-year-old captain Chen Yuguo was in the wheelhouse of his trawler last week, carrying out minor repairs after a six-week fishing trip to the disputed Spratly Islands.

A portrait of “Comrade” Mao Zedong hung in a place of honor behind him, alongside an expensive satellite navigation system supplied by the Chinese government. Chen said catches are much better in the Spratlys than in China’s depleted inshore waters, but the captain said he is also fulfilling his patriotic duty.

“It is our water,” he said, “but if we don’t fish there, how can we claim it is our territory?”

... The government is also pushing the fishermen further from shore. It provides fuel subsidies, with higher rates for bigger boats and journeys to the Spratlys. The Hainan government heavily subsidizes the construction of larger, steel-hulled trawlers, and an expensive satellite system was provided virtually free of charge to about 50,000 vessels.

China also relies heavily on space-based capabilities for both its nuclear and conventional missile targeting and compellence and deterrence. China has the world’s widest array of conventional missiles and a growing nuclear arsenal—including the recent MIRVing of its DF-5B ICBM. China sees its missile capability as a key for deterrence and thus for power projection.

At the tactical and local levels, space provides critical support to China’s ability to use Ladwig’s final three hard power elements of power projection—punishment, armed intervention, and conquest. For China, this means successfully being able to wage “informationized” war in the form of advance battle management and IS&R systems in joint war farce ranging from close-in battle to deep strikes and large-scale maneuver warfare.

### **Anti-Access/Area Denial (A2/AD)**

Implementing an anti-access (A2)/area-denial (AD) strategy is another key aspect of China’s focus on the “informationization” of warfare, and expanding its influence and warfighting capability in the Pacific and on regional level. While the Chinese do not refer such military capabilities as A2/AD, it is clear that this is a strategy to which their efforts are directed. A2/AD is essentially conventional counterforce targeting combined with restricting enemy access to a certain strategic location, thus ensuring that the opposition must engage from a further distance than optimal.

China's A2/AD programs rely on a mix of space-based systems including C4ISR and SATNAV (BeiDou) capabilities. China is relying on land and sea launch capabilities as well as sea-based systems that utilize "Long View" space support ships to perform tasks like monitoring and tracking space vehicles – such as spacecraft, missiles, and rockets – while also coordinating and communicating with ground-based assets. This system can increase space operations and situational awareness while also providing potential military applications.

China's focus on A2/AD stems from the internal assessment that their mostly likely warfighting scenario would center on Taiwan or their various maritime territorial claims. Given the potential for U.S. intervention—the only military force capable of matching China—the PLA believes it is of paramount importance to be able to deny and restrict US access to the battlefield. While the United States does have a substantial presence in the Asia-Pacific—in Japan, South Korea, Guam, amongst others—it is feasible that the China could effectively implement A2/AD. Especially considering the proximity of Taiwan and the various claimed islands to China's coastline.

Yet, actual A2/AD operations are extremely complicated. They require an advanced infrastructure across space, land, and sea, paired with either extensive large-scale combat experience or very demanding and realistic large-scale exercises. In assessing China's capabilities for A2/AD warfare, the 2016 edition of the U.S. Department of Defense report on Chinese military power addresses eight different aspects: information operations, cyber operations, long-range precision strike, ballistic missile defense (BMD), surface and undersea operations, space and counterspace, Integrated Air Defense System (IADS), and air operations.<sup>27</sup>

Nearly all of these are reliant on space capabilities in some fashion. As largely a counterforce strategy, A2/AD relies substantially on precise tracking and intelligence information. China needs to be able to locate and target, at long ranges, enemy aircraft carriers, ships, planes, submarines, and missiles all throughout the Pacific Ocean. This cannot be done without space-based assets. Both missile targeting and missile defense rely substantially on information only space satellites can provide.

One example of the importance of space for the success of China's A2/AD strategy is the land-based DF-21D anti-ship ballistic missile (ASBM). The DF-21D is the first anti-ship missile of its kind and presents a real threat United States naval capabilities in the Pacific. Andrew S. Erickson notes:<sup>28</sup>

The ASBM poses a direct threat to the foundations of U.S. power projection in the Asia-Pacific, potentially undermining U.S. influence there.

While U.S. airbases around China already are vulnerable to Chinese ballistic and cruise missiles, the ASBM targets the last relatively uncontested airfield without requiring China to develop the naval resources necessary to challenge the U.S. Navy directly at sea. For the first time since the 1920s, the United States faces a direct threat to a platform that has represented the core of its naval power projection: the aircraft carrier strike group. U.S. policymakers must face the possibility that Beijing might decide to use ASBMs in the event of conflict, and that the PLA might be able to strike and disable one or more aircraft carriers if countermeasures proved inadequate.

While the DF-21D offers China an unprecedented boost in implementing A2/AD, Erickson warns that despite numerous successful tests of the “hardware” the “software” C4ISR component is not yet reliable.

Other limits to China’s space-based capability are highlighted in by a July 2016 report from the RAND Corporation that wargames a potential China-U.S. conflict. In putting together potential war scenarios, RAND considers what the conflict would look like in both 2015 and 2025. The conclusion is that China needs time to focus on the kind of substantial technological advancements that could make a war in 2025 very different conflict from a conflict in 2015. RAND notes:<sup>29</sup>

The current rate of advances in military technology, especially in Chinese A2AD and in cyberwar and ASAT capabilities of both sides, implies a potential for major change in the decade to come, which dictates examining 2025 cases distinct from 2015 cases.

As of 2015, U.S. losses of surface naval and air forces, including disabled aircraft carriers and regional air bases, could be significant, but Chinese losses, including to homeland-based A2AD systems, would be much greater. Within days, it would be apparent to both sides that the early gap in losses favoring the United States would widen if fighting continued. By 2025, though, U.S. losses would increase because of enhanced Chinese A2AD. This, in turn, could limit Chinese losses, though these would still be greater than U.S. ones. It could be unclear then whether continued fighting would result in victory for either side.

ASAT capabilities are critical because the denial of information to the opponent is another key aspect of China’s A2/AD strategy. If China is to counter the current dominance of the United States in space-based C4ISR, it must focus intently on ASAT capabilities to insure battlefield information dominance. A major future war in in the Asia-Pacific might well involve Chinese ASAT attacks on US space capabilities through kinetic or cyberattacks, and avoiding this is equally critical to any US effort to implement effective A2/AD.

### **Anti-Access/Area Denial Sea-based Space Programs**

In a conflict, ship-based C4ISR capabilities could have advantages over ground-based installations. Again, Andrew S. Erickson provides a history and more in-depth description of the Chinese program. It began in 1965 with Premier Zhou Enlai and was further developed in the 1970s under Project 718. In order to support Chinese ICBM sea tests, the Yuanwang program was initiated, though it was delayed by subsequent political events. It was jointly designed and developed by the Seventh Academy of the Sixth Ministry of Machine Building, the Seventh Ministry of Machine Building, and the Commission of Science and Technology for National Defense’s concept-study team.<sup>30</sup>

Design and development of the Yuanwang started in 1974, with construction from 1975 and the first ships ready for trials in the late 1970s. Though six were originally built, only three are in operation today. It appears that the Yuanwang-class ship was first used in 1980 to retrieve the instrument package from China’s first successful DF-5/CSS-4 ICBM test – showing that the ships were able to successfully track missiles from the sea. The ships were further deployed in support of civilian and military space launches and tracking of space operations, including communications satellites, ballistic missile tests, and manned spacecraft (the Shenzhou). The fleet complements the PRC’s two Tianlian data-relay satellites and many ground stations, facilitating communication between satellites and these stations.<sup>31</sup>

The Yuanwang fleet was technologically upgraded starting in the 1980s; for example, the ships were initially able to track almost 25,000 miles above Earth, later increasing to almost 250,000 miles. Better radars improved the communication and tracking systems; most of the ships in the fleet have C- and S-band monopulse tracking radar, velocimetry systems, cinetheodolite laser ranging and tracking systems, computers, and navigation and positioning approaches. A variety of communications systems can secure data transfer, and the ships can operate in any maritime environment except polar areas. The ships could be used to detect and track foreign satellites and provide support to any PRC attempt to threaten them.<sup>32</sup>

While a ship-based tracking system has advantages such as flexibility, there are also disadvantages – it is expensive to operate and maintain, and during longer missions the lack of necessary engineers and equipment could make repairs difficult. Deploying such critical systems overseas makes them vulnerable targets, and any signals interference – or PRC supporting vessels – could affect their operation. Their sea-based nature also makes advanced communications connectivity difficult, especially during bad weather. There are still technological issues, such as calibration and stabilization that frustrate the ships' operations.<sup>33</sup>

As of mid-2008, the fleet had “completed 68 maritime space-tracking missions, sailed more than 1.4 million nautical miles safely, and performed more than 7,600 days of operations at sea.... During 2011-12, Yuanwang ships 3, 5, and 6 completed a cumulative 120,000-nautical-mile, 539-day trip to provide space-tracking and control support for the docking of the Tiangong-1 space-lab module and Shenzhou-8 spacecraft.” There have also been reports that a seventh ship was under construction; in 2006 the chief engineer of Yuanwang 6 noted that another boat was in the pre-research stages and could potentially be used in deep-space exploration missions. There has also been significant research on ship-based multi-target simulators to track and control satellite launches or missiles, which the PLA sees as a key capability.

The Yuanwang could also provide support to PRC development of ground-based laser and kinetic anti-satellite capabilities. Overall, Andrew S. Erickson notes:<sup>34</sup>

In reapplying indispensable positioning information and controlling space assets overseas, the *Yuanwang* fleet represents a vital node in China's aerospace infrastructure. The construction and proliferation of these ships over the past four decades underscores their importance and utility to the country's space and military operations. Space-tracking vessels have successfully participated in full-range ICBM tests, submarine-to-shore guided-missile underwater-launch tests, communications-satellite launches, manned and unmanned space-vehicle launches, and an Antarctic visit. They have played a significant role in the development and testing of technologies and weapons.... Chinese research literature also points to a larger role for space TT&C ships as the nation's space operations continue to expand.

### **Anti-Access/Area Denial Land-based Space Programs**

China also has a broad range of land-based stations that enhance its space warfare capabilities in ways that can threaten or attack US power projection capabilities. A 2012 report notes that:<sup>35</sup>

China has three satellite launch centers and stations: Jiuquan (also known as Base 20 and Dongfeng Space City), Xichang (Base 27), and Taiyuan (Base 25). The country is currently constructing a station in Wenchang (also known as Wenchang Space City and Wenchang Satellite Launch Center), which should be operational in 2013. Additionally, it has two control facilities: an Aerospace Command and Control Center in Xi'an (also known as Base 26). The Aerospace Telemetry Oceanic Ship Base is a crucial ground station, as it tracks *Yuanwang* data on both commercial satellites and spacecraft. Established in 1978 in Jiangyin,

Jiangsu Province, the base sends the ships it operates primarily to the Pacific and Indian Oceans. China operates three integrated land-based space-monitoring and control network stations in Kashi, Jiamusi, and Sanya....

China has overseas tracking stations in Karachi, Pakistan; Malindi, Kenya; and Swakopmund, Namibia. The Malindi station, in an Indian Ocean coastal town, became operational in July 2005 to support the *Shenzhou 6* mission. In Swakopmund, the station works in conjunction with *Yuanwang 3* to provide telemetry, tracking and command (TT&C) support during *Shenzhou* spacecraft landings. China also had a ground station in Tarawa, Kiribati; but it was dismantled in 2003 after Kiribati recognized Taiwan. Beijing plans to construct three ground-control stations in South America by 2016 for deep-space network support. Additionally, China reportedly shares space-tracking facilities with France, Sweden, and Australia.

## ***Space Capabilities and Developments***

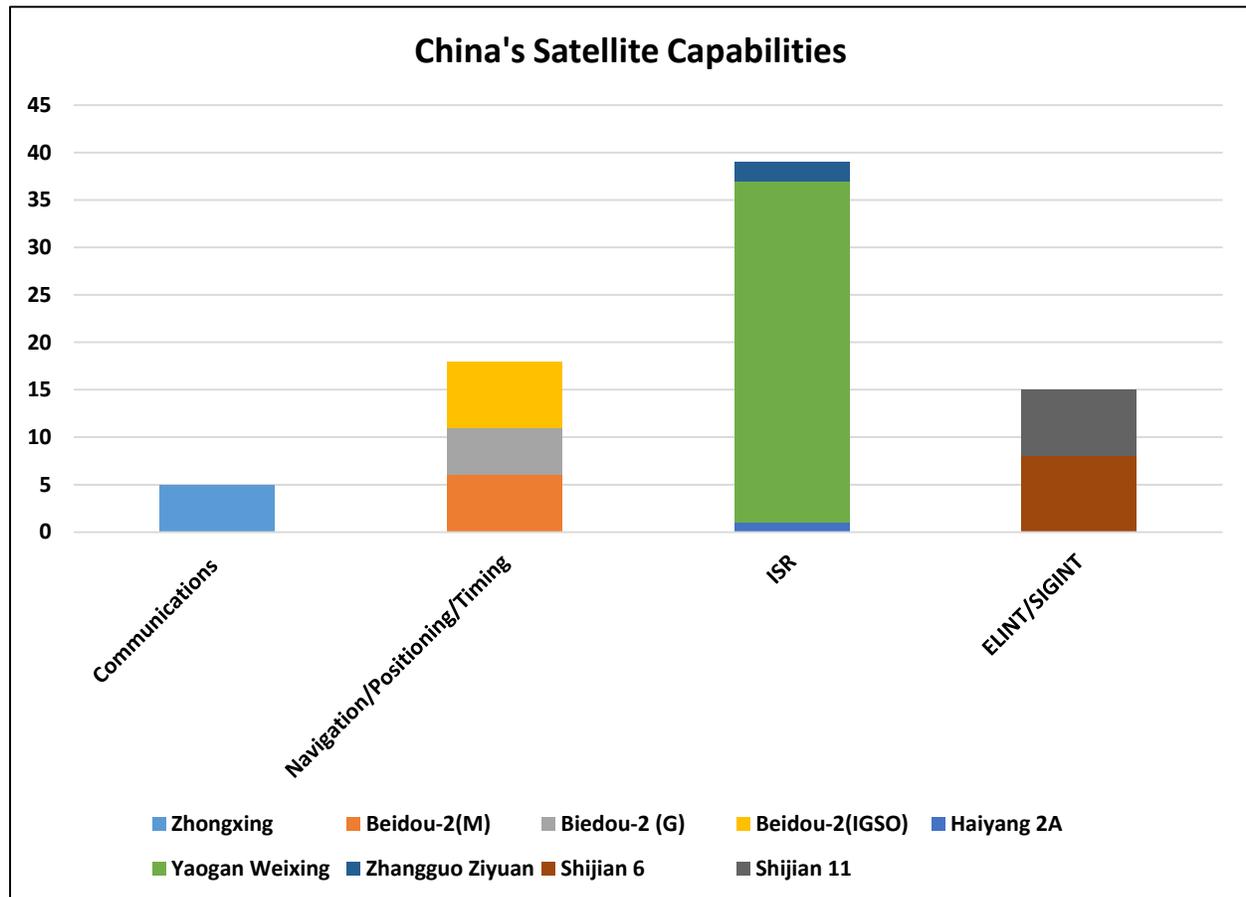
China's growing space capabilities translate into military capabilities that affect all aspects of conventional and nuclear targeting, ground-air-sea operations, precision conventional strike capacities, and missile defense. China is also using its intelligence collection efforts to improve technological capacity.

Chinese companies are also looking at increasing domestic development and production through the acquisition of parts manufacturers, leasing businesses, cargo airlines, materials producers, and airport operators. However, many of these Chinese companies that are pursuing joint ventures and technical cooperation agreements alongside acquisitions have deep ties to the military, raising issues for American regulators:<sup>36</sup>

The main contractor for the country's air force, the state-owned China Aviation Industry Corporation, known as AVIC, has set up a private equity fund to purchase companies with so-called dual-use technology that has civilian and military applications, with the goal of investing as much as \$3 billion. In 2010, AVIC acquired the overseas licensing rights for small aircraft made by Epic Aircraft of Bend, Ore., using lightweight yet strong carbon-fiber composites — the same material used for high-performance fighter jets.

Provincial and local government agencies in Shaanxi Province, a hub of Chinese military aircraft testing and production, have set up another fund of similar size for acquisitions. Last month, a consortium of Chinese investors, including the Shaanxi fund, struck a \$4.23 billion deal with the American International Group to buy 80 percent of the International Lease Finance Corporation, which owns the world's second-largest passenger jet fleet.

Indeed, even China's ostensibly peaceful space developments like the BeiDou SATNAV system, manned space missions, and launch vehicles should be viewed, at minimum, as dual-use capabilities that the PLA will utilize if needed.

*Figure 1.1: China's Active Satellite Capability*

Source: Source: IISS *Military Balance*, 2016. Adapted by Anthony H. Cordesman and Joseph Kendall at the Center for Strategic and International Studies.

### Space-based C4ISR

Chinese military journals, defense white papers, and scholarly articles all focus on the concept of “information dominance” on the battlefield.<sup>37</sup> In order to achieve this goal, China has invested substantial time and resources into developing an advanced C4ISR capability on the ground and in the space. **Figure 1.1** depicts that the majority of China’s satellites are related to ISR. To achieve a C4ISR system truly capable of achieving information dominance, a vast space-based component is a necessity. The 2016 DoD report on China notes China’s deep commitment to C4ISR development:<sup>38</sup>

The PLA views technological improvements to C4I systems as essential to improve the speed and effectiveness of decision-making while providing secure and reliable communications to fixed and mobile command posts. The PLA is fielding advanced automated command systems like the Integrated Command Platform (ICP) to units at lower echelons across the force. The adoption of the ICP enables multi-service communications necessary for joint operations. These C4I advancements are expected to shorten the command process. The new technologies introduced into the PLA enable information-sharing—intelligence, battlefield information, logistical information, and weather reports—on robust and redundant communications networks, to improve commanders’ situational awareness. In particular, the transmission

of ISR data in near real-time to commanders in the field could facilitate the commanders' decision-making processes and make operations more efficient.

These technical improvements have greatly enhanced the PLA's flexibility and responsiveness. "Informationized" operations no longer require in-person meetings for command decision-making or labor-intensive processes for execution. Commanders can issue orders to multiple units at the same time while on the move, and units can rapidly adjust their actions through the use of digital databases and command automation tools. The PLA also seeks to improve its C4I capabilities by reforming its joint command institutions at the national and regional levels.

The 2015 DoD report on Chinese military power provides further details about China's C4ISR developments:<sup>39</sup>

China possesses the most rapidly maturing space program in the world and is using its on-orbit and ground-based assets to support its national civil, economic, political, and military goals and objectives. China has invested in advanced space capabilities, with particular emphasis on satellite communication (SATCOM), intelligence, surveillance, and reconnaissance (ISR), satellite navigation (SATNAV), and meteorology, as well as manned, unmanned, and interplanetary space exploration. In addition to its on-orbit assets, China's space program has built a vast ground infrastructure supporting spacecraft and space launch vehicle (SLV) manufacture, launch, C2, and data downlink.

By the end of October 2014, China had launched 16 spacecraft, either domestically or via a commercial space launch provider. These spacecraft mostly expanded China's SATCOM and ISR capabilities, while a few others tested new space technologies. Noteworthy 2014 accomplishments for China's space program include:

**First Sub-meter Resolution Imager:** Following its launch in August, the Gaofen-2 became China's first satellite capable of sub-meter resolution imaging. China reportedly plans to use the satellite for a variety of purposes, including the sale of commercial imagery.

**Lunar Sample-Return Technology Test:** In late October, China launched the Chang'e-5 test spacecraft. This mission will test technologies related to retrieving and returning a lunar sample to Earth. China plans to launch the actual Chang'e-5 Lunar Sample Return mission in 2017.

**Fourth Space Launch Center Complete:** China completed construction of the Wenchang Space Launch Center (SLC) on Hainan Island in 2014 and plans to begin launching its next-generation Long March-5 and Long March-7 SLVs from the facility no later than 2016.

The practical implications are massive for China's development of C4ISR capabilities. Nearly all of China's strategic goals and military plans rely on information dominance, or at least denying the opposition information dominance. As previously noted, China believes success in a Taiwan Strait crisis or war with the United States in the Pacific will rely on the ability to implement an anti-access anti-denial (A2/AD) strategy. The key components of A2/AD—long-range precision strikes, theater ballistic missile defense, information dominance, and conventional counterforce tracking—are impossible without extremely advanced C4ISR.

Andrew S. Erickson notes in his report assessing China's DF-21D anti-ship ballistic missile—which is seen as a game changer for China in being able to implement a successful A2/AD strategy -- that:<sup>40</sup>

The supporting command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) technologies probably still lag behind the requirement to identify and track a U.S. aircraft carrier in real time under wartime conditions. Improving C4ISR capabilities, however, is a high priority in China's military modernization program. U.S. countermeasures are another matter entirely: there is every reason to believe that they are already formidable.

Furthermore, advanced C4ISR capabilities could lead China to changing its nuclear posture for no first use to launch on warning. Plus, advanced intelligence capabilities are important for China to monitor and protect its increasingly threatened maritime claims in the South and East China seas.

The November 2015 US-China Economic and Security Review Commission provides detailed insight into the space-based infrastructure that China is developing to establish an advanced C4ISR capability.<sup>41</sup>

China is fielding sophisticated satellites that feature electro-optical (EO), synthetic aperture radar (SAR), and electronic reconnaissance (ELINT) sensors. EO sensors passively detect light images of maritime and ground-based targets. Although EO sensors can achieve the highest resolution of these types, they are adversely affected by poor weather conditions and cannot image at night. SAR sensors use a microwave transmission to create images of maritime and ground-based targets. They tend to have lower resolution than EO sensors but can image during night or day and in all weather conditions. ELINT sensors detect electronic signal emissions and then determine emitter locations. Combining these varying capabilities is crucial for locating and tracking a moving target. A study by authors affiliated with the PLA Navy Aerospace Engineering Academy illustrates the importance of integrating the information obtained from ISR satellites for long-range antiship ballistic missile (ASBM) strikes:

*During the process of planning [to use] the firepower of an ASBM, [there is a need] for obtaining reliable target intelligence information for guiding the missile attack. This could be achieved by integrating EO imaging satellites, SAR imaging satellites, ELINT satellites, naval ocean surveillance satellites, mapping resource satellites, and highly accurate commercial remote sensing satellite imagery, which could be purchased on the international market. Through the integration of the data obtained via a number of different satellites, and with the addition of processing and data fusion, [one could] guarantee missile guidance requirements for all types of target information for a long range ASBM strike.*

China's major military-relevant ISR satellites are the Yaogan, Shijian, Gaofen, and Haiyang, each of which is examined in detail in the following paragraphs. China also has a large number of imaging and remote sensing satellites that are owned and operated by civilian or commercial entities. Given the PLA's central role in the development, launch, and operations of all of China's satellites, these civilian and commercial satellites likely contribute to the PLA's C4ISR efforts whenever it is technically and logistically feasible for them to be so utilized, and they would probably be directly subordinate to the PLA during a crisis or conflict.

#### *Yaogan Satellites*

The Yaogan series of satellites, the first of which was launched in 2006, serves as the core component of China's maritime ISR architecture. Chinese state-run press claims the satellites are used to conduct scientific experiments and carry out land surveys, among other functions. Because the series is owned and operated by the PLA, however, it likely is used primarily for broad area maritime surveillance in support of the PLA's efforts to detect, track, and target foreign ships, such as U.S. carrier strike groups. China to date has launched 37 Yaogan satellites, including EO, SAR, and ELINT variants.

#### *Shijian Satellites*

China's Shijian series of satellites, the first of which was launched in 1971, is owned and operated by China's Academy of Space Technology. The Shijian satellites have a variety of configurations and missions. Although some have been used for strictly civilian purposes, such as crop breeding, many appear to be military ISR satellites based on their suspected payloads, their orbital characteristics, and the secrecy surrounding their launches. Some Shijian satellites likely feature ELINT sensors used by the PLA for broad area maritime surveillance. Others probably are equipped with infrared sensors to detect ballistic missile launches in support of a future early warning system.<sup>127</sup> According to Mr. Pollpeter, the development of such a system could indicate a change in China's nuclear posture:

*The deployment of a space-based ballistic missile early warning system may also signal a change in China's nuclear doctrine from "no first use" to "launch on warning." China's current nuclear force doctrine relies on retaliating only after a nuclear first strike from an opponent. A "launch on warning" system would make China's nuclear force more survivable since China would have warning that an attack is imminent, but would also present the possibility for false warnings, which could be catastrophically destabilizing during a conventional conflict.<sup>1</sup>*

#### *Gaofen Satellites*

The Gaofen series of EO/SAR satellites, the first of which was launched in 2013, features China's first high-definition satellite and first satellite capable of sub-meter resolution; the series also incorporates several design innovations. According to Beijing, the Gaofen-1 "has been used in land resource investigation, mineral resource management, atmospheric and water environment quality monitoring, and natural disaster emergency response and monitoring," and its imagery has supported "tens of national ministries and agencies, local governments, research institutions, universities, enterprises and organizations in China." China also employed the Gaofen-1 to assist in the search for missing Malaysian airliner MH370 in 2014, demonstrating its ability to conduct broad maritime surveillance that could be useful for the PLA. China launched the second Gaofen in 2014 and two more in 2015, and is expected to launch as many as four more by 2016.

#### *Haiyang Satellites*

The Haiyang series of satellites, the first of which was launched in 2002, is owned and operated by the State Oceanic Administration. The series primarily supports China's civilian and scientific organizations involved in monitoring the characteristics of the ocean environment, including pollution, topography, wind fields, surface temperatures, and currents. The fact that the State Oceanographic Administration oversees China's maritime law enforcement organizations, however, suggests these satellites also play a role in monitoring and enforcing China's maritime claims in the East and South China seas. Indeed, in 2012 a Chinese official said future Haiyang satellites will be used to monitor the disputed Senkaku Islands and Scarborough Reef. To date, China has launched three Haiyang satellites (two of which are operational) and plans to launch five more by 2020.

### **BeiDou Navigation Satellite System**

The BeiDou satellite positioning, navigation, and timing system has been in development and regional use since 2000, and is meant to be China's alternative to dependence on the U.S. government owned Global Positioning System (GPS) technology. The second generation version has been operational in the region since 2012 and is planned to be available globally by 2020. The system will "enable subscribers outside of China to purchase receivers and services that give civilian and military applications greater redundancy and independence in a conflict scenario that employs space assets."<sup>42</sup>

The BeiDou system is an example of the overlapping military-civilian nature of China's space programs. On one hand, it is an impressive technological feat with innumerable potential commercial purposes. On the other, it is a recognition that if China were to be engaged in a war it is likely to be with Western countries or Western-backed states in the region. Consequently, it is necessary that China have an alternative to U.S. government operated GPS. Currently, GPS holds a 95% market share in China.<sup>43</sup>

The 2015 DoD report continued to explain space launch trends and provided a graph depicting the new satellites launched each year since 2010, seen in **Figure 1.3**:<sup>44</sup>

Over the last five years, the number of Chinese space launches and satellites placed on orbit has remained relatively consistent, with China typically launching 15-20 SLVs, and placing 17-25 satellites on orbit each year (See Figure 1). Two noteworthy trends in China's space launches since 2010 have been the increase in remote sensing/earth resource satellites and the decline in launches of navigation satellites.

Since 2010, the number of Chinese remote sensing and earth resources satellites launched as a percentage of total launches has increased. Satellites in this category accounted for more than one half of the satellites China launched during the last two years, suggesting China places a great deal of priority on launch of its remote sensing satellites.

China launched 13 Beidou navigation satellites between 2010 and 2012, but did not launch any in 2013 or 2014. Although this may seem unusual, this drop-off of navigation satellite launches was expected. By the end of 2012, China had completed launches of the “regional phase” of its Beidou-2 satellite navigation project and reportedly began testing of the system in 2013. According to China’s Satellite Navigation Office, China will resume launching navigation satellites for its worldwide satellite navigation constellation in 2015 and hopes to complete it as early as 2017.

Kevin Pollpeter adds in a March 2015 report that BeiDou is being implemented in a three-part process and **Figure 1.2** depicts BeiDou satellite launches:<sup>45</sup>

Beidou is China’s satellite navigation system and is intended to reduce China’s reliance on the U.S. Global Positioning System (GPS). Similar to the human spaceflight, lunar exploration, and earth remote sensing programs, Beidou is one of China’s 16 mega-projects under the Medium and Long-term Plan for Science and Technology Development. China is spending significant sums on Beidou and plans to spend between \$6 billion to \$8 billion on the development of Beidou technologies to 2020. Like GPS, Beidou is fundamentally a military-run program with civilian applications. Beidou’s architecture, however, differs substantially from GPS in terms of technology, number of satellites, and performance.

Like other programs, China’s Beidou navigation satellite program has followed a three-step development plan. This plan has produced two generations of the system (Table 8). In Step 1, the program launched an experimental regional system, Beidou-1, in 2000 that became operational in 2003. Beidou-1 uses an active system called radio determination satellite service (RDSS). This system comprised two satellites in geostationary orbit, a backup satellite, at least one ground station, and customer receiver/transmitters that communicated with each other. These receivers both pick up the satellite signal and send a signal back to the satellites, which then forward it to the ground station. The ground station then calculates the position of the receiver and communicates this data to the receiver. Beidou-1 could achieve accuracies of up to 20 meters. It also supports a short message service for messages of up to 120 characters.

In Step 2, development of the more advanced Beidou-2 system was initiated in 2007 and began operating on a regional basis in 2012. Beidou currently provides regional coverage with 16 satellites using the same active system used by Beidou-1. This system uses an open code that provides accuracies of 10 meters or better, depending on the location, and a restricted military service that could provide better accuracies. GPS, on the other hand, uses as few as 24 satellites to provide positioning accuracies of just several meters. Chinese officials, however, claim that with the optimized positioning of Beidou satellites over China and the construction of thousands of differential ground stations, Beidou’s accuracy will be boosted to one meter and possibly even centimeters. This is in comparison to a GPS accuracy of three to five meters in China. Currently, maritime users can receive accuracies of three centimeters, and with the introduction of a recently developed Beidou receiver chip, other users can receive accuracies of 2.5 meters.

In Step 3, Beidou-2 will expand to provide a global service by 2020, with 35 satellites using a passive system similar to the one used by GPS. Like its predecessor, Beidou-2 also provides a short message service that allows communication between Beidou receivers.

The November 2015 report by the US-China Economic and Security Review Commission adds depth on both the historical impetus for BeiDou and the PLA’s early utilization of the system:<sup>46</sup>

Although Beidou has a wide and growing range of civilian applications that will benefit China’s economic development, China developed its indigenous PNT system primarily for military purposes. Prior to the deployment of Beidou, most PLA units used GPS for positioning and maneuver and most PLA precision weapon systems used GPS for guidance. The PLA has considered this dependence on a foreign PNT system to be a strategic vulnerability since at least the mid-1980s. These fears were exacerbated during the 1995–1996 Taiwan Strait Crisis. According to a retired PLA general, the PLA concluded that an

unexpected disruption to GPS caused the PLA to lose track of some of the ballistic missiles it fired into the Taiwan Strait during the crisis. He then said that “it was a great shame for the PLA . . . an unforgettable humiliation. That’s how we made up our mind to develop our own global [satellite] navigation and positioning system, no matter how huge the cost. Beidou is a must for us. We learned it the hard way.”

The PLA in the early 2000s began to gradually incorporate Beidou into its ground, air, and naval forces, and by the late 2000s tracking, and secure communications. Public information about China’s incorporation of Beidou into its weapons systems is scarce, but China almost certainly is equipping its ballistic and cruise missiles to operate with both GPS and Beidou. If this is true, PLA operators could switch to Beidou to guide a missile to its target if GPS were (1) denied by the United States during a conflict or (2) deemed unusable by PLA commanders due to operational security concerns. Additionally, the availability of Beidou would allow China to attack an adversary’s access to GPS without disrupting the PLA’s own capabilities.

The 2016 DoD report on Chinese military power notes more recent BeiDou launches and ongoing work before the systems’ targeted completion in 2020:<sup>47</sup>

China’s Beidou SATNAV constellation began the next step of its construction in 2015 with the launch of the Beidou II-S, an inclined geosynchronous orbit (IGSO) satellite, on March 30. In 2015, China launched two more medium Earth orbit satellites and two more IGSO satellite. This phase of the project plans to extend the Beidou network beyond its current regional focus to provide global coverage by 2020.

**Figure 1.2: China's BeiDou Satellite Launches**

| Spacecraft                | Launch Year | Comments                                |
|---------------------------|-------------|-----------------------------------------|
| Beidou-1A                 | 2000        | NA                                      |
| Beidou-1B                 | 2000        | NA                                      |
| Beidou-1C                 | 2003        | NA                                      |
| Beidou-1D                 | 2007        | NA                                      |
| Beidou-2<br>Compass-M1    | 2007        | Test satellite/Atomic clock malfunction |
| Beidou-2<br>Compass-G2    | 2009        | Drifting                                |
| Beidou-2<br>Compass-G1    | 2010        | GEO                                     |
| Beidou-2<br>Compass-G3    | 2010        | GEO                                     |
| Beidou-2<br>Compass-IGSO1 | 2010        | Inclined GEO                            |
| Beidou-2<br>Compass-G4    | 2010        | GEO                                     |
| Beidou-2<br>Compass-IGSO2 | 2010        | Inclined GEO                            |
| Beidou-2<br>Compass-IGSO3 | 2011        | Inclined GEO                            |
| Beidou-2<br>Compass-IGSO4 | 2011        | Inclined GEO                            |
| Beidou-2<br>Compass-IGSO5 | 2011        | Inclined GEO                            |
| Beidou-2<br>Compass-G5    | 2012        | GEO                                     |
| Beidou-2<br>Compass-M3    | 2012        | MEO                                     |
| Beidou-2<br>Compass-M4    | 2012        | MEO                                     |
| Beidou-2<br>Compass-M5    | 2012        | MEO                                     |
| Beidou-2<br>Compass-M6    | 2012        | MEO                                     |
| Beidou-2<br>Compass-G6    | 2012        | GEO                                     |

Source: Kevin Pollpeter, *China Dream, Space Dream: China's Progress in Space Technologies and Implications for the United States*, US-China Economic and Security Review Commission, March 2, 2015, p.74.

Note: Figure 1.X does not include the BeiDou satellite launches that occurred in 2015.

## Manned Spaceflight

In 2003, China established itself as the third country to independently launch a human into space with Shenzhou 5 and takionaut Yang Liwei. China has subsequently launched four more manned missions and established one of the world's most advanced space programs. The 2016 China IHS report provides detail into the military aspects of China's manned space program.<sup>48</sup>

The Shenzhou spacecraft, including the autonomous orbital modules, were controlled from the Beijing Aerospace Command and Control Centre, which received an enormous amount of mission operation data from the long-duration modules, and the Xian Satellite Control Centre at Weinan, which also received data from them. The tracking stations at Qingdao, Xiamen, and Kashi also tracked the modules. The Kashi station, because of its extreme western location, has played an especially important role in tracking and supporting the Shenzhou vehicles. The SIGINT complex at Kashi would have been the first recipient of any ELINT mission data collected by the Shenzhou orbital modules, both to clear the tape recordings and to process the data for any time-urgent intelligence.

In September 2008, Shenzhou-7 featured a three-man crew and China's first spacewalk. It also reaffirmed China's willingness to combine civilian and military functions, including possible defensive and offensive space combat missions. According to the US Strategic Command the Shenzhou-7 spacecraft passed to a point about 45 km from the ISS on 27 September 2009. While Washington, Moscow, and Beijing did not comment on this close pass, it suggested China was testing space docking or "co-orbital" ASAT intercept capabilities. The same mission featured a launch and rendezvous with an autonomous microsatellite.

China will launch its next manned space mission in October 2016. The Shenzhou 11 will launch two takionauts into space with the mission to dock with the Tiangong-2 space lab.<sup>49</sup>

Furthermore, China's Shenzhou space crafts have been equipped with substantial ELINT, surveillance, and long-range observation technology.<sup>50</sup>

## Launch Vehicles

China has and continues to develop a wide array of launch vehicles for its space program. Further underlining the connection between the PLA and the space program is the fact that China's early space launch vehicles were developed using the technology from its DF-4 and DF-5 ICBMs. The 2015 DoD report on China described additional space capabilities that China could use for military application:<sup>51</sup>

China boasts the most dynamic space program in the world today, supported by a robust capacity for space-lift. China's space-lift infrastructure, including space-launch centers and space-launch vehicles (SLV), affords China tremendous flexibility in current as well as future space mission planning. China currently operates eight specialized SLVs with lift capacities ranging from light to medium-heavy lift and the capability to deploy satellites at altitudes ranging from low earth orbit (LEO) to geosynchronous orbit (GEO) in support of its national goals and objectives.

*Long March-2C and -2D:* The LM-2C and LM-2D SLVs provide China light-lift capability into LEO, including sun synchronous orbits (SSO) favored by intelligence, surveillance, and reconnaissance (ISR) satellites.

*Long March-4B and -4C:* The LM-4B and LM-4C provide China a medium-lift capability into LEO, including SSO. These are the largest SLVs China regularly employs on LEO missions.

*Long March-2F:* The LM-2F provides China a heavy-lift capability into LEO. China has only employed the LM-2F for launches associated with its manned space program, including the launch of its Shenzhou and Tiangong spacecraft.

*Long March-3A, -3B, and -3C:* The LM-3-series SLVs provide China a capability to launch medium, intermediate, and heavy satellites on missions into GEO. Two (LM-3C) or four (LM-3B) modular strap-on boosters may be added to a common core, as necessary.

Three launch centers, located at high and low latitudes and accompanied by mostly unobstructed launch corridors, afford China ease of access to a full range of orbital inclinations.

*Jiuquan Satellite Launch Center (JSLC):* Located in the desert of northwest Gansu Province, the JSLC is the only launch complex currently supporting China's manned space program.

*Taiyuan Satellite Launch Center (TSLC):* Located in northern Shanxi Province, the TSLC may support launches into various LEO orbits.

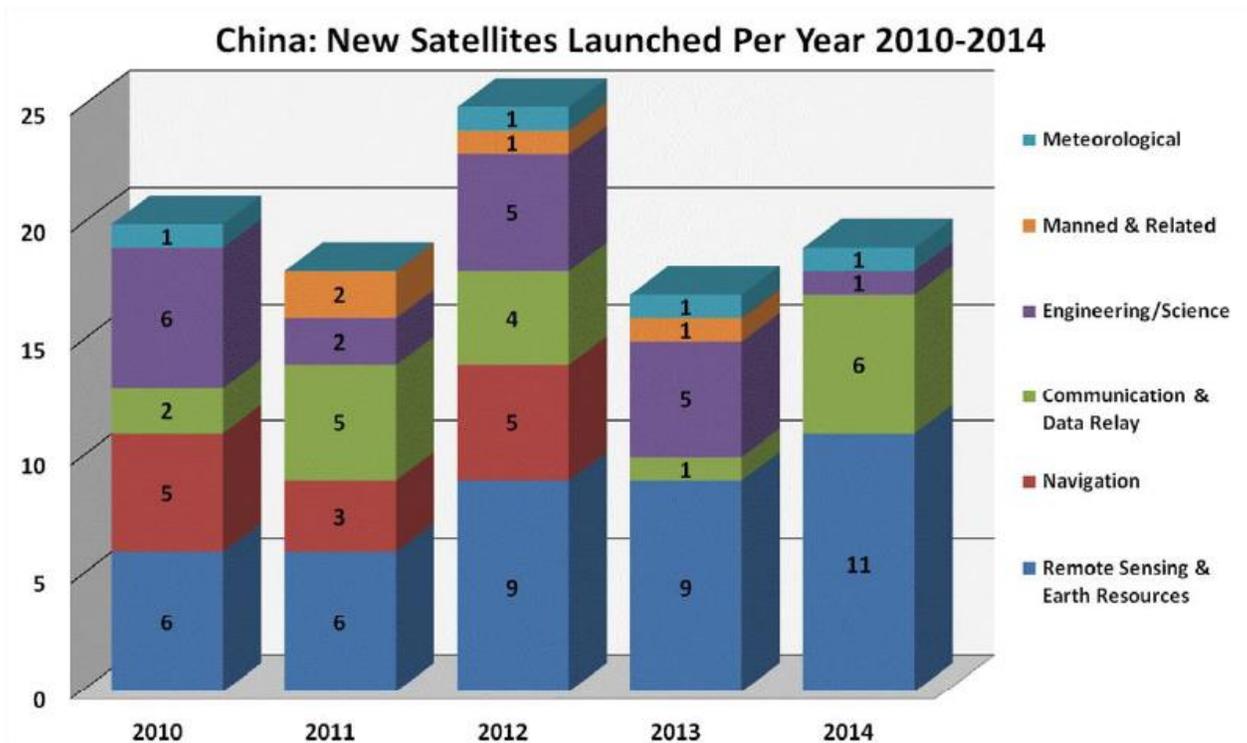
*Xichang Satellite Launch Center (XSLC):* Located in southwest Sichuan province, the XSLC is the only Chinese launch complex currently supporting missions to GEO.

China recently completed construction of its fourth and largest spaceport on Hainan Island, located off China's southern coast. Named Wenchang Satellite Launch Center, it will launch China's newly developed LM-5 SLV, a heavy-lift SLV that will more than double China's current lift capacity on LEO and GEO missions. The new SLV and launch center are essential to China's national goals of constructing a space station by 2022 and engaging in manned lunar exploration. The first flight of the LM-5 could occur as early as 2015.

The 2016 Department of Defense reported noted that China had developed two new launch vehicles:<sup>52</sup>

September 2015 saw the successful debut of both the Long March (LM)-6 and the LM-11 "next generation" SLVs. The LM-6 is a small liquid-fueled SLV designed to carry up to 1000 kg into low Earth orbit (LEO), and the LM-11 is described as a "quick response" SLV designed to launch a small payload into LEO on short notice in the event of an emergency.

Additionally, China plans to launch its heavy-lift Long March-5 (LM-5) rocket at some point in Fall 2016.<sup>53</sup> The Long March-5 will offer China heavy-lift capabilities to launch large satellites, its future space station, and potentially undertake deep space exploration. The LM-5 is projected to be able to carry a payload of 25,000 kg to low-earth orbit (LEO).<sup>54</sup> This compares relatively similarly to United Launch Alliance's Delta IV Heavy—the main heavy launch vehicle of the U.S. military—which can carry 28,370 kg to LEO.<sup>55</sup>

**Figure 1.3: DoD Assessment of Chinese Space Launch Trends**

Source: DoD Annual Report to Congress: Military and Security Developments Involving the People's Republic of China, April 2015.

### ***Chinese Counterspace and ASAT Capabilities***

As important as it is for China to possess C4ISR, SATNAV, and SATCOM capabilities, the Chinese believe it is equally important to deny their opponents those capabilities in a combat situation. This is of paramount importance for garnering “information superiority”. China is developing counterspace capabilities that affect the country’s entire spectrum of warfighting capacities, from the tactical to the strategic levels. Both China and Russia “continue developing systems and technologies that can interfere with or disable vital U.S. space-based navigation, communication, and intelligence collection satellites.”<sup>56</sup> In the case of China, these capabilities are broad and growing, they include “direct-ascent antisatellite missiles, co-orbital antisatellite systems, computer network operations, ground based satellite jammers, and directed energy weapons.”<sup>57</sup>

DIA Director James Clapper stated in 2015 testimony to the Senate that:<sup>58</sup>

Threats to US space systems and services will increase during 2015 and beyond as potential adversaries pursue disruptive and destructive counterspace capabilities. Chinese and Russian military leaders understand the unique information advantages afforded by space systems and services and are developing capabilities to deny access in a conflict. Chinese military writings highlight the need to interfere with, damage, and destroy reconnaissance, navigation, and communication satellites. China has satellite jamming capabilities and is pursuing antisatellite systems. Russia’s 2010 Military Doctrine emphasizes space defense as a vital component of its national defense. Russian leaders openly assert that the Russian armed forces have antisatellite weapons and conduct antisatellite research. Russia has satellite jammers and is pursuing antisatellite systems.

## Direct-Ascent ASATs

As has been touched upon earlier, China has tested anti-satellite (ASAT) weapons that could have a massive impact on US battle management and ISR systems, and may have some capability to use EMP weapons. A summary of China's direct-ascent ASAT tests can be seen in **Figure 1.4**. A 2013 editorial in the state-run Global Times stated, "it is necessary for China to have the ability to strike US satellites. This deterrent can provide strategic protection to Chinese satellites and the whole country's national security."<sup>59</sup>

Direct-ascent ASAT weapons are the most developed and regularly tested fixture of China's counterspace capabilities. The technology is similar to that of ballistic missile defense (BMD) and similarly direct-ascent weapons rely on kinetic-kill to destroy the targeted satellite.

The 2016 report from IHS on China's military capabilities goes in depth regarding Chinese direct-ascent ASATs:<sup>60</sup>

On 11 January 2007, China used a direct-ascent ASAT interceptor to destroy a Chinese FY-1C weather satellite operating in a polar orbit over 500 miles (800 km) above the earth. Later identified by Pentagon officials with the designator SC-19, this ASAT is derived from the DF-21-based KT-1 SLV. The fourth stage contains a new interceptor that probably uses a combination of infrared and radar sensors to complete its interception. The 11 January test was later revealed to be China's third attempt to destroy the same FY-1C satellite with a SC-1 ASAT. The first attempt may have occurred in late 2005. US officials have noted that these tests utilized a mobile launch platform, which displayed a "worrisome level of flexibility".

Statements by US officials indicate that China may now be building a stockpile of SC-19 interceptors even as it continues to improve and refine this system. It is one component of a multi-dimensional programme to limit or prevent the use of space-based assets by potential adversaries during a time of conflict. Given the precedent of the KT-1, it is possible now that the planned larger KT-2 and KT-2A mobile solid-fuel SLVs may be developed into ASATs that can reach much higher orbits, threatening US navigation and high-level surveillance satellites. At the 2006 Zhuhai Airshow, CASC also revealed an air-launched SLV for LEO launches, similar in size and function to the US Orbital Corporation Pegasus. It was shown being launched from an H-6 bomber, but other aircraft might also serve as launch platforms. With additional boosters such a vehicle could be developed into an ASAT for higher polar orbits but with the added tactical flexibility of its air-launched platform.

The November 2015 US-China Economic and Security Review Commission report adds further detail on how direct-ascent ASAT technology functions:<sup>61</sup>

Direct-ascent antisatellite missiles are designed to disable or destroy a satellite or spacecraft using one of several possible kill mechanisms, such as a kinetic kill vehicle. The missiles typically are launched against preselected targets, as they must either wait for the target satellite to pass overhead within a certain distance from the launch site, or target a stationary satellite within range of the launch site. Unlike co-orbital antisatellite systems (discussed later in this section), direct-ascent antisatellite missiles do not establish a persistent presence in space, enter into long-term orbits, or loiter to await commands to engage a target.

Compared to other types of counterspace weapons that temporarily disable or disarm satellites, direct-ascent ASATs are destructive in ways that go beyond their military target. This was highlighted by China's 2007 kinetic-kill ASAT test that destroyed an inactive Chinese Fengyun weather satellite, which was widely derided by the international community.

Michael Krepon noted the dangers of kinetic-kill counterspace weapons in a September 2013 report:<sup>62</sup>

A kinetic-energy ASAT test conducted in 2007 by the People's Liberation Army (PLA) ended complacency over the hazards of space debris. This ASAT test produced more latent capabilities to engage in space warfare have grown, and have become more prominent than 3,000 pieces of debris large enough to

track, and tens of thousands of smaller pieces, endangering human spaceflight and hundreds of satellites, without regard for ownership and nationality... As a result of these tests, as well as other significant debris-causing events, recognition of the potential environmental consequences of space warfare is unquestionably greater now than during the Cold War. Reaction to the PLA's 2007 ASAT did not spark mass protests, unlike the case of atmospheric testing. This ASAT test did, however, alarm space operators to such an extent that an international norm against further tests of this kind might take hold.

Thus, it seems likely if kinetic-kill counterspace weapons were deployed in a warfare situation that the collateral damage to both commercial and military satellite infrastructures would be catastrophic. The 2007 test incident also revealed some of diplomatic issues involved. Jeffrey Lewis noted that, "Chinese policymakers appear to have been genuinely surprised at the reaction to international outrage prompted by their 2007 ASAT test".<sup>63</sup>

The DoD's 2016 report elaborated on China's direct-ascent ASAT capabilities while noting the way in which China had continued to test without causing space debris:<sup>64</sup>

China is also developing anti-satellite capabilities and has probably made progress on the antisatellite missile system it tested in July 2014. China is employing more sophisticated satellite operations and is probably testing dual-use technologies in space that could be applied to counterspace missions.

In the summer of 2014, China conducted a space launch that had a similar profile to the January 2007 test. In 2013, China launched an object into space on a ballistic trajectory with a peak altitude above 30,000 km, which could have been a test of technologies with a counterspace mission in geosynchronous orbit.

Although Chinese defense academics often publish on counterspace threat technologies, no additional antisatellite programs have been publicly acknowledged. PLA writings emphasize the necessity of "destroying, damaging, and interfering with the enemy's reconnaissance...and communications satellites," suggesting that such systems, as well as navigation and early warning satellites, could be among the targets of attacks designed to "blind and deafen the enemy."

It is far from clear, however, that the destructive impacts of using ASAT would deter China in any serious warfighting contingency. The other risks and cost of such a war would make winning paramount, and it is unclear how a U.S. or other response would play out in deterrence terms. The cost of escalating to nuclear conflict would involve risks so serious that the ASAT war would not trigger such escalation. The ability to use precision conventional weapons to target critical land-based targets and infrastructure would be a potential way to escalate without using ASATs, but like other aspects of deterrence in space, it remains a concept that have never been tried, and where establishing some stable level of intra-conflict deterrence would have to take place under some of the worst possible conditions.

### ***Figure 1.4 China's Direct-Ascent ASAT Tests***

**Table 1: Summary of Direct-Ascent Antisatellite Tests**

| <b>Date</b>   | <b>Orbital Debris</b> | <b>Missile</b> | <b>Notes</b>                                                |
|---------------|-----------------------|----------------|-------------------------------------------------------------|
| July 2005     | No                    | SC-19          | Rocket test                                                 |
| February 2006 | No                    | SC-19          | Failed intercept and destruction of an orbital target       |
| January 2007  | Yes                   | SC-19          | Successful intercept and destruction of an orbital target   |
| January 2010  | No                    | SC-19          | Successful intercept and destruction of a suborbital target |
| January 2013  | No                    | SC-19          | Successful intercept and destruction of a suborbital target |
| May 2013      | No                    | DN-2           | Rocket test                                                 |
| July 2014     | No                    | SC-19          | Successful intercept and destruction of a suborbital target |

Source: "China's Space and Counterspace Programs", 2015 Report to Congress, US-China Economic and Security Review Commission, November 2015, p. 294,

[http://origin.www.uscc.gov/sites/default/files/annual\\_reports/2015%20Annual%20Report%20to%20Congress.PDF](http://origin.www.uscc.gov/sites/default/files/annual_reports/2015%20Annual%20Report%20to%20Congress.PDF)

### **Co-orbital Anti-satellite Weapons**

These same considerations apply to other counterspace weapons. One such technology that China has put substantial effort into are co-orbital anti-satellite platforms. These are essentially armed satellites with an attack device that can be used against an enemy satellite. Co-orbital ASAT weapons behave like a regular satellite in orbit until a decision is made to deploy them against a target.

The US-China Economic and Security Review Commission report from November 2015 states:<sup>65</sup>

China's recent space activities indicate that it is developing co-orbital antisatellite systems to target U.S. space assets. These systems consist of a satellite armed with a weapon such as an explosive charge, fragmentation device, kinetic energy weapon, laser, radio frequency weapon, jammer, or robotic arm. Once a co-orbital satellite is close enough to a target satellite, the co-orbital satellite can deploy its weapon to interfere with, disable, or destroy the target satellite. Co-orbital satellites also may intentionally crash into the target satellite.

Since 2008, China has tested increasingly complex space proximity capabilities. Although these capabilities have legitimate applications for China's manned space program, the dual-use nature of the technology and China's secrecy surrounding the tests suggest China also is using the tests to develop co-orbital counterspace technologies.

- During a manned space mission in September 2008, China's Shenzhou 7 spacecraft deployed the BX-1, a miniature imaging satellite, which then positioned itself into an orbit around the spacecraft. The activities of the BX-1 may have been designed to test a dual-use on-orbit inspection capability for future inspector satellites. In addition to aiding China with maintenance

of its satellites, inspector satellites could approach U.S. satellites in orbit to collect detailed images and intelligence on them. Moreover, at one point the BX-1 passed within 45 kilometers of the International Space Station, apparently without prior notification, suggesting it may have been simulating a co-orbital antisatellite attack.

- In June 2010, China launched the SJ-12 satellite. Over the next two months, the satellite conducted a series of maneuvers and came within proximity of the SJ-6F, an older Chinese satellite that was placed into orbit in 2008. The activities of the SJ-12 may have been designed to test a co-orbital antisatellite capability, such as on-orbit jamming. Moreover, during its maneuvers, the SJ-12 apparently bumped the SJ-6F, causing it to drift slightly from its orbital regime. This activity suggests China also could have used the test to demonstrate the ability to move a target satellite out of its intended position by hitting it or attaching to it.
- In July 2013, China launched a rocket carrying the CX-3, SY-7, and SJ-15 satellites, one of which was equipped with a robotic arm for grabbing or capturing items in space. Once all three were in orbit, the satellite with the robotic arm grappled one of the other satellites, which was acting as a target satellite. The satellite with the robotic arm then changed orbits and came within proximity of a separate satellite, the SJ-7, an older Chinese satellite that was orbited in 2005. Robotic arms can be used for civilian missions such as satellite repair, space station construction, and orbital debris removal; they also can attach to a target satellite to perform various antisatellite missions.

Compared to kinetic-kill ASAT weapons, there are substantial benefits to the deployment of co-orbital ASATs. Operational use is much less likely to engender uncontrolled escalation, debris is non-existent or minimal, and they can easily pass as dual-use vehicles.

The 2016 IHS report on China notes:<sup>66</sup>

China may also be developing co-orbital weapons. These "assassin" satellites would reside in orbit awaiting orders to attack other satellites. International oversight regarding the weaponization of space is currently weak, with the Outer Space Treaty primarily focusing on the basing of nuclear weapons, or other forms of weapons of mass destruction, in space. In a 21 November 2009 report on PLAAF strategy development, Chinese academic Jiang Feng, of the China Strategy Institute, told Hong Kong newspaper *Wen Wei Po* that the PLAAF was developing "assassin satellites, laser interceptor satellites ...[and]... a new model orbital bomber".

A dual use co-orbital "assassin" or repair satellite was tested during the last week of September 2013. Following its launch on 20 July 2013, a satellite equipped with a space robotic arm – either the Shiyang-7 (SY-7: Experiment-7) or the SJ-15 maneuvered close to a third payload, the Chuangxin-3 (CX-3: Innovation-3), and then to a separate satellite, the Shijian-7. The robot-arm equipped satellite probably made contact with one of the target satellites, demonstrating its "dual use" potential; the ability to manoeuvre and contact a satellite could be used to damage critical components.

### **Directed-Energy Weapons**

Directed-energy weapons are an additional non-kinetic counterspace weapon that the Chinese have developed. Generally, directed-energy weapons possess only the capability to temporarily disable or disarm a target satellite. As a category, directed-energy weapons encompass capabilities like lasers, radio frequency, microwave, and particle-beam. The Pentagon notes that the Chinese see many of these capabilities as key to electronic warfare on the ground in a conflict with the United States.<sup>67</sup> Consequently, they have also sought to utilize them in their counterspace capabilities—particularly against U.S. GPS.

Kevin Pollpeter's March 2015 report on China's space program notes:<sup>68</sup>

China is also developing directed-energy weapons such as lasers, high-powered microwave, and particle beam weapons for ASAT missions. The Defense Department concluded in 2006 that China had "at least one...ground-based laser designed to damage or blind imaging satellites." Lasers at higher power levels can permanently damage satellites and at lower power levels can temporarily blind the imagers of a remote sensing satellite. Lasers can be based on the ground, on aircraft, on ships, or in space. In 2006 it was reported that China had fired a laser at a U.S. satellite. According to U.S. officials, the intent of the lasing is unknown and did not damage the satellite, suggesting that China could have been determining the range of the satellite rather than trying to interfere with its function.

China is also researching radio frequency (RF) weapons that could be used against satellites. Radio frequency weapons using high power microwaves can be ground-based, space-based, or employed on missiles to temporarily or permanently disable electronic components through either overheating or short circuiting. RF weapons are thus useful in achieving a wide spectrum of effects against satellites in all orbits. RF weapons employed on satellites may be detected since the satellite would need to be close to the target satellite for the weapon to be effective. A satellite armed with an RF weapon on a crossing orbit with the target satellite, however, may not be recognized as a threat. RF weapons launched on rockets could detonate near the target satellites and thus may not be detected. Because RF weapons affect the electronics of satellites, evaluating the success of an attack may be difficult since no debris would be produced.

### **Cyber ASAT Capabilities**

There has been substantial focus on China's cyber capabilities in both government and public circles. Numerous attacks emanating from China have led to the intellectual property of American companies, government, and people being compromised. Kevin Pollpeter notes that China's space capabilities may have developed substantially as a result of cyberattacks, "In 2014, the network security firm CrowdStrike released a report detailing cyber activities against U.S. and European aerospace companies since 2007."<sup>69</sup>

In April 2016, the Pentagon acknowledged that the Chinese view advanced cyberattack capabilities as key to informationized war and implementing an effective A2AD strategy. Considering the importance of space capabilities for both those strategies it is unsurprising that China has focused on developing cyberattack capabilities for satellites. Cyber ASAT also offers the plausible deniability that Beijing has been shown to favor in numerous instances like its deployment of a maritime militia made up of fisherman in the South China Sea.

The US-China Economic and Security Review Commission report notes regarding China's cyber capabilities in outer space:<sup>70</sup>

Chinese military doctrine and the integration of computer network operations, electronic warfare, and counterspace reflected in certain Chinese military organizations and research programs indicate the PLA during a conflict would attempt to conduct computer network attacks against U.S. satellites and the ground-based facilities that interact with U.S. satellites. According to one Chinese author:

*A military satellite cannot connect with the Internet. Therefore, some people think "hackers" cannot attack a satellite's command and control [system]. But in actuality, the microwave antenna of the satellite control is open, so one can intercept satellite information through technological means and seize the satellite's command and control [system]. Using this as a springboard to invade the enemy's independent network systems is entirely possible.*

If executed successfully, such attacks could significantly threaten U.S. information superiority, particularly if they are conducted against satellites with sensitive military and intelligence functions. For example, access to a satellite's controls could allow an attacker to damage or destroy the satellite; deny, degrade, or

manipulate its transmissions; or access its capabilities or the information, such as imagery, that can be gained through its sensors.

Chinese hackers likely have been responsible for several computer network operations against U.S. space assets, though the U.S. government has not publicly attributed any of them to China. If responsible, China likely used these intrusions to demonstrate and test its ability to conduct future computer network attacks and to perform network surveillance.

- In October 2007 and July 2008, cyber actors attacked the Landsat-7, a remote sensing satellite operated by the U.S. Geological Survey, resulting in 12 or more minutes of interference on each occasion. The attackers did not achieve the ability to command the satellite.<sup>107</sup>
- In June and October 2008, cyber actors attacked the Terra Earth Observation System satellite, a remote sensing satellite operated by NASA, resulting in two or more minutes of interference on the first occasion and nine or more minutes of interference on the second occasion. In both cases, the responsible parties achieved all steps required to command the satellite but did not issue commands.
- In September 2014, cyber actors hacked into the National Oceanographic and Atmospheric Administration's (NOAA) satellite information and weather service systems, which are used by the U.S. military and a host of U.S. government agencies. NOAA stopped the transmission of satellite images to the National Weather Service for two days while it responded to the intrusion and "sealed off data vital to disaster planning, aviation, shipping, and scores of other crucial uses," according to a U.S. media report citing a discussion with NOAA officials. The U.S. government has not publicly attributed the attack to any country or actors; however, then Congressman Frank Wolf stated, "NOAA told me it was a hack and it was China."

## ***U.S. Space Capabilities and Response to China***

The United States has long been dominant in space and that remains the case (**Figure 1.5**). In many ways, China's pursuit of advanced capabilities is an attempt to replicate the space infrastructure the United States has already built. Still, the U.S. space preponderance and technological advantage has led to a massive reliance by the U.S. military on its space-based capabilities. Consequently, China sees this reliance as a weakness on the part of the United States.

Considering the possible advantage that the first-strike party has in space warfare, China's growing ASAT capabilities are of deep concern to Washington. The United States has consistently reacted harshly to China's ASAT tests. In 2007 following China's kinetic ASAT test, Gordon Johndroe, the National Security Council's (NSC) chief spokesman said in a statement:<sup>71</sup>

The United States believes China's development and testing of such weapons is inconsistent with the spirit of cooperation that both countries aspire to in the civil space area. We and other countries have expressed our concern regarding this action to the Chinese.

Even as China moved away from kinetic tests in outer space, the United States remained concerned with their tests. In 2014 following China's nonorbital ASAT test, Frank Rose, the U.S. Deputy Assistant Secretary of State for Space and Defense Policy, commented:<sup>72</sup>

Despite China's claims that this was not an ASAT test; let me assure you the United States has high confidence in its assessment, that the event was indeed an ASAT test. ASAT weapons directly threaten individual satellites and the strategic and tactical information they provide, and their use could be

escalatory in a crisis. They also present a threat to key assets used in arms control monitoring, command and control and attack warning. The destructive nature of debris-generating weapons has decades-long consequences as well: they can increase the potential for further collisions in the future, which only create more debris.

In 2008, the United States conducted its own ASAT test, and shot down one of its own satellites, while making sure to minimize debris. The test was largely seen as a reaction to the Chinese test the year before and as signaling from the U.S military. The Department of Defense release following the test stated that:<sup>73</sup>

A network of land-, air-, sea- and space-based sensors confirms that the U.S. military intercepted a non-functioning National Reconnaissance Office satellite which was in its final orbits before entering the earth's atmosphere, defense officials announced in a press release. (Video)

At approximately 10:26 p.m. EST today, a U.S. Navy AEGIS warship, the USS Lake Erie (CG-70), fired a single modified tactical Standard Missile-3 (SM-3) hitting the satellite approximately 153 miles (133 nautical miles) over the Pacific Ocean as it traveled in space at more than 17,000 mph. USS Decatur (DDG-73) and USS Russell (DDG-59) were also part of the task force.

The objective was to rupture the fuel tank to dissipate the approximately 1,000 pounds (453 kg) of hydrazine, a hazardous fuel which could pose a danger to people on earth, before it entered into earth's atmosphere. Confirmation that the fuel tank has been fragmented should be available within 24 hours.

Due to the relatively low altitude of the satellite at the time of the engagement, debris will begin to re-enter the earth's atmosphere immediately. Nearly all of the debris will burn up on reentry within 24-48 hours and the remaining debris should re-enter within 40 days.

The Department of Defense continues to invest heavily in space and space-based systems as well, with \$7.1 billion requested in the FY 2017 defense budget.<sup>74</sup> Noticeably, the DoD requested for \$108 million for the Joint Interagency Combined Space Operations Center (JICSPOC) to be built in Colorado.<sup>75</sup> The JICSPOC combines the STRATCOM, Air Force Space Command, and the space intelligence community like the National Reconnaissance Organization (NRO) under one roof with the goal of better coordination.<sup>76</sup> The JICSPOC is expected to do work regarding war planning for space. Announced in September 2015, the DoD described the JICSPOC:<sup>77</sup>

The center will have the capability to develop, test, validate and integrate new space system tactics, techniques and procedures in support of both DoD and Intelligence Community space operations.

The increasing threats to space capabilities necessitates better operational integration of these two space communities, as well as civil, commercial, allied and international partners. The JICSPOC experimentation and test effort will boost the ability to detect, characterize, and attribute irresponsible or threatening space activity in a timely manner.

Ultimately, the output of the JICSPOC will enhance U.S. space operations, contribute to operational command and control within the DoD, and improve the nation's ability to protect and defend critical national space infrastructure in an increasingly contested space environment.

The United States does face a potential disadvantage in countering China's space capabilities. While the United States puts great value on maintaining space dominance, the weaker party may still gain an advantage in launching an ASAT attack. As noted earlier, conventional deterrence has not yet been fully adapted to deal with space warfare, and this is not to the advantage of the

United States as the most dominant spacefaring nation. Additionally, there have been no major open source innovations announced regarding ways that space assets can be protected.

**Figure 1.5: U.S.-China Space Launches**

**Table 2: Chinese versus U.S. Space Launches, 2010–2014**

|                                                   | <b>2010</b> | <b>2011</b> | <b>2012</b> | <b>2013</b> | <b>2014</b> |
|---------------------------------------------------|-------------|-------------|-------------|-------------|-------------|
| <b>Chinese Launches<br/>(Satellites Deployed)</b> | 15 (20)     | 19 (18)     | 19 (25)     | 14 (17)     | 16 (19)     |
| <b>U.S. Launches<br/>(Satellites Deployed)</b>    | 15 (41)     | 19 (39)     | 16 (35)     | 20 (85)     | 23 (110)    |

Source: “China’s Space and Counterspace Programs”, 2015 Report to Congress, US-China Economic and Security Review Commission, November 2015, p. 294,

[http://origin.www.uscc.gov/sites/default/files/annual\\_reports/2015%20Annual%20Report%20to%20Congress.PDF](http://origin.www.uscc.gov/sites/default/files/annual_reports/2015%20Annual%20Report%20to%20Congress.PDF)

**Figure 1.6: U.S. Satellites by Classification**

**Table 16. U.S. satellites by class and orbit**

| <b>Satellite class</b> | <b>Orbit</b> |            |            |                   | <b>Total</b> |
|------------------------|--------------|------------|------------|-------------------|--------------|
|                        | <b>LEO</b>   | <b>MEO</b> | <b>GEO</b> | <b>Elliptical</b> |              |
| Commercial             | 95           | 0          | 112        | 3                 | 210          |
| Military               | 62           | 32         | 51         | 7                 | 152          |
| Government             | 103          | 0          | 13         | 4                 | 120          |
| Civil                  | 19           | 0          | 1          | 0                 | 20           |
| <b>Total</b>           | <b>279</b>   | <b>32</b>  | <b>177</b> | <b>14</b>         | <b>502</b>   |

Source: Kevin Pollpeter, *China Dream, Space Dream: China’s Progress in Space Technologies and Implications for the United States*, US-China Economic and Security Review Commission, March 2, 2015, p.74.

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<sup>2</sup> The doctrine was originally promulgated in 1993 as “Local Warfare under High Technology Conditions” by Jiang Zemin. Hu Jintao later released his own version of the doctrine, “Local Warfare under Conditions of Informatization,” to emphasize the importance of information technology. As both doctrines have similar principles, “Local Warfare under Conditions of Informatization” will be used to refer to both concepts interchangeably in order to avoid confusing the reader.

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