China's Development of Space Warfare and Its Operational Applications

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Introduction

As early as March 2011, the journal *Aerospace America* featured an article with the title "China's Military Space Surge,"[1] which warned that there had been a rapid increase in China's capability to conduct warfare in space. Such capabilities would then in turn threaten and jeopardize the ability of the carrier battle groups of the United States to conduct operations in the Pacific. This article was soon translated into Japanese and published in *Space Japan Review*. This and other high profile articles highlight the anxieties on the part of the U.S. and Japan about China's increasing ability to militarize space, and also their concerns about its implications for the peace and security of East Asia and the entire Pacific Asia region.

On December 31, 2015 China announced the creation of three new branches of armed forces to be added into the reformed People's Liberation Army (PLA): Army General Command, Strategic Support Force, and the PLA Rocket Force. While the PLA Rocket Force replaced the old Second Artillery Corps, what is even more intriguing is the mission of the new Strategic Support Force. According to Chinese media, the Strategic Support Force will be responsible for overseeing intelligence, technical reconnaissance, satellite management, electronic warfare, cyberwarfare, and psychological warfare. It is no coincidence that Gao Jin (高津), the newly appointed commander of the Strategic Support Force, is also an expert on rocket science, which has further fueled media speculations that the Strategic Support Force has been created for the purpose of conducting future space warfare.[2]

In fact, China has been increasing the focus on the military applications of space since the end of Persian Gulf War in the 1990s. During that war, the United States mobilized dozens of satellites to aid the American-led coalition forces, enabling them to defeat Iraqi forces with extraordinary efficiency and ease. The Persian Gulf War greatly shocked PLA observers at the time, and served as a reminder that the conduct of modern warfare had been transformed by the arrival of a new generation of technology. Chinese military theorists then began to study the concept of "space warfare." The most influential was Chang Xian-Qi (常顯奇), who categorized space warfare into three distinct phases based on his observations of U.S. planning: the "Entry into Space," the "Utilization of Space," and the "Control of Space." "Entry into Space" is represented by the delivery of a military-purpose spacecraft into its designated orbit path. "Utilization of Space" is to harness the power of existing space assets to aid military operations across the land, naval, and air domains. For example, such power can manifest in the forms of using space sensors to conduct surveillance and gather intelligence for Anti-Access/Area Denial (A2/AD) against potential foes, to provide ballistic missile early warning, satellite navigation and communications, among other purposes. The "Control of Space" phase focuses on establishing "space superiority" with the missions of: (1) increasing survivability of one's own military satellites and systems; (2) disrupting, sabotaging, or destroying opposing countries' satellites and their systems when necessary; and (3) directly using space-based

[1] Covault, Craig. "China's military space surge." Aerospace America 49.3 (2011): 32-37.

[2] Gertz, Bill. "Chinese Military Revamps Cyber Warfare, Intelligence Forces". Washington Free Beacon. January 27, 2016. <http://freebeacon.com/national-security/chinese-military-revamps-cyber-warfare-intelligence-forces>.

weapons to aid in combat operations on the ground.[3]

China's Space Warfare Capabilities

After years of development, China has established an operational level of space warfare capabilities. It is useful here to provide an assessment of China's current capabilities in terms of the three different phases in conducting space warfare.

Entry into Space

Currently China's satellite launch vehicles can be divided into two distinct series: The "Long March" rockets and "Kuaizhou" rockets.

Long March Launch Vehicles[4]

The new series of Long March rockets currently being developed are the Long March 5 (LM-5), Long March 6 (LM-6), and Long March 7 (LM-7). The table below shows the payload capacity of each series.

Designed as a smaller launch vehicle, Long March 6 (LM-6) made its test flight on September 20, 2015 and delivered 20 small satellites into orbit, successfully demonstrating the feasibility of a multiple satellite launch. In terms of medium launch vehicles, Long March 7 (LM-7) has been under development since 2011 and is expected to make its first test flight at some point in 2016. Its primary missions will consist of launching remote sensing low-earth orbit satellites, supplying the space station, and delivering manned space missions. For heavy launch capabilities, the Long March 5 (LM-5) has been in development since 2007 and had a successful ground test in early 2015. It is also expected to make its first test flight in 2016 and to become the primary launch vehicle for China's future space mission to the moon.

Table 1: Payload capability of newest "Long March" series launch vehicle[5]

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[3] Chang Xianqi, "Military Astronautics", National Defense Industry Press, 2002.

[4] There are 15 types of rockets developed from Long March 1 (LM-1) to Long March 4 (LM-4) series rockets. Currently in service are Long March 2C (LM-2C), Long March 2D (LM-2D), Long March 2F (LM-2F), Long March 3A (LM-3A), Long March 3B (LM-3B), Long March 3C (LM-3C), Long March 4B (LM-4B), Long March 4C (LM-4C). Among them, Long March 2F (LM-2F) has been designed with delivering manned-space vehicle in mind.

[5] For example, see:

[1] SinoDefence, "China's new space boomers", July 4, 2012. <https://sinodefence.com/2012/07/04/chinas-new-space-boomers>.

[2] SinoDefence, "CZ-5 and CZ-7 to make debut flight in 2016", January 22, 2016. <https://sinodefence.com/2016/01/22/cz-5-and-cz-7-to-make-debut-flight-in-2016>.

[3] Gunter's Space Page, "CZ-6 (Chang Zheng-6)", February 21, 2016.

Rocket Type	Launch weight (T)	Liftoff thrust (kN)	Payload (kg)		
			LEO	SSO (700km)	GTO
Long March 5 (CZ-5-504)	N.A.	~10451	25000	N.A.	14000
Long March 6	~103.2.	1177	1500	1080	N.A.
Long March 7	594	7200	13500	5500	N.A.

Kuaizhou Launch Vehicle

Evolved from the earlier Kaituozhe (KT) rockets, China's "Kuaizhou" series are solid-fuel rockets developed by China Aerospace Science and Industry Corporation (CASIC). They are capable of delivering satellites weighing between tens of kilograms to over a hundred kilograms into low-earth orbit. Satellites can be mounted on Kaituozhe series rockets in a short amount of time, which makes them the ideal launch vehicle to serve as a type of quick-response force in space, known as "Operationally Responsive Space."[6]

Utilization of Space

Since China first launched its Dong Fang Hong I satellite in April 24, 1970,[7] it has made significant progress in developing a whole range of satellites with a variety of different functions. Those satellite systems that are capable of supporting ground, air, and naval military operations are listed below:

<http://space.skyrocket.de/doc_lau/cz-6.htm>.
[4] SinoDefence, "CZ-6 launcher takes to the sky", September 20, 2015. <https://sinodefence.com/2015/09/20/cz6-takes-to-the-sky>.
[6] Gregory Kulacki, "Kuaizhou Challenges U.S. Perceptions of Chinese Military Space Strategy", September 27, 2013, Union of Concerned Scientists. <http://allthingsnuclear.org/gkulacki/kuaizhou-challenges-u-s-perceptions-of-chinese-military-space-strategy>.
[7] See Launch Record listed by China Great Wall Industry Corporation's website, <http://www.cgwic.com/Launchservice/LaunchRecord.html>.

Table 2: China's Satellite Systems[8]

Type	Series Name	Note
Reconnaissance satellite	Fanhui Shi Weixing (FSW)	Not a true sun-synchronous orbit (SSO). Image data only recoverable after satellite return to Earth
	Gaofen	First Chinese low-earth orbit satellite with designed lifespan of more than 5 years
		High resolution optical remote sensing satellite
		L-band synthetic aperture radar (SAR) satellite
	Huanjing	Capable of hyperspectral and infrared-based multi-spectral synthetic aperture radar imaging
	Tianhui	Capable of capturing three-dimensional pictures
Navigation satellite	BeiDou-1 BeiDou-2	Regional navigation system Global navigation system, expected to be operational by 2020
Weather satellite	Fengyun 1, Fengyun 3	Polar orbit satellite
	Fengyun 2	Geosynchronous orbit satellite
Ocean satellite	Haiyang	Ocean color sensing satellite
Communication satellite	Fenghuo	"Zhongxing-22" tactical communications satellite "Zhongxing-20" strategic communications satellite
	Tianlian	Data relay satellite Geosynchronous orbit
Electronic intelligence satellite	Yaogan	Capable of functioning as triangulation network

The electronic intelligence satellites, "Yaogan" remote sensing satellites, data relay satellites, and navigation satellites deserve special attention.

Electronic intelligence satellites

Electronic intelligence satellites (ELINT) can be divided into active and passive types. Active ELINT satellites use space-based radar to detect the position and nature of ships, while passive ELINT satellites rely on the detection of radar emissions from ships to pinpoint their exact position. In March 2010, China launched Yaogan 9 which consisted of three satellites with approximate orbits of 1100 km at 63.4 degrees. Because Yaogan 9 satellites have characteristics similar to the first generation Naval Ocean Surveillance System (NOSS) developed by the United States Navy, Western observers believe that they are designed specifically with ocean-based ELINT collection missions in mind.[9] Aside from Yaogan 9, China has already launched four sets of other "Yaogan" series ELINT satellites.[10] The newly augmented Yaogan ELINT satellites will increase the revisit frequency so that the target acquisition latency can be further reduced.

"Yaogan" remote sensing satellites

[8] Feng-Tai Hwang, Hao-Chi Chang and Yen-Sen Chen, "Space Capability Technical Assessment - China Case Study", 29th International Symposium on Space Technology & Science, Nagoya, Japan, 2013

[9] Ian Easton, Mark A. Stokes, China's Electronic Intelligence (ELINT) Satellite Developments: Implications for U.S. Air and Naval Operations, Project 2049 Institute, 2011.

[10] Yaogan-16, 17, 20, and 25 are ELINT satellites. See S. Chandrashekar and Soma Perumal, "China's Constellation of Yaogan Satellites & the Anti-Ship Ballistic Missile – An Update", International Strategic and Security Studies Programme, 2015.

"Yaogan" satellites produce images based on the electromagnetic signatures reflected from the ground. As there are two different means of collecting such electromagnetic signatures, there are active type Yaogan satellites which utilize synthetic aperture radar, and passive type Yaogan satellites which rely on optical image sensing. Between 2006 and late 2015, China launched a total of 27 Yaogan satellites. Five of them are ELINT satellites, while the rest are remote sensing satellites. Though China officially claimed that they are designed for land surveillance, agricultural research, disaster monitoring, and other scientific uses, Western observers suspect that these satellites are in practice used for military remote sensing purposes.

Data relay satellite

Tianlian I, China's first data relay satellite was launched in April 2008. Tianlian I-02 and Tianlian I-03 were launched in July 2011 and July 2012, respectively.[11] Tianlian I satellites serve similar functions to the tracing and data relay satellites (TDRS) of the United States, they help to relay data communication between satellites and the ground. Such data relay satellites are crucial for China's manned-space missions and any future moon exploration mission. Tianlian I-02 satellite is located around 177 East Longitude where it may serve as part of the A2/AD data link.

Navigation satellite

To emulate the U.S. Global Positioning System (GPS) and the Russian GLONASS system, China has developed its own BeiDou navigation satellite system. Two BeiDou-1 satellites were launched in October and December 2000 respectively, and the third was launched in May 2003.[12] These three experimental BeiDou-1 satellites together formed China's first-generation satellite navigation system. However, the BeiDou-1 system covered only China and the surrounding areas, and thus only constituted a regional navigation system. BeiDou-1 also required users to transmit positioning requests first before navigation signals could be retransmitted back to them from the satellites via ground control center, as user position data had to be calculated at the ground control center. China began the deployment of BeiDou-2, its second-generation navigation system, in 2007. BeiDou-2 will consist of 5 geosynchronous orbit satellites and 30 medium earth orbit satellites, and it is expected to have complete global coverage in-service by 2020.[13]

Control of Space

The ultimate form of the ability to control space lies in the capacity to destroy other countries' satellite systems. Such destruction can be achieved by direct attack or co-orbital attack. On January 11, 2007, China launched an anti-satellite missile (ASAT) and destroyed a retired Fengyun 1 weather satellite that was orbiting at an altitude of

[11] See Launch Record listed by China Great Wall Industry Corporation's website, <http://www.cgwic.com/Launchservice/LaunchRecord.html>.
[12] Launch Record listed by China Great Wall Industry Corporation's website, <http://www.cgwic.com/Launchservice/LaunchRecord.html>.
[13] Introduction of BeiDou Navigation Satellite system published on its official website. >http://www.beidou.gov.cn/2011/12/06/20111206e06b16a3bd8846459b969277a3317e5b.html>.

865 kilometers. The destruction created a huge amount of space debris in low-earth orbit that remains and endangers the safety of other satellites. Co-orbital attacks, on the other hand, rely on sending an interceptor satellite into the same orbit path and height as the intended target, with the intention of the two coming into direct contact with one another following a few natural orbits, at which point the interceptor satellite will explode and destroy the targeted enemy satellite. When China launched the manned Shenzhou 7 mission in September 25, 2008, a small satellite named BX-1 which weighed 40 kilograms was released from the Shenzhou vehicle. Four hours later it passed by the International Space Station at a distance of merely 25 kilometers.[14] Another example is the rendezvous of the Shijian 12 and Shijian 6 satellites that took place soon after the launch of Shijian 12 on June 15, 2010. Although these two separate incidents did not result in actual co-orbital attack, Western observers see them as clear demonstrations and exercises of China's co-orbital attack capability.[15]

It is useful here to provide an assessment of China's current capabilities in terms of the three different phases in conducting space warfare. China has proven its "Entry into Space" capabilities, as it has already developed a range of highly mature satellite launch vehicles and facilities with high launch success rates. It is able to deliver various types of satellites into low earth orbit, sun-synchronous orbit, and geosynchronous orbit. China's "Entry into Space" capability should therefore be rated as "high."

In terms of "Utilization of Space" although China possess a comprehensive fleet of satellites, its BeiDou navigation satellite system currently still only able to deliver regional navigation services. In addition, China's remote sensing satellites still lag far behind the United States in both quality and quantity. China's "Utilization of Space" capability should therefore be rated "medium."

In terms of "Control of Space," China has conducted successful tests of anti-satellite weapons, proving its possession of anti-satellite capability at least against certain low-earth orbit satellites. However, China still has a long way to go before such weapons are actually deployed and become operational, and there is currently no publicly available information that indicate that China has any plan for developing space-based weapon platforms. China's "Control of Space" capability should therefore be rated "low."

Table 3: Assessment of China's Space Warfare Capabilities

	Low	Medium	High
Entry into Space			◎
Utilization of Space		◎	
Control of Space	◎		

Applications of Space Systems in Anti-Access/Area Denial Warfare

[14] Brian Weeden, "China's BX-1 microsatellite: a litmus test for space weaponization", The Space Review, 2008, <http://www.thespacereview.com/article/1235/1>.
[15] GlobalSecurity.org, "Chinese Demonstrates Satellite to Satellite Rendezvous, Inspection Test Bed for Duel Purpose Military Technology", <http://www.globalsecurity.org/space/world/china/sj-12.htm>

Among security analysts, there has been a dramatic increase in discussions concerning A2/AD in recent years.[16] Such a trend reflects the reality that A2/AD has been widely identified as the most likely strategy China would use in a conflict with the United States over the Taiwan Strait and the surrounding areas. In its most basic form, A2/AD calls for China to deploy means that can deny United States the ability to intervene in the region militarily. In particular, such strategy would focus on preventing U.S. carrier battle groups from entering the Western Pacific region in the first place. The U.S. Center for Strategic and Budgetary Assessment (CSBA) categorized A2/AD into two distinct parts: "Anti-Access" focuses on preventing U.S. military forces (such as fighter jets) from entering large stationary bases in the region, such as Kadena Air Base in Okinawa. "Area Denial" focuses on defeating U.S. naval forces entering the region.

To actually accomplish the goals of A2/AD, China has to build a comprehensive system that is able to combine and coordinate various detection, confirmation, tracking, and strike systems into one package. The trike system in this case would be the Dong-Feng 21 (DF-21) anti-ship ballistic missile. Detection, confirmation, and tracking systems would be comprised of land-based, over-the-horizon radar and satellites in space. Hypothetically, an implementation of the A2/AD mission would look similar to the following: (1) ocean surveillance satellite systems report detected target to over-the-horizon radar via data relay satellites and communication satellites; (2) over-the-horizon radar tracks and surveilles the detected target; (3) satellite systems or unmanned aerial vehicles (UAV) provide continuous updates on the detected target's real-time location; and (4) anti-ship ballistic missiles are launched against the target.[17]

Ultimately the accuracy of such A2/AD attacks is interdependent on how large the circular error probability of the strike systems are and how precise the satellite sensing systems are. To increase efficiency and ease of attack, especially against moving targets such as aircraft carriers, anti-ship ballistic missiles need to be provided with continuous updates on the target's location. It will also be useful to shorten the amount of time it takes between when sensors pick up target to the point when attack is launched, and this would involve increasing the efficiency of the individual components such as data relay, data processing, target identification, and weapon delivery.

Conclusion

Since China began development of its space program in the 1970s, it has now built up a capability in conducting space warfare that can no longer be ignored. China has matured in the "Entry into Space" phase, and it has also made significant progress in the "Utilization of Space" phase in recent years.

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[16] For example,
[1] Sam J. Tangredi, "Anti-Access Warfare-Countering A2/AD Strategies", Naval Institute Press, 2013.
[2] Christopher J. McCarthy, "Anti-Access/Area Denial: The Evolution of Modern Warfare", US Naval War College. <https://www.usnwc.edu/Lucent/OpenPdf.aspx?id=95>.
[3] Jonathan F. Solomon, "Defending The Fleet From China's Anti-ship Ballistic Missile: Naval Deception's Roles in Sea-based Missile Defense", Georgetown University, 2011.

[17] Chen Haidong et.al., "Study for the Guidance Scheme of Reentry Vehicles Attacking Slowly Moving Targets", Missiles and Space Vehicles, No. 6, 2000.

In terms of China's capability in the "Utilization of Space," attention should be focused not only on the rollout of new hardware such as satellite launches, but also the degree to which China is able to effectively integrate the various sources of data into its information downlink, processing, analyzing, and finally command and control systems. We should therefore pay particular attention to China's newly established Strategic Support Force and whether it would make efforts to integrate space information into improving the overall command, control, communications, and computer systems and intelligence, surveillance and reconnaissance (C4ISR) capabilities of its military.