2021 Report on the Defense Technology Trend Assessment –Assessment of the New Generation of Chinese Communist Party's Military Technology

Editors-in-Chief

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Preface

The inauguration of U.S. President Joe Biden in 2021 has been considered the beginning of a shift in the international strategic environment. It was anticipated that the strategic confrontation between the U.S. and China that began with former U.S. President Donald Trump would de-escalate as Biden advocated a strategic competitive relationship with the Chinese Communist Party. However, over the past year, initial predictions of de-escalation of U.S.-China relations have been undermined by the Chinese Communist Party's continued military aggression, ethnic and religious oppression in Xinjiang, as well as its national security legislation constricting human rights in Hong Kong, which have alarmed countries in the Indo-Pacific region. As a result, Biden was forced to continue Trump's Indo-Pacific strategy to curb the Chinese Communist Party's attempts. In particular, the immediate fall of Afghanistan to Taliban control after the withdrawal of U.S. troops from the country has raised international concerns regarding whether the U.S. will uphold its strategic assurances and commitments to its allies.

Over the past year, the U.S. conducted intensive joint military exercises and training in the Indo-Pacific region with regional and allied countries. In addition to the existing Quad security structure, the U.S. established a trilateral alliance (AUKUS) with the United Kingdom and Australia to upgrade the strength of its Indo-Pacific maritime alliance. In addition, Japan, Canada, the Netherlands, Germany, France, and other countries have been regularly invited to hold joint naval exercises in the Indo-Pacific region, demonstrating the determination of the U.S. and its allied countries to deter the Chinese Communist Party with superior

military power. As a consequence of this dynamic, other regions such as Northeast Asia, Southeast Asia, South Asia, the Middle East, and Europe have been affected in terms of security.

Published this year, the 2021 Report on the Security Landscape of the Indo-Pacific Region distinguishes between the strategic context and the actions of major powers that affect the Indo-Pacific region, the responses and actions of major Indo-Pacific nations, and the security implications for the Indo-Pacific region. The 15-chapter assessment report is herewith presented to provide a reference for relevant policymaking stakeholders.

As the Chinese Communist Party entered its 100th year of establishment, the political and military dynamics of the CCP in 2021 reflected a Xi Jinping in haste to establish his position in history and perpetuate his power. The "2021 Report on the Development of the Chinese Communist Party's Politics and Military" analyzes and assesses the internal and external challenges confronting the CCP from the primary perspectives of political, military, economic and social. In terms of the internal environment, the CCP released its 14th Five-Year Plan and 2035 Visionary Goals and promoted its dual-cycle policy, which not only emphasizes strategic technologies and enterprises with R&D potential but also aims to foster semiconductor industries to achieve technological autonomy. Furthermore, under the goal of maintaining stability and sustainable governance, the CCP, mindful of the coming 20th Party Congress, will intensify, not relax, its control over social, public opinion, media, and military forces.

In terms of external relations, the CCP is alienated from the international community because of its series of actions suppressing human rights and democracy and its use of a wolf warrior diplomacy to deflect international criticism. As the U.S.-China dynamic intensifies, the U.S.-Taiwan military cooperation relationship has dramatically escalated, bringing an increasing number of countries to support Taiwan and its participation in international bodies. There are divergent views on whether the CCP is overconfident and expanding externally

as a result of its rising national power, or whether it is in a state of international isolation and unrest, seeking internal stability and preventing external forces from taking advantage of the situation and adopting strong control measures. This year's 2021 Report on the Development of the Chinese Communist Party's Politics and Military provides a critical perspective on the CCP, with the hope of gaining a deeper understanding of the nature of the CCP regime.

In the wake of media reports of the launch of hypersonic missiles into space orbit in the South China Sea, the U.S.-China nuclear arms race has evolved into a competition for missiles capable of traveling faster than five times the speed of sound. While the Chinese Communist Party is actively strengthening its military intelligence, the development of new-generation military technology capabilities is not only of concern to advanced Western countries, it is also expected to impact the military balance in the Indo-Pacific region. The "2021 Report on the Defense Technology Trend Assessment—Assessment of the New Generation of Chinese Communist Party's Military Technology," pulls together forward-looking insights regarding the Communist Party's conventional military forces, strategic forces, strategic support equipment, general-purpose technology, and policy support, and analyzes the Communist Party's current and potential future defense technology capabilities and policies.

The Institute for National Defense and Security Research's research efforts range from the study of national security, the Chinese Communist Party's political and military forces, and operational concepts at the national level to the study of national defense strategies and resources, cyber security, and decision-making at the strategic level, bolstered by cross-evidence of strategic theory and practice. In addition, many scholars and experts from different fields have been invited to give lectures, teach classes, and integrate research across fields to strengthen the depth and breadth of the Institute's research results and to build research capacity.

The 2021 assessment reports are a manifestation of the annual research results of INDSR's four research institutes. In view of many topics and volumes, there are

inevitably errors and omissions, and we hope that all parties will be kind enough to offer their comments.

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Introduction

China's military power has been rapidly increasing, spanning from traditional and non-traditional forces to cyber and space domains. This development has complemented its overall warfare prowess. Therefore, China's sea power, nuclear power, and potential ability to attack Taiwan are closely watched, all of which are emphasized in the "2021 China Military Power Report" by the U.S. Department of Defense.

China has shifted from "a rich country with almighty forces" to "almighty forces of a rich country" as a result of the significant improvement in its economic strengths. It has embarked on various long-term development projects for military equipment and policies in the development of national defense technologies. A large number of financial resources have been invested in multiple R&D initiatives for critical military technologies. These developments have significantly enhanced China's national defense technologies and capabilities in recent years, evidenced by its performance upgrade of a variety of weaponry and equipment platforms. Further, it provides the physical conditions for the President of China, Xi Jinping, to realize his ambitions for China. While the U.S. still has indisputable advantages in military technology, the gap between the U.S. and China is narrowing. This trend suggests that China may surpass the U.S in certain key technologies, and the ensuing growth in China's military power may cause dramatic changes to the power structure of the Indo-Pacific region, even the entire world.

Hence, The "2021 Report on the Defense Technology Trend Assessment—Assessment of the New Generation of Chinese Communist Party's Military Technology "conducts an assessment of China's development of key next-generation military technologies. This assessment covers four areas: China's conventional military force; strategic military strength; strategic support equipment; military and civil dual-use technology and policy measures, including round forces, new-generation naval weapons, aerospace equipment, nuclear

warhead, tactic weapon-delivery capability, missile defense capability, electronic reconnaissance capability, cyberwarfare capability, space warfare capability, carrier rocket and orbiters, UAV, alternative energy for military use, propaganda technology, and legal analysis of the military industry. Furthermore, it is expected that the introduction and analysis on these subjects establish an effective understanding of the PLA's possible directions moving forward. Moreover, this will serve as a basis and a reference to Taiwan's future development of national defense strategies and military forces.

PART ONE

Conventional Forces

Chapter 1

New-generation Military Equipment of the PLA Ground Force

Jyh-Shyang Sheu*

I. Introduction

While the development of the People's Liberation Army (PLA) Navy, Air Force, and Rocket Force has been in the spotlight, group troops, including the Ground Force and Navy Marine Corps, still play an important role for China as a traditional land power.

After the military reforms in 2015, the percentage of the Ground Force in the PLA has been reduced further to below 50%.[1] As mentioned in the white paper entitled "2019 China's National Defense in the New Era", in addition to the reduction in the percentage of the Ground Force in the PLA. the original 18 group armies were consolidated into 13 group. Meanwhile, the organization was transformed into the flat structure of "corps-brigade-battalion". In accordance with the commands of "mobile operations and multi-dimensional defense and attack", the PLA has transformed its Ground Force from a "regional defense type" to a "trans-theater operation type" and continued to elevate its capabilities for precise, multi-dimensional, trans-theater, multi-functional, and sustainable operations.[2]

In the meantime, the PLA Navy Marine Corps have been growing at an alarming rate in recent years. The number of brigades was increased from two to seven in

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1 "China's Military Reform PLA Ground Force Reduced Its Manpower to Below Half," *Central News Agency*, December 19, 2017, https://www.cna.com.tw/news/firstnews/201712190098.aspx.

2 "China's National Defense in the New Era," *The State Council Information Office of the People's Republic of China*, July 24, 2019, http://www.gov.cn/zhengce/2019-07/24/content_5414325.htm.

2017 by partially restructuring the Ground Force.[3] One of the fastest-growing troops, it is equipped with navy, sea, air, and land capabilities, as it includes Aviation and Special Forces. Given its high delivery capabilities, the PLA Navy Marine Corps deserves the same high level of attention. According to Xi Jinping's comment on October 13, 2020 during an inspection, the PLA Navy Marine Corps focuses on the sovereignty over the lands and oceans it claims and the protection of overseas interests. As far as the development direction is concerned, the PLA Navy Marine Corps stresses that it should be "integrated and versatile in operation, swift in response, and capable of fighting under multi-dimensional conditions".[4] That said, the PLA Ground Force is still considered the long-term amphibious leading force in the attack on Taiwan.[5] On the other hand, the PLA Navy Marine Corps is more focused on rapid projections, possibly responsible for establishing and enhancing the stronghold after landing operations so that heavy armies can press further.

The abovementioned two ground forces both emphasize the "trans-theater operations" capability. Broadly speaking, the PLA's "trans-theater operations" cover the conventional warfare, as well as network-electronic warfare and cognitive warfare. Therefore, the PLA emphasizes innovation in "long-range capability", "information-firepower integration warfare", "precise strike", and "low altitude operations". In addition to command and control, network-electronic warfare, and battlefield situational awareness that have been highlighted in recent years, the PLA Ground Force also stresses long-range precision strike, air assaults, and light mobility forces.[6] Given its emphasis on information warfare, the PLA Ground Force focuses on the development of information technology and

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3 David Lague, "China Expands Its Amphibious Forces in Challenge to U.S. Supremacy Beyond Asia," *Reuters*, July 20, 2020, https://www.reuters.com/investigates/special-report/china-military-amphibious/.

4 Meng Sun, Ching-tong Li, "Reporting from the Battle Position ｜ A brigade of PLA Navy Marine Corps: Our Goal is to Grab the Beach and go on the Land," *Ministry of National Defense of the People's Republic of China*, June 2, 2021, http://www.mod.gov.cn/big5/power/2021-06/02/content_4886696.htm.

5 "PLA Embarks on Military Training at Multiple Maritime Spaces. Experts: Prevention of Further Collusion between the U.S. and Taiwan," *Xinhua Net*, July 20, 2021, http://www.xinhuanet.com/mil/2021-07/20/c_1211248201.htm.

6 "Era of Trans-theater Operations, Challenges Faced by the New PLA Ground Force," *people.cn*, September 14, 2017, http://military.people.com.cn/BIG5/n1/2017/0914/c1011-29535324.html.

"information-firepower integration warfare". This development includes such as by using Unmanned Aerial Vehicles (UAVs), to assistanse for target acquisitions or command control, network warfare, and enhancement of battlefield situational awareness.

With the Taiwan Strait in the middle, the PLA Ground Force can only directly attack Taiwan initially with the new long-range mutable rocket launcher. However, the invasion and occupation by ground troops remain one of the key routes to victory in the invasion of Taiwan. Therefore, Taiwan should still keep a close eye on China's development of ground equipment to ensure effective resistance with defense planning and military deployment. This chapter will be centered on the aforesaid long-range firepower, air assault, and mobility in the exploration of the PLA's key development of ground equipment.

II. Development of Key Equipment

1. Firepower Projection Capability

(1) *Development of wheeled self-prepelled Howitzer and general tactical vehicles*

The PLA has been highly focused on its artillery for a long time. In its 2019 China Military Power Report, the U.S. Defense Intelligence Agency mentioned that artillery is the key to the PLA Ground Force. Its importance is evidenced by over one-third of the military force based on artillery.[7]

In recent years, China has been developing mobility artillery by using wheeled platforms (e.g., trucks and off-road vehicles) to carry howitzer. While these vehicles are automated and digitalized to a certain degree, they are still rather simple and low-cost compared to the traditional expensive and precise self-propelled howitzers. The "mobilization" of towed artillery can effectively control costs. The major military exhibition, such as Zhuhai, have displayed similar

[7] "China Military Power: Modernizing a Force to Fight and Win," *U.S. Defense Intelligence Agency*, 2019, p. 58, https://www.dia.mil/Portals/27/Documents/News/Military%20Power%20Publications/China_Military_Power_FINAL_5MB_20190103.pdf.

Chinese systems. One example is Dongfeng Mengshi 4x4 assault vehicles (similar to hummers) equipped with 120 mm gun-mortars and 122 mm howitzers. In fact, the 6x6 truck chassis was adopted back in 2009, in conjunction with the PCL-09 track-mounted howitzers added with PL-96 122 mm howitzers.

Many new wheeled self-propelled artillery howitzers have emerged in recent years. For example, the PLA Ground Force claimed in 2019 on its Weibo that the PCL-181 truck-mounted self-propelled howitzer system[8]—an integrated 6x6 truck and 155 mm gun-howitzer[9]—was deployed in Tibet in 2017. Its 25-ton weight is lighter than the PZL-05 self-propelled howitzers. Further, the PCL-181's export model number is SH-15, equipped with an automatic targeting system, semi-automatic loading, and digital control. Its deployment has been confirmed for the 73rd, 74th, and 75th Group Armies, as well as the Tibet Military District.[10] The PCL-181 can use precision munition with the support of the BeiDou Navigation Satellite System.[11]

Another new vehicle is the PCL-171 howitzer disclosed by China Central Television (CCTV) during the second half of 2020. The PCL-171 is integrated with 122 mm howitzers into the third-generation Dongfeng Mengshi protective tactical vehicle CTL-181A. It is equipped with semi-automatic ammunition loaders and may have already been in service in the PLA Ground Force.[12] Different models have been launched for 6x6 CTL-181A with a protective chassis—a medium-size tactical off-road vehicle with a payload of 3.65 tons. It is worth noting that the carriage of this vehicle has been modified for the 120 mm heavy mortar exclusively for the purpose of providing mortar maneuvering capability instead of turning it into a self-propelled mortar. Equipped with a self-propelled air defense system and

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8 Gabriel Dominguez, "PLAGF Units in Tibet Fielding New Vehicle-mounted Howitzer," *Jane's Defence Weekly*, January 8, 2019.

9 "PCL-181 155mm Self-propelled Howitzer," *Global Security*, January 8, 2021, https://www.globalsecurity.org/military/world/china/pcl-181.htm.

10 Gabriel Dominguez, "New Chinese 155 mm SPH Also in Service with PLA's 74th Group Army," *Jane's Defence Weekly*, July 10, 2020.

11 "PCL-181 155mm Self-propelled Howitzer," *Global Security*, January 8, 2021, https://www.globalsecurity.org/military/world/china/pcl-181.htm.

12 Gabriel Dominguez, "Footage Suggests 122 mm CTL181A-based SPH is in PLAGF Service," *Jane's Defence Weekly*, December 10, 2020.

a vehicle-launched bridge, this vehicle is poised to become the shared platform for light/ medium combined arms brigades.

Meanwhile, the CM-501GA tactical cruise missiles and the CM-501XA loitering munition appeared in the 2019 International Defense Exhibition & Conference (IDEX), which may be adopted by the PLA. These are also expected to be integrated with 6x6 vehicles and equipped with the vertical launch system (VLS).[13]According to the CCTV report on July 24, 2021, the Tibetan PLA also used the new 4x4 modular 20-tube multiple rocket launcher (MRL). As it is on 122 mm or 220 mm rockets, the similarity with the NORINCO SR-7 multiple rocket launcher (MRL) suggests its origination from that system.[14] In fact, similar systems were seen in January 2020 on the Tibet Military District's WeChat official account. The deployment in the troop was earlier than the said date. All the abovementioned equipment shows the trend of mobilization. These light and fast fire power can venture into the areas not easily accessible to heavier units. They are the likely opponents in Taiwan's defense of its national territories.

(2) *Long-Range Multiple Launch Rocket System*

The long-range multiple launch rocket system has been closely watched for a long time due to its ability to directly attack Taiwan across the strait. At the military parade for the 70th Anniversary of the Founding of The People's Republic of China in 2019, new long-range firearms similar to the Norinco AR-3 were presented. According to South China Morning Post's quote from the Modern Ships magazine, these are called "PCL-191."[15] The modularized launch system can be loaded with eight 370-mm rockets at a range of 350km or two 750-mm Fire Dragon 480 at a claimed range of 500km. It was deployed at the PLA's Eastern Theater at the end of 2019.[16] Similar Fire Dragon 480 750-mm ballistic missiles appeared at

[13] Neil Gibson, "PLA Set to Adopt New Tactical Missile System," *Jane's Defence Weekly*, March 6, 2019.
[14] Gabriel Dominguez, "New MRL System in Service with PLA's Tibet Military Command," *Jane's Defence Weekly*, July 27, 2021.
[15] Some reports and analyses call this long-range rocket launcher "PCH-191" or "PHL-16."
[16] Minnie Chan, "China's New PCL191 Multiple Launch Rocket System Casts Shadow over Taiwan Strait," *South China Morning Post*, December 7, 2019, https://www.scmp.com/news/china/military/article/3041007/chinas-new-pcl191-multiple-launch-rocket-system-casts-shadow.

the 2018 Defense Services Asia Exhibition, called the "Fire Dragon 280A." This type of missile is 7.38 meters long and equipped with 480 kg high-explosive/ pre fragmented warheads, capable of accommodating different kinds of warheads. It uses an inertial navigation system and is supported by a satellite positioning system (i.e., BeiDou Navigation Satellite System), allowing a circular error probable (CEP) of about 30 meters. Based on the range of 290km claimed at that time,[17] this could be the same type of missiles or the predecessor.

Meanwhile, the PHL-03 300-mm long-range rocket launcher in service for years has also seen performance improvement. According to CCTV in October 2020, the range of PHL-03's new guided rocket has extended from 130km to 160km. It also claims to have high information and intelligence capabilities.[18] In early 2021, CCTV reported that the PLA's 79th Group Army used the PHL-03 to hit a moving target on the seas.[19] The 80th Group Army's long-range fire system was equipped with UAV reconnaissance and target capability in June 2021 to demonstrate its multi-wave missile strike and joint fire strike capabilities on the seas[20] and anti-ship potential.

China's long-range fire system adopts both non-guided and guided rockets, with the export model of guided rockets claiming to have an accuracy of 30m CEP.[21] It uses an inertial navigation system and is guided with a satellite positioning system (i.e., BeiDou Navigation Satellite System), creating a threat to stationary facilities or equipment with limited mobility.

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[17] Gabriel Dominguez, "DSA 2018: China's Norinco Reveals Fire Dragon 280A Tactical Missile," *Jane's Defence Weekly*, April 17, 2018.

[18] Gabriel Dominguez, "Update: PLAGF Brigade under Xinjiang Military Command Receives New PHL-03 MRLs," *Jane's Defence Weekly*, May 10, 2021.

[19] "Chinese PHL03A Long Range Rocket System Destroys Ship Target," *Army Recognition*, January 4, 2021, https://www.armyrecognition.com/defense_news_january_2021_global_security_army_ industry/chinese_phl03a_long_range_rocket_system_destroys_ship_target.html.

[20] "Military Drills at All Fronts! The 80th Group Army's Long-range Firearms Strike Targets on the Seas," *Xinhua Net*, June 11, 2021, http://www.xinhuanet.com/mil/2021-06/11/c_1211196532.htm.

[21] Lt. General P.C. Katoch (Retd), "China Deploys Long Range MLRS," *SP's Land Forces*, May 6, 2021, https://www.spslandforces.com/experts-speak/?id=761&h=China-Deploys-Long-Range- MLRS.

2. Development of Armored Vehicles

Among the armored cars, the recently deployed Type 15/ ZTQ-15 light tank from Taiwan, related to the VT-5 light tank for exports, is worthy of attention. The PRC Ministry of National Defense announced its deployment at the press conference on December 27, 2018.[22] At the military parade in 2019 for the 70th Anniversary of the Founding of The People's Republic of China, China deemed it one of the armaments based on the new and high-tech.[23] The 30-tons class ZTQ-15 is equipped with a 1,000 HP diesel engine. The use of the hydropneumatic suspension system allows for high mobility as it accommodates complicated terrains. Its 105-mm rifled guns can fire traditional ammunition and anti-tank missiles.[24] When used in conjunction with the armor-piercing fin-stabilized discarding sabot (APFSDS), it can shoot through c. 500-mm rolled homogeneous armors (RHA)[25] at a normal operating distance. The ZTQ-15 comes with modernized fire control and is highly digitalized. Its gun stabilizer system was the centerpiece of propaganda in the military programs of CCTV. While modular and attachable composite armors and explosive reactive armors (ERAs) provide protection to the vehicle, it also comes with a laser warning system to send out alerts when aimed at by the enemy's laser (for distance measurement or by guided missiles).

Given its lighter weight, the ZTQ-15 is suitable for the terrains in Tibet or South China, where heavy vehicles are not appropriate. Alternatively, it can join the amphibious operations during landing. It is deployed at the PLA troops in Tibet, Xinjiang, and Yunnan, as well as by the PLA Navy Marine Corps. Before the Chinese government's official confirmation of this tank in 2018, the ZTQ-15 with

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[22] "Ministry of National Defense: 15 Light Tanks Have been Deployed at the Troops," *Ministry of National Defense of the People's Republic of China*, December 27, 2018, http://www.mod.gov.cn/info/2018-12/27/content_4833052.htm.

[23] The State Council Information Office of the People's Republic of China, "China's National Defense in the New Era," *people.cn*, July 24, 2019, http://politics.people.com.cn/BIG5/n1/2019/0724/c1001-31253793.html.

[24] Franz-Stefan Gady, "China's People's Liberation Army Inducts New Lightweight Tank," *The Diplomat*, January 2, 2019, https://thediplomat.com/2019/01/chinas-peoples-liberation-army- inducts-new-lightweight-tank/.

[25] Samuel Cranny-Evans, "PLAGF's 75th Group Army Receives Additional Type 15 Lightweight Tanks," *Jane's Defense Weekly*, September 22, 2020, https://www.janes.com/defence-news/news-detail/plagfs-75th-group-army-receives-additional-type-15-lightweight-tanks.

PLA Navy Marine Corps camouflage was already seen online.[26] In the June 2021 report, CCTV formally acknowledged the use of this tank by the PLA Navy Marine Corps.[27]

3. Development of Helicopters

In recent years, PLAGF Aviation has been introducing many new-generation models. The Z-10 attack helicopter and the Z-20 utility helicopter can generally be deemed the military highlight in the 13th Five-Year Plan.[28] The Z-20, similar to Black Hawk(UH-60), started service in early 2018, signaling an important milestone.[29] This type of helicopter is highly versatile and can serve as a common platform for different military forces and special units. Until early 2021, it was known that Z-10 had been deployed at the Tibet Military District, PLA Central Theatre, and PLA Southern Theatre. The modified model was seen, with the exhaust port for engines facing upward to reduce infrared signals to the ground.[30] Meanwhile, the anti-ship Z-20F also has a derivative Navy Z-20S, equipped with eight KD-10 anti-tank missiles, suggesting that the PLA Navy Marine Corps may deploy it for attack missions.[31]

China is also developing and improving old models. For example, the Z-8L comes with a wider body than the Z-8G's, and its warhead is equipped with new photoelectric turrets, the electronic warfare system, and radar warning receivers (RWRs) for better survivability. However, it retains the original electronic warfare systems, such as missile approach warning systems, terrain-following radar, satellite communications, and antennas for BeiDou Navigation Satellite System/

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[26] Gabriel Dominguez, "PLAN Possibly Equipping Marine Corps with New Lightweight Battle Tank," *Jane's Defence Weekly*, July 18, 2018.

[27] Zhao Lei, "New Light-duty Tank Delivered to PLA Navy's Amphibious Force," *China Daily*, July 9, 2021, https://www.chinadaily.com.cn/a/202107/09/WS60e7a425a310efa1bd660b96.html.

[28] Jon Grevatt, "Progression Plan: China's Advanced Technology Objectives," *Jane's Defence Weekly*, February 2, 2021.

[29] Mike Yeo, "Chinese Media Reveals Specs of Harbin Z-20 Helo," *Defense News*, October 14, 2019, https://www.defensenews.com/global/asia-pacific/2019/10/14/chinese-media-reveals-specs-of- harbin-z-20-helo/.

[30] Gabriel Dominguez and Andreas Rupprecht, "Update: Footage Suggests PLA's Xinjiang Military Command Operating Z-20 Helicopters," *Jane's Defence Weekly*, February 8, 2021.

[31] Andreas Rupprecht, "Image Emerges of Another Z-20S Helicopter Prototype," *Jane's Defence Weekly*, July 26, 2021.

GPS.[32] The Z-8L may be deployed by the PLA Ground and Navy Marine Corps on amphibious assault ships.[33] This helicopter was showcased on July 1, 2021 at the 100th anniversary of the founding of the Communist Party of China[34] and serviced in the harassment of Taiwan at the end of August.[35] China's Z-11 in early "reference" to Eurocopter AS350 has also seen the updated Z-11WB light attack helicopter/ reconnaissance helicopter. It was heard that volume production began in December 2020,[36] which should have been in service already. Further, its training models have appeared at the Chinese People's Liberation Army Aviation School.[37]

III. Battlefield Values and Impacts

In sum, the development of the ZTQ-15, vehicle-mounted howitzers, and air assault force speaks of the PLA's emphasis on trans-theater operations and stronger projection capability. The long-range fire attack ensures the PLA Ground Force to have certain long-range strike capability instead of relying on the Rocket Force completely.

Even the improved old PHL-03 and PCL-191 only have a range of over 160km and can barely attack the target along the western coast of Taiwan. If the range can reach 500km, it will pose a significantly greater threat to stationary and semi-mobile important facilities and equipment in western Taiwan. While long-range fire attacks accompanied with inertia navigation and satellite assistance can achieve

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[32] Gabriel Dominguez and Andreas Rupprecht, "Update: Images Show Wide-body Variant of Z-8G Helicopter Undergoing Load-carrying Trials," *Jane's Defence Weekly*, August 8, 2020.

[33] Liu Xuanzun, "China Unveils First Indigenous 15 Ton-class Transport Helicopter; Amphibious Assault Role Expected," *Global Times*, August 25, 2020, https://www.globaltimes.cn/content/1198797.shtml.

[34] "China Publicly Debuts Z-8L Heavy-Lift Helicopter," *Aviation Week*, July 1, 2021, https://aviationweek.com/defense-space/aircraft-propulsion/china-publicly-debuts-z-8l-heavy-lift- helicopter.

[35] Yu-hsuan Huang, "Two Z-8 Helicopters as the New Joiners to Harass Taiwan. Approaching the Midline of the Taiwan Strait and Over Taiwan's Airspace," *Up Media*, August 27, 2021, https://www.upmedia.mg/news_info.php?SerialNo=122839.

[36] Andreas Rupprecht and Gabriel Dominguez, "Update: CHAIG's Z-11WB Light Attack Helo to Enter PLA Army Aviation Service 'Soon'," *Jane's Defence Weekly*, January 4, 2021.

[37] Andreas Rupprecht and Gabriel Dominguez, "Update: Image Suggests Training Variant of Z-11 Helo in Service with PLA Army Aviation Academy," *Jane's Defence Weekly*, May 10, 2021.

strikes with certain precision, the costs of ammunition also go up. Weapons that can be considered short-range ballistic missiles (SRBM), such as Fire Dragon 480, may be even more expensive. Although they may still be cheaper than the Rocket Force's ballistic missiles, the feasibility of deployment in large quantities is another issue. This type of standoff weapons (SOWs) are less of a threat to forces of good mobility. Nonetheless, they are major problems for airports, radar stations, command and control nodes, and key infrastructure and facilities.

As far as the force projection is concerned, the ZTQ-15 is a rare gem light tank among modern battle tank, given its design and weight of 30 tons. In the foreseeable future, perhaps only the Mobile Protected Firepower (MPF) light tank and its comparable under development by the U.S. Armed Forces will have the mobility and terrain negotiating capability to achieve effects in the Taiwan Strait conflict. A new Y-20 transport aircraft can carry two vehicles. During an amphibious operation and despite its lack of amphibious capability, the ZTQ-15's advantage of easy projection can still greatly enhance the fire power and protection in the first wave of invasion assault. It could be the heaviest military vehicle encountered by Taiwan's armies in the initial phase defense against invaders. Although a 30-plus ton vehicle can only carry limited weaponry, its laser warning device, composite armor, and explosive reactive armor (ERA) have certain protective effects. Its modernized range and electronic system also enhance awareness advantages, which likely creates a first-mover advantage against the old-fashioned, yet-to-be-improved tanks owned by the ROC Armed Force. Equipment such as wheeled Self-propelled howitzers boosts the firepower of the light/ medium combined arms brigade. The strengths in mobility and projection enable the rapid deployment of significant fire support, while the development of a shared platform simplifies logistics. In addition, vertical assault forces such as helicopters expand the PLA's capability in deep battles. In the Taiwan Strait environment, air assault is essential to the invasion of Taiwan, where there are no large amphibious landing points. If the PLA can improve projection capabilities to a certain degree, it may even take the plunge and deploy ground troops even with partial advantages at sea and in the air. Therefore, it is necessary to devise relevant countermeasures and

responses sooner rather than later.

IV. Conclusion

This chapter attempts to explore the possible ground threat from the PLA in Taiwan's defense of its national territories. The equipment mentioned above provides China with more options in ground deployment and force projection. The long-range fire attack is essentially the epitome of the evolution of long-ran precision weaponry. That said, the many aforesaid strengths of light mobile vehicles complement heavy corps. The advantage in mobility compensates for the shortcomings of heavy units in complex and difficult terrains and the insufficiency in amphibious capabilities. Heavy units can provide subsequent and necessary support and progress deeper into the assault. In the modern battlefield, a high degree of information and network capabilities are required to enhance awareness through the collaboration of various platforms, in addition to human training. Only by doing so can the equipment work its military strengths. Therefore, the development of robust and relevant capabilities other than platforms is currently the most critical task for the PLA.

Chapter 2

Review of the New-generation Weapon Development of the PLA Navy

Hsin-Biao Chiang*

I. Introduction

The PLA Navy's development of platforms underwater, on the water surface, and over the air, such as anti-ship ballistic missiles (ASBMs), submarine-launched ballistic missiles (SLBM), and electromagnetic weapons, have constantly been improving in quality and quantity, thereby achieving significant results. Among these, electromagnetic weapons are known for low costs and high effects, which may change the patterns of warfare in the future once in service.

Therefore, this annual report on technological trends focuses on the PLA Navy's ship-based electromagnetic weapons. The weaponization of optoelectronics laser technology is mainly based on high-energy laser (HEL), high-power microwave (HPM), low frequency and extremely low frequency (LF & ELF), particle-beam weapons, plasma weaponry, radio frequency (RF), sonic weaponry, coilgun (Gauss rifle), electromagnetic railguns (EMRGs), electrothermal-chemicals (ETCs), electrothermal guns, high-altitude electromagnetic pulses (HEMPs), reconnection guns, Advanced Arresting Gear (AAG), and Electromagnetic Aircraft Launch System (EMALS). These are all new concept weaponry, distinctively different from traditional artillery. The first seven categories are classified as directed-

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energy weapons (DEWs),[1] and the remaining are the weapons and equipment driven by strong magnetic force through electricity. Limited by space, this paper only assesses laser, microwave, and electromagnetic railguns as more developed new concept weapons of the PLA Navy ship-base electromagnetic weapons. The characteristics and weaknesses are summarized, and the potential impact on modern warfare is analyzed. While this paper does not cover other electromagnetic weapons, equipment, and possible platforms, the ROC Armed Force, national defense research institutions, and think tanks should keep a close eye on the development trends given the equally profound impact on military warfare.

II. Development of the Ship-based Electromagnetic Weapons of PLA Navy

1. High Energy Laser Weapons

Under China's State High-Tech Development Plan (the 863 Program) that started in 1986, laser weapons were among the 20 prioritized military R&D highlights.[2] This includes carbon dioxide (CO2) laser, chemical oxygen-iodine laser (COIL), free-electron laser (FEL), and X-ray laser. The output power of CO2 laser and COIL is above 10,000 watts. The destructions caused by the thermal effects of strong lasers have been well tested by extensive theoretical analyses and experiments. In an anti-missile test in 2000, the PLA's high-energy laser weapons destroyed a laterally launched missile. Despite the success in the initial test, it was not deployed in the troops, possibly due to issues in energy storage, recycling, and oversizing/ overweight. Laser weaponry requires large power supplies. Although a solid-state laser (SSL) boasts longevity, its heavy 10-ton weight limits its applicability—a daunting challenge to carry it with airplanes or vehicles. Thus, it

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1 Edited by the Editorial Committee of Common Terms in Mainland China, *Compilation of Common Terms in Mainland China* (Taipei: Showwe Information, 2009), p. 172.

2 Dallas Boyd (principle), Jeffrey G. Lewis and Joshua H. Pollack (contributed), *Advanced Technology Acquisition Strategies of the People's Republic of China* (Contract Number: DTRA01-03-D-0017, T.I. 18-09-03) (Virginia, USA: Defense Threat Reduction Agency Advanced Systems and Concepts Office, 2010), p. 81.

can only be installed at fixed land positions or on large warships. If the electricity supply issue can be resolved, its advantage and efficiency of continuous firing will be easily deployed. After twenty years of testing and improvement, China seems to have overcome the difficulty in storage, size, and weight. It is even said that laser weaponry has been installed on the anti-aircraft deck of the 055 destroyers (above the bridge).[3]

2. High Power Microwave System

In general, microwave weapons seek to render electronic systems overloaded and functionless by aiming at the target with high-power-directed energy pulses. The higher the energy, the greater the microwave system's interference to the target electronic systems (e.g., generators and communications systems). High-power microwave weapons can even cause physical damage to targets.[4]As microwave weapons on naval ships boast high power and long beam propagation distances, they are less restricted in terms of weight, space, and power than high-energy laser weapons. Some equipment has been installed on large warships for real battle testing and assessment, which will likely become a standard weapon for PLA Navy ships within the next five years. Deputy Head of Northwest China Nuclear Technology Institute, Huang Wen-Huang, and his team have been studying directed-energy weapons (DEWs) for years and received the first prize of the National S&T Progress Award in January 2017. According to relevant academic papers, the system developed by the team may be used for anti-missile systems on warships. This system is primarily done with microwave interfering and damaging the missiles from the enemy or the electronic equipment on the platform. Relevant tests and simulations were carried out in 2010 at the Northwest Desert, which showed meaningful results.[5] The ROC Armed Force should never underestimate

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[3] Richard D. Fisher, Jr., "China's Progress with Directed Energy Weapons," paper presented at the Testimony before the U.S.-China Economic and Security Review Commission hearing (Washington, D.C., USA: February 23, 2017), p. 8.

[4] Jeffrey Lin and Peter W. Singer, "China's New Microwave Weapon Can Disable Missiles and Paralyze Tanks," *Popular Science*, January 27, 2017, https://www.popsci.com/china-microwave-weapon-electronic-warfare/.

[5] Louis A. Del Monte, *War at the Speed of Light: Directed-Energy Weapons and the Future of Twenty First Century Warfare* (Nebraska, U.S.: University of Nebraska Press, 2021), p. 106.

the potential threat from China's high-power microwave weapons.

3. Electromagnetic Railguns (EMRGs)

Since the 1980s, when the U.S. listed the R&D of electromagnetic railguns (EMRG) in its Strategic Defense Initiative (SDI), the development and application of electromagnetic kinetic weapons have entered the world of modern warfare like in science fiction.[6] Electromagnetic railguns are named for the two electromagnetic tracks of the warhead.[7] The gigantic electromagnetic force pushes the metal warhead and strikes at the target at the ultra-speed of 4-7 Mach. This means it can go much further than any bullets of ammunition and cause greater damages to the target. For instance, the Lorentz force of 32 megajoules (MJs) can push out a solid projectile of 10kg in weight and hit-to-kill a target 100 knots away with ultrasonic kinetic energy.[8] In April 2014, the PLA Navy Type 072-class amphibious landing ship (Haiyang Shan, Pennant number 936) conducted the first test on the sea. Later in March and December of 2018, there were multiple disclosures of successful trials of electromagnetic railguns on the sea.

The U.S. intelligence determines that the year 2025 is the earliest timeframe for the PLA Navy to deploy electromagnetic railguns in service.[9] In June 2021, the U.S. Navy formally terminated its electromagnetic railgun R&D project initiated in 2005.[10] This information has two implications. First, the problems in the materials and energy storage of electromagnetic railguns are unlikely to be easily solved. Second, China may have made significant progress on these issues. Ordinary shipboard artillery can fire approximately 600 shots. Due to the limitation

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6 Brian Weeden and Victoria Samson ed., *Global Counterspace Capabilities: An Open Source Assessment* (Washington D.C., USA: Secure World Foundation, April 2019), pp. 3-13.

7 Josh K. Elliott, "Why China's 'Miracle' Railgun Weapon Should Scare the U.S. Navy," *Global News*, January 3, 2019, https://globalnews.ca/news/4810853/china-railgun-warship-weapon/.

8 Arthur Dominic Villasanta, "Type 055 Second Generation Chinese Destroyers to be Armed with Railguns," *China Topix*, July 27, 2016, https://www.chinatopix.com/articles/96685/20160727/second-generation-chinese-destroyers-armed-railguns.htm.

9 Jared Keller, "China's Electromagnetic Railgun Is Apparently Already Roaming the High Seas," *Task and Purpose*, December 29, 2018, https://taskandpurpose.com/military-tech/chinas-electromagnetic-railgun-sea-trials/.

10 Konstantin Toropin, "The Navy Finally Pulls the Plug on the Railgun," *Military.com*, July 2, 2021, https://www.military.com/daily-news/2021/07/02/navy-finally-pulls-plug-railgun.html.

of materials resistant to high heat, an electromagnetic railgun may need to replace its gun barrel after ten to twenty shots. Further, relevant electronic components will also be burned and eroded. However, frequent replacements of gun barrels and electronic components seem uneconomical. The efficiency of energy storage is also highly relevant to the continuous firing capability of electromagnetic railguns. Hence, it is estimated that the earliest service will be in 2025 despite the "successful" test in 2018, as there should still be some outstanding problems with the PLA Navy's electromagnetic railguns. This means the pushout of the commissioning timeframe of the 055A destroyer due to the planned installation of electromagnetic railguns.

III. Advantages and Disadvantages of Ship-based Electromagnetic Weapons and their Impacts on the Battles

1. High Energy Laser Weapons

Laser weapons use powerful directed laser beams to destroy the target directly or render it functionless. It is a high-tech concept weapon that uses the strong energy of high-brightness laser beams to damage or injure the enemy's airplanes, missiles, satellites, and personnel. This type of weapon has advantages other weapons cannot compete with, including fast shooting speed, high precision, long-range interception, quick transfer of fire, freedom from electromagnetic interference, strong staying power, and no pollution to the environment. Meanwhile, the main shortcomings lie in the high energy requirement, bottlenecks in high-energy battery technology, oversizing and overweight, inability to handle all-weather operations, and vulnerability to cumulus clouds, dense fogs, heavy snows, and stormy rains. It is difficult to overcome energy attenuation caused by atmospheric disturbance and abruption of laser energy in the atmospheric environment. Despite all these, China has obtained significant achievements in the R&D of directed-energy weapons (DEWs), particularly with airborne laser (ABL), anti-satellite (ASAT) laser, and tactical high-energy laser (THEL).

There have been multiple cases evidencing China's application and achievement in weaponizing lasers. In 2005-2006, China used high-energy land-based lasers several times to illuminate the U.S. spy satellites flying over China's airspace[11] in order to dazzle or blind them.[12] In May 2018, the U.S. Armed Forces accused the PLA's base in Djibouti of using laser weapons against the U.S. reconnaissance airplanes on numerous occasions.[13] In February 2020, No. 161 Fleet of the PLA's Southern Theatre entered the West Pacific for "Long-Sea Navigation" training and used lasers to point at the U.S. Armed Forces P-8A maritime anti-submarine aircraft. The U.S. accused this as an "unsafe and unprofessional behavior."[14] According to these cases, high-energy laser weapons are non-lethal but sufficient to render the enemy and the enemy's military equipment hors de combat. During the (Abu Dhabi) International Defence Exhibition & Conference (IDEX) in February 2017, China Poly Group Corp. claimed that it was developing a navy 30+ kW Silent Hunter—a fiber-optic laser system that could destroy approaching missile boats or reconnaissance and strike integrated UAVs one kilometer away. With precise positioning, it can also neutralize the seekers of subsonic missiles or precision-guided munitions (PGM). Moreover, high-energy laser weapons are expected to dramatically reshape naval warfare.[15] The laser weapon powers required for the destruction of specific targets are summarized in Table 2-1:[16]

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[11] Ajey Lele, *Strategic Technologies for the Military: Breaking New Frontiers* (CA., USA: SAGE Publications, 2009), pp. 96-97.

[12] Yousaf Butt, "Effects of Chinese Laser Ranging on Imaging Satellites," *Science and Global Security*, No. 17, 2009, p. 30.

[13] Gordon Lubold and Jeremy Page, "Laser from Chinese Base Aimed at U.S. Military Pilots in Africa's Skies, Pentagon Charges," *The Wall Street Journal*, May 3, 2018, https://www.wsj.com/articles/laser-from-chinese-base-aimed-at-u-s-military-pilots-in-africas-skies-pentagon- charges-1525351775.

[14] Ryan Browne, "US Says Chinese Warship Fired Military Laser at US Aircraft," *CNN*, February 28, 2020, https://edition.cnn.com/2020/02/27/politics/chinese-laser-us-aircraft/index.html.

[15] Richard D. Fisher, Jr., "China's Progress with Directed Energy Weapons," p. 8.

[16] Ben Goodlad, "Star Wars: High Energy Laser Weapons Awakening," *Jane's Intelligence Briefings*, April 21, 2016, http://janes.ihs.com/Janes/display/jibr2260-jibr.

Table 2-1 Laser Weapon Powers Required to Destroy Specific Targets

Power in kW				
~10 kW	10~90 kW	100 kW	500~999 kW	1 MW
UAV				
	Rockets, artilleries, and mortars			
		Speed boats/trucks		
			Missiles	

Source: Jane's Intelligence Briefing, April 21, 2016.

2. High Power Microwave Weapons

The main characteristics of microwave weapons include broad beams, wide ranges, fast speeds, and great power. Attacks can be made without aiming at targets. It is not subject to the impact of weather or the atmospheric environment. As the transmission is sufficient to penetrate walls and glass, the barrier limitations are relatively low. The light size and volume imply a small space required, which allows a large number of platforms for installation. Unseeable and impalpable, microwave weapons are known as the "invisible killer". However, its major shortcoming lies in poor resistance to interference. More so, as it is impossible to differentiate proponents from opponents, friendly armies and their electronic equipment near the target zone are likely to be damaged. Further, damage assessment is difficult. Active denial systems (ADS) are one of the applications of high-power microwave weapons, whose millimeter wave (mmWave) transmitter is suitable for enforcing protection missions.[17] In continuous conflicts, HPMs can be used to intimidate enemies by achieving four strategic goals: (1) punishment; (2) risks; (3) decapitation; and (4) denial.[18] These coercive effects are particularly

[17] Edward H. Lundquist, "Transforming War at Sea Through Disruptive Technologies: New Weapons Are Energizing the Maritime Battlespace," *Defense Media Network*, May 21, 2011, https://www.defensemedianetwork.com/stories/transforming-war-at-sea-through-disruptive-technologies/.

[18] Jack McGonegal, *High Power Microwave Weapons: Disruptive Technology for the Future* (Diss., Air Command and Staff College, 2020), p. 14.

useful to counter-terrorism and for countervalue targets.[19]

Jin Canrong said in an interview in November 2020 that the PLA used microwave weapons to repel the Indian army during the Ladakh conflict. While the Indian government condemned this as fake news, the Year-End Review—2020 Ministry of Defence published in January 2021 accused China of using unorthodox weapons and causing dizziness and nausea among the Indian soldiers at the mountains near the Pangong Lake. Hence, they had to withdraw[20]—an indirect confirmation of the fact. Microwave weapons can also attack satellites, ballistic missiles, cruise missiles, airplanes, naval ships, armored vehicles, communications systems, radar, and computer equipment. In particular, it can physically damage and paralyze command nodes important to communications hubs and combat links to an irreparable degree. In February 2017, the UK Daily Star newspaper said that, even without firing a bullet, China's newest ray weapon could neutralize the enemy tanks, take down military planes, and obliterate warships. Peter Warren Singer, a U.S. expert in modern warfare, believes that microwave weapons have punished the frontier of offensive and defensive operations and changed war activities for the future.[21] Its influence cannot be ignored.

3. Electromagnetic Railguns (EMRGs)

Electromagnetic railguns (EMRGs) are known for high speeds, long ranges, severe destructivity, resistance to interception and interference, large load capacities, and low costs. They may replace land-attack cruise missiles (LACM) for tactical air support and naval gunfire support (NGFS) going forward, which

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[19] In the military theories, countervalue refers to assets valuable to opponents but not constituting military threats. Examples are cities and civilians.

[20] Press Information Bureau, "Year End Review–2020 Ministry of Defence," *Government of India*, January 1, 2021, https://pib.gov.in/PressReleseDetail.aspx?PRID=1685437; Aakriti Sharma, "Has India Finally Acknowledged That Chinese PLA Used Microwave Weapons Against Indian Soldiers in Ladakh?," *The Euro Asian Times*, January 6, 2021, https://eurasiantimes.com/has-india-finally-acknowledged-that-chinese-pla-used-microwave-weapons-against-indian-soldiers-in-ladakh/.

[21] Henry Holloway, "China's 'Killer Microwave' Drone to Blast Planes, Fry Warships and Paralyse Tanks," *Daily Star*, February 12, 2014, https://www.dailystar.co.uk/news/latest-news/china-war-weapon-microwave-drone-16983208.

is revolutionary to naval warfare, tactical operation, sea platform designs, and equipment development. In sum, it is a new concept weapon set to change the ways of war. The main weaknesses of EMRGs include the extremely high electromagnetic power requirement and the difficulty in storing electricity. The power supply systems are bulky, heavy, complex in structure, and prohibitively high in cost. The high heat and the electric arc during launch ablates the slideway and reduces the lifespan of gun barrels. In addition, shooting precision is subject to the influence of the atmospheric environment; the further the range, the greater the error. It is difficult for the EMRG anti-load capacity to reach the ideal shooting range. For example, a range of 400 km imposes a loading of 40,000 Joules on electronic components, which remains a daunting technical challenge.

The long list of shortcomings with electromagnetic railguns can be generalized into three key areas. (1) Electricity generation and storage: Electromagnetic railguns require a powerful electromagnetic force for hypervelocity projectiles (HVPs). It is also necessary to store the energy for launching at any time; (2) The ultra-heat after launch needs to be dealt with; otherwise, the electromagnetic slideway will be disintegrated by the ionized plasma caused by vaporization due to extreme heat;[22] (3) It is relatively easy to handle the friction heat born by solid bullets during flight. Guided non-solid bullets ensure precision at the possible expense of hit-and-kill effectiveness. Therefore, the key to China's success in the development of electromagnetic railguns is the materials capable of coping with high heat. Based on the strike of a target 2,000 km away by the DF-17 hypersonic missile at the 20 times of velocity of sound and the successful return and landing by the Shenzhou-12, the challenge lies in the installation of miniature seeker components for HVP and the materials resistant to ultraheat. Moreover, whether the increased bullet costs undermine the overall advantages of electromagnetic railways is worthy of assessment. China's military technology and science research institutes have been working on guided warheads and electromagnetic rockets.

[22] Tate Nurkin, *China's Advanced Weapons Systems* (Prepared for U.S.-China Economic and Security Review Commission) (USA: Jane's by IHS Markit, 2018), p. 213.

The next generation of electromagnetic railguns and electromagnetic rockets are expected to enter service in 2030.

IV. Conclusion

Both microwave and laser weapons are state-of-the-art technology with or close to the transmission speed of light. Although the functioning principles of these two types of weapons are similar, they kill and hurt in different ways. Laser weapons are out for a hard kill by focusing laser beams precisely toward targets for neutralization. On the other hand, microwave weapons aim for a soft kill by interfering or burning military electronic components, which require much lower energy than lasers and can be installed in small platforms such as UAVs. Both of these directed-energy weapons (DEWs) have already demonstrated many use cases on the battlefield. They will enter service earlier than electromagnetic railguns, which will take a few more years for maturity and readiness.

The key for electromagnetic weapons to work depends on a large amount of electricity. Traditional naval ships with mechanical propulsion and power systems separated from each other cannot continuously meet the needs of electromagnetic weapons. Other weapons and facilities can only supply electricity for different sections at the same time. In contrast, the integrated electric propulsion (IEP) system can greatly enhance the efficiency of electricity and meet the requirements for naval ship motion, weapon launches, equipment operation, and electricity for living. Meanwhile, the PLA Navy has no ships equipped with integrated electric propulsion yet—a probable limiting factor why electromagnetic weapons (particularly electromagnetic railguns) have not been installed onboard.

Judging from the installation of an electromagnetic aircraft launch system (EMALS) and advanced arresting gear (AAG) on Type 003 aircraft carriers, it can be certain that the power system of Type 003 aircraft carriers is an integrated electric propulsion to provide strong support for electromagnetic equipment on the ship. The PLA Navy's electromagnetic weapons can be used for air and missile

defense (AMD), anti-access/ area denial (A2/ AD), closed-in weapon systems (CIWS), counter-space, counter UAVs or counter drones, and electronic warfare (EW). Given the high effectiveness of electromagnetic weapons and equipment to future warfare, China will continue to splash money and efforts on R&D and deploy integrated electric propulsion on different naval ships over the next few years. This matter should be closely watched.

Chapter 3

Development of China's Major Aviation Equipment

Jui-Min Hung*

I. Introduction

The 14th Five-Year Plan (2021-2025) for National Economic and Social Development and Vision 2035 of the People's Republic of China (the 14th Five-Year Plan) published in March 2021 classified the aerospace and aviation industry as one of the strategic and emerging sectors and the new pillar of China's industrial system.[1] This shows that aviation equipment is currently on the top of China's national agenda.[2] The technology in use or under development for such equipment underpins whether the PLA Air Force is able to smoothly migrate from the defensive position for its national territories to airland battles, both in offensive and defensive operations. In addition, as the PLA planes have significantly stepped up their harassment of Taiwan, it is also necessary to keep a close eye on their newest development in order to establish an effective response strategy. This chapter analyzes some of China's main aircraft, engines, and airborne weapon systems and assesses their development, influence, and outlook.

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1 "Outline of the 14th Five-Year Plan (2021-2025) for National Economic and Social Development and Vision 2035 of the People's Republic of China," *Central People's Government of the People's Republic of China*, March 13, 2021, http://big5.www.gov.cn/gate/big5/www.gov.cn/xinwen/2021-03/13/content_5592681.htm.

2 China refers to the People's Republic of China herein.

II. Development of Key Equipment

1. Main Aircraft Force

(1) *J-20*

The J-20 fighter was defined as the fifth generation of military aircraft during its debut in 2011, entered formal service in 2017, and is still under constant improvement by the Beijing government. In the adoption of the Electro-Optical Targeting System and the nose cone design with technology and design similar to those of the U.S. Air Force, F-22 and F-35, the J-20 fighter also came up with some unique technology, including an excellent capacity for its built-in fuel tank. In recent years, the main progress with the J-20 fighter has been the surface finish, including Low Observable (LO) technology and overall manufacturing quality, such as (pneumatic) actuators and intakes.[3] However, the lag in the engine R&D makes it impossible for the J-20 fighter to perform super-cruise, and its radar cross-section (RCS) is also too high. While its rectangular faceted nozzle achieves stealth by reducing radar returns from the engine,[4] it will be hard-pressed to achieve the Very Low Observable (VLO) standard before the completion of its own engine, WS-15.

There have been a small number of J-20 fighters produced. The 15 J-20 fighters at the 100th anniversary of the founding of the Communist Party on July 1, 2021 were the largest public parade to date.[5] According to various data sources, there is no definite conclusion regarding its total numbers.[6] It is generally believed to

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[3] Justin Bronk, "Russian and Chinese Combat Air Trends," *Royal United Services Institute*, October 30, 2020, https://static.rusi.org/russian_and_chinese_combat_air_trends_whr_final_web_version.pdf p. 41.

[4] "The Shorter the Engine, the More Powerful J-20? Breakthrough in Rectangular Faceted Nozzle to Reduce Infrared Radiation by 80%," *Tencent*, November 18, 2020, https://new.qq.com/omn/20201118/20201118A0I52I00.html.

[5] Ning-che Liu, "Celebrating the 100th Anniversary of the Founding of the Communist Party of China: 15 J-20 Fighters Debut in Large Numbers at Tiananmen Square," *Ta Kung Pao*, July 1, 2021, http://www.takungpao.com/news/232108/2021/0701/604195.html.

[6] Examples are relevant discussions: Hsi-fu Ou, "Chinese Communist Party Exaggerates Strengths of J-20," *National Defense Security Real-time Assessment*, July 8, 2021, https://ppt.cc/fvpGTx; Lu Bo-Hua, "At Least 150 J-20 Fighters in Service, PLA Air Force Announces It Attains the Threshold as Strategic Aircrafts," *China Times*, August 31, 2021, https://www.chinatimes.com/realtimenews/20210831005816-260409?chdtv.

be in the range of 24 to 150 fighters. There is not much public information on the J-20 fighters in live-fire exercises. Meanwhile, the question remains whether its technology is mature enough to engage in battles—perhaps why there have been only a small number of J-20 fighters produced to date.

(2) *Y-20*

Over the recent years, there have been attempts to remodel Y-20 transport aircraft into an aerial tanker Y-20U as the PLA's main force in order to provide air refueling by three aircraft to accommodate six to eight J-11 Series or J-20 fighters.[7] The fuel volume each Y-20U can carry is three times larger than HY-6 aerial tankers. On the other hand, while the Il-78 has a similar fuel carrying capacity with Y-20U, the Y-20U's glide ratio is larger, given its supercritical wings which provide a better climb performance and greater fuel efficiency.[8]

Furthermore, the Y-20U's development is approaching its final stage, with the completion of the prototype's first flight in 2018. The aerial pictures at Xi'an Yanliang Airport on December 30, 2020 showed the parking of four Y-20U aircraft completely remodeled, which means that its remodeling plan has been completed or the quality is sufficient to achieve serial production.[9] On September 3, 2021, pictures of Y-20U aircraft's training with J-16 fighters were taken.[10] All these signs suggest that Y-20U has been gradually entering the PLA Air Force's military power.

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7 Xiao Shan, "Successful Remodeling by China to Greatly Y-20 Aerial Tankers," *Groupe Radio France Internationale*, April 28, 2019, https://ppt.cc/fQlMMx.

8 "HY-6 Y-20U enlisted, enhancing PLA Air Force's remote warfare capability," *MP Headlines*, September 13, 2021, https://min.news/zh-tw/military/b37960ae2e05a807c86bee45188539a9.html.

9 Mike Yeo, "Satellite Images Suggest China's New Tanker Aircraft is Under Production," *Defense News*, February 18, 2021, https://www.defensenews.com/global/asia-pacific/2021/02/18/satellite-images-suggest-chinas-new-tanker-aircraft-is-under-production/.

10 Greg Waldron, "China's Y-20U Tanker Spotted Flying with Fighter," *Flight Global*, September 3, 2021, https://www.flightglobal.com/defence/chinas-y-20u-tanker-spotted-flying-with-fighter/145332.article.

2. Engines

(1) *WS-15*

The first batch of J-20 fighters produced in 2016 was equipped with AL-31FN Series 3—the modified version of Russia's AL-31F engines—at a thrust of 137 kN. Despite China's intention to push for the replacement of AL-31FN with 160-180 kN WS-15 engines for J-20 fighters as early as possible, the final test remains a hurdle. Hence, the J-20 fighter had to use the WS-10C engine as a transition.[11] As the improvement model of WS-10B, WS-10C has the thrust vector control capability and a thrust of 145 kN.[12] At the Zhuhai Airshow from September 28 to October 3, 2021, the J-20 fighter with "a Chinese heart" made its debut.[13] While the Beijing officials did not specify which domestic engine is this Chinese heart, it is likely an indication of the near completion of the re-equipment of J-20 fighters with WS-10C.[14] That said, WS-10C's thrust is still behind the 156 kN F-119 engines for F-22 fighters and 190 kN F-135 engines for F-35 fighters. The requirement for WS-15 is rather urgent.

Furthermore, we can see China's constant progress in the key technologies of engine production in recent years. For instance, while an engine's turbine blades must resist strong heat and high temperatures, the turbine inlet temperature in the new generation engines, such as F-135, reaches 1,980 degrees Celsius. Special alloys must be used to withstand the working temperature above 1,000 degrees Celsius. After the rare metal rhenium was discovered in Shaanxi in 2010 for high-temperature alloys, the single crystal blades made with rhenium alloys reached

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[11] Minnie Chan, "China Wants to Modify the Engines on its J-20 Stealth Fighter to Match the US's F-22," Business Insider, January 11, 2021, https://www.businessinsider.com/china-modifies-j20-stealth-fighter-engine-to-match-us-f22-2021-1?r=US&IR=T.

[12] Ning-che Liu, "Domestic Aviation Development Finally Takes Off, WS-10 Enters the 14-Ton Era, Remodeling of Multiple Aircrafts at the Same Time," *HK01*, November 21, 2020, https://www.gushiciku.cn/dl/0ln53/zh-tw.

[13] "How Big the Challenges to Overcome for Statement about "Chinese Heart" of J-20 Fighter?," *Sina Military Section*, September 29, 2021, https://mil.news.sina.com.cn/china/2021-09-29/doc-iktzscyx7084139.shtml.

[14] "As Closing Remarks for Zhuhai Airshow, Experts Comment on China's New Weapons and UAVs under Development," *Voice of America*, October 5, 2021, https://www.voachinese.com/a/booming-Chinese-drone-industry-is-aiming-at-practical-military-defense-and-offense-20211005/6257705.html.

the first-flight standard in 2017.[15] In 2020, the Chinese media revealed that China is able to mass produce single-crystal blades,[16] which indicates sufficient stability in quality—a big boost to the service life of WS-15. Furthermore, Cheng Ronghui, Chief Designer of WS-15, was listed at the top of the list of candidates for 2020 Military People of the Year[17]—an indirect validation of the meaningful development of WS-15 to date.

(2) *WS-20*

The PLA Air Force hopes to replace the Russia-made D-3 and its improved version, the WS-18 engine, with WS-20. Compared to D-30's bypass ratio of 1:2.24 and WS-18's bypass ratio of 3, WS-20's bypass ratio reaches 1:5. Currently, the development with WS-20 is smooth. On November 23, 2020, the Y-20 equipped with WS-20 completed its first flight.[18] There has been subsequent increasing news flows about relevant tests.[19] On July 14, 2021, the Aviation Industry Corporation of China's official Weibo posted a Y-20 carrying four big alcohol barrels, implying the start of the retrofit with WS-20.[20] At the 2021 Zhuhai Airshow, the Y-20 Chief Designer Tang Chang-Hong said that "Y-20 is equipped with a Chinese heart and has been going well",[21] which is also a statement on the satisfaction of the WS-20 development.

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[15] "Superb New Materials for Chinese Aircraft Engines, Able to Hold Shape under 117 Tons of Weight," *Sina Military Section*, September 5, 2017, http://mil.news.sina.com.cn/jssd/2017-09-05/doc-ifykqmrv9836273.shtml.

[16] "Congratulations! China's First Volume Production of Single Crystal Blades for Aircrafts," *kknew.cc*, May 11, 2020, https://kknews.cc/zh-sg/n/9vmgm4b.html.

[17] "WS-15 Chief Engineer at Top of Military Engineering Awards. Testimony of Great Success of WS-15," *Zhihu*, December 15, 2020, https://zhuanlan.zhihu.com/p/337112609.

[18] Wen Chu, "Major Breakthrough: China's Y-20 with Domestic WS-20 Engines Takes First Flight," *MdEditor*, June 13, 2021, https://ppt.cc/fbdShx.

[19] "Newest Photo of Y-20B Equipped with Four WS-20 Engines in Test Flight. Aviation "Heart Disease May Have Healed," *MdEditor*, July 19, 2021, https://www.gushiciku.cn/dl/0zZ9G/zh-tw.

[20] "Y-20B Likely to Be Officially Confirmed for Newly Changed Aircraft Engines of High Bypass Ratio Meeting Expectations," *Sina Military Section*, July 17, 2021, https://mil.news.sina.com.cn/china/2021-07-17/doc-ikqciyzk6037298.shtml.

[21] "J-20 Fighter and Y-20 Installed with Chinese Hearts! Closeup at Aviation Exhibitions: Big Country, Heavy Weapons, Power of China," *CCTV International*, September 30, 2021, https://www.youtube.com/watch?v=75M9wdqKzEA&ab_channel=CCTV%E4%B8%AD%E6%96%87%E5%9B%BD%E9%99%85.

3. Airborne Weapon Systems

(1) *Anti-Radiation Missile (ARM)*

The two missiles hanging on the J-11BS's side wing shown in the video released by the PLA Air Force in November 2020 are believed to be China's most recently developed Anti-Radiation Missiles (ARMs), with the same features as China's CM-102 ARM for exports and India's Rudram-1 ARM.[22] This suggests that the new ARM may be developed on the technological basis of the former. In addition, it adopts a Double-Pulse Solid Rocket Motor that matured on the PL-15 and has a range further than CM-102's 100 km.[23]

(2) *Air-to-air Missiles*

The PL-21 showcased in 2016 is the ultra-long-range air-to-air missile (AAM) at the forefront of R&D efforts. Similar to the PL-15, it is equipped with a Double-Pulse Solid Rocket Motor, whose combustion chamber has a diaphragm that divides incendiary agents into two independent ignition systems. Ignition timing for different systems is controlled by the airborne computer on the rocket. After the completion of the first pulse, the ignition for the second pulse can be determined according to actual requirements, which enables effective management of rocket fuels and increases flight distance. Meanwhile, the PL-21's Active Radar Homing achieves independent guiding by emitting and receiving radar waves. It is said that the PL-21's range already reaches 300 km or even 400 km,[24] which is a great improvement from the PL-15's range of 200 km.

However, as the Chinese authority has never published information related to PL-21, how it achieved technological breakthroughs is closely watched. While a Double-Pulse Solid Rocket Motor increases the range, the solid propellant rocket

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[22] Thomas Newdick, "This May Be Our First Glimpse of China's New Air-Launched Anti-Radiation Missile," *The Warzone*, November 9, 2020, https://www.thedrive.com/the-war-zone/37513/we-may- just-have-got-the-first-glimpse-of-chinas-new-air-launched-anti-radiation-missile.

[23] "New Weapon for J-16D to Suppress S400 and Standard 6 System (Picture)," *Sina Military Section*, November 12, 2020, https://www.cna.com.tw/news/firstnews/202103310114.aspx.

[24] "With a Missile Length of Six Meters, Larger than J-20 Fighter's Internal Weapon Bay, Can PL-21 Attain a Range of 400km?," *Military Comments Online*, April 29, 2021, https://club.6parkbbs.com/military/index.php?app=forum&act=threadview&tid=16369457.

engine requires its own oxidant and fuels. The longer the range, the heavier the weight and the larger the size. This attribute is accompanied by greater complexity and higher costs.[25] In addition, the solid propellant rocket engine also affects the detection and strike of targets. Therefore, whether the PL-21 development is as reported by the Chinese media remains observed.

III. Battlefield Values and Impacts

1. Major Aircrafts

(1) *J-20*

Considering the limited number of the manufactured fifth generation, the PLA Air Force will rely on the fourth generation of fighters as its main force over the next few years. According to the report, "Military and Security Developments Involving the People's Republic of China 2020", submitted by the U.S. Department of Defense in September 2020 to the Congress, the PLA's major fighters are J-10, J-11, and J-16, at a total number of over 800.[26]

However, the small number of J-20 fighters are already playing a role in air defense by accompanying the four generations of fighters in the event of the enemy's invasion of China's airspace. The P-15-equipped J-20 poses a grave threat to the opponent's intelligence, surveillance, and reconnaissance (ISR) capability. In addition, a better-performing built-in fuel tank strengthens its role as a long-range interceptor, allowing it to strike the approaching energy aircraft far from the homeland. This is a thorny problem for the U.S. Armed Forces, which rely on aerial tankers overseas air combats.[27]

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[25] "PL-20/PL-21," *Global Security.org*, January 5, 2021, https://www.globalsecurity.org/military/world/china/pl-21.htm.

[26] Office of the Secretary of Defense, "Military and Security Developments Involving the People's Republic of China 2020," *U.S. Department of Defense*, September 1, 2020, https://media.defense.gov/2020/Sep/01/2002488689/-1/-1/1/2020-DOD-CHINAMILITARY-POWER-REPORT-FINAL.PDF, pp. 50-51.

[27] Justin Bronk, "Russian and Chinese Combat Air Trends," *Royal United Services Institute*, October 30, 2020, https://static.rusi.org/russian_and_chinese_combat_air_trends_whr_final_web_version.pdf, p. 41.

(2) *Y-20*

The Y-20U's service can effectively boost the range and the operating radius of the PLA Air Force.[28] According to the Hong Kong media, the completion of each air refueling increases by 25-30% of the operating radius of the H-6N bomber and by 30-40% of the operating radius of the J-8 and J-10 fighter aircraft,[29] which implies a significant enhancement of the J-20 fighter's air superiority in the West Pacific. With the air supply from Y-20U, the J-20 fighter can continue to cruise without worrying about fuels. Its operating radius is expected to lengthen from 1,700 km to 2,500 km.[30] In the face of the U.S. Armed Forces fleeting from the First Island Chain and the Second Island Chain during conflicts at the Taiwan Strait, the J-20 fighter will be able to strike out by intercepting to ensure air dominance during the invasion of Taiwan.

2. Engines

(1) *WS-15*

The lag in the WS-15 development means the J-20 fighter has no adequate power. Under this circumstance, thrust vector control is a liability because it increases the fighter's weight.[31] While the retrofit with WS-10C improves the problem of insufficient thrust, the J-20 fighter still cannot achieve a super-cruise without an afterburner. Until the testing with WS-15 is completed, the J-20 remains unable to fully exercise its performance as a fifth-generation fighter.

(2) *WS-20*

The installation of WS-20 provides two benefits to Y-20. First, Y20 can

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[28] Hsi-fu Ou, "China's Aerial Tanker Fleet," *National Defense Security Real-Time Assessment*, April 28, 2021, https://ppt.cc/f1wLWx.

[29] "Strongest Protection- H-6U Refueling for All Air Space and Air Force's Strengths up by Folds," *Ta Kung Pao*, April 19, 2021, http://www.takungpao.com.hk/news/232108/2021/0419/576130.html.

[30] "First Picture of Air Refuelling of J-20 Fighter Released by Chinese Military, Implying Combats Extended to Guam," *Radio France Internationale*, November 13, 2020, https://ppt.cc/fwoYkx.

[31] Jamie Hunter, "China's Enhanced J-20B Stealth Fighter May Arrive Soon, Here's What It Could Include," *The Warzone*, July 20, 2020, https://www.thedrive.com/the-war-zone/34990/chinas-enhanced-j-20b-stealth-fighter-may-arrive-soon-heres-what-it-could-include.

enter mass production without worrying about insufficient engines. Estimates from Chinese experts based on the requirements of battles and rescue missions demonstrate that the PLA currently needs to equip 400 Y-20 aircraft.[32] As the delivery of D-30KP-2 engines from Russia is slow, there were embarrassing situations when no engine was available to Y-20.[33]

The WS-20's quality reliability implies that Beijing can fully control the Y-20's supply chain. Further, it is possible to construct a strategic transport force based on Y-20 according to actual requirements. Moreover, Y-20 can fully perform its capabilities. A stronger thrust can increase the effective loading from 50 tons to 66 tons and make it possible to ship main equipment, such as Type 99 Main Battle Tanks previously not manageable by Il-76. The improvement in fuel consumption extends the range and the loiter time,[34] which empowers Y-20 to undertake strategic transport missions for further distances and achieve goals for the air force.

3. Airborne Weapon Systems

(1) *Anti-Radiation Missile (ARM)*

China's progress in anti-radiation missiles (ARMs) will have tremendous benefits on the offshore battles for its air force. This is critical considering the enhanced air force capabilities in recent years among China's neighboring countries with strained ties. India's purchase of S-400 missile systems from Russia is one example, whose delivery is expected at the end of 2021. Meanwhile, the delivery and deployment of Pac-2 performance enhancements and Pac-3 missiles purchased were completed in Taiwan. The PAC-3 Missile Segment Enhancement

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[32] "Y-20 Becomes One of World's Top 10 Strategic Transport Aircrafts. Over 400 in Demand," *HK 01*, January 8, 2021, https://ppt.cc/f1q1ix.

[33] Chia-hsin Hsieh, "Chinese Military Magazine Says Only 40 Y-20 Aircrafts Can Be Produced with Engines Available. In Urgent Need of Domestically Developed Engines," *Sina Military Section*, July 26, 2014, https://ppt.cc/flqlix.

[34] "Newest Photo of Y-20B Equipped with Four WS-20 Engines in Test Flight. Aviation "Heart Disease May Have Healed," *MdEditor*, July 19, 2021, https://www.gushiciku.cn/dl/0zZ9G/zh-tw.

(MSE) is scheduled for completion in 2026.[35] By working with the J-16D electronic warfighter, it will be able to effectively destroy the aforesaid anti-aircraft missiles.

(2) *Air-to-air missile*

The PL-21's length of nearly six meters makes it impossible to be hung on the J-20 fighter's internal weapon bay, and it would expose the J-20 fighter if hung outside. It is generally believed that the PL-21 would be hung on the J-16 for long-range strikes. The PL-21's ultra-long-range strike capability can play a pivotal role in the destruction of business intelligence and logistic supplies of the enemy's air force system. Air Early Warning (AEW) airplanes and aerial tankers usually operate away from hot war zones, up to 300 km away. Therefore, the PL-21's successful development with a range of 400 km can effectively attack high-value targets, such as Air Early Warning (AEW) airplanes and aerial tankers, and strongly enhance the PLA's anti-access/ area denial (A2/ AD) capabilities.

IV. Conclusion

As far as the PLA Air Force's overall development in aviation equipment is concerned, the shift from the defense of national territories to airland battles—both for offensive and defensive operations—indicates the intention of the new cohort of leaders in Beijing for the PLA Air Force to go out and go big in offshore attack and defense missions. The recent technological reforms and breakthroughs at different levels in fighters, transport aircraft, ARMs, and air-to-air missiles enable the PLA Air Force to fly from defense to offense. China's stronger remote warfare capabilities are an increasing threat to the neighboring countries in the Indo-Pacific. The growing intensity of Chinese aircraft harassing Taiwan is a case in point. It is meant to intimidate Taiwan and demonstrate the rising strengths of the PLA Air

[35] "R.O.C. Armed Force Confirmed Purchase of PAC-3 Missile Segment Enhancement (MSE) from U.S. Armed Forces. Deployment to Be Completed in 2026," *Central News Agency*, March 31, 2021, https://www.cna.com.tw/news/firstnews/202103310114.aspx.

Force.

That said, Beijing is still faced with many challenges, and engines have been the Achilles heel of the PLA Air Force. The slowness in the engine R&D prevents many aircraft under development from fulfilling the full capabilities and indirectly undermines the utilization benefits of airborne weapons. The Chinese government's strong emphasis on engines can be seen in many policies. However, China is still behind the U.S. and European countries in this regard. Whether it can overcome the long list of problems will determine the strategic development of China's air force over the next few years.

PART TWO

Strategic Forces

Chapter 4

China's Development of Nuclear Warheads

Wen-Chung Chai*

I. Introduction

In July 2021, the U.S. media mentioned that James Martin Center for Nonproliferation Studies in Monterey, California has determined, based on satellite images, that China is building a large number of intercontinental ballistic missile (ICBM) launch facilities in Yumen, Gansu. Meanwhile, the Chinese official media denied the allegation and claimed that the so-called "missile launch facilities" are wind turbine foundations under construction. After the media coverage, the opinions from social media on military strategies were divided. Some thought it was a deliberate misjudgment from the U.S, while others believed China was deceiving the enemies. However, the truth of this particular event is not important. When we track long-term trends, we will never change the determination on overall directions due to one-off events. As mentioned in the introduction, China started to modernize its nuclear weapons—as a natural course of action—after it had completed the modernization of traditional military equipment. It is important to the realization of their dreams as a powerful nation and a powerful military force. With traditional weapons alone, it is not possible to obtain any advantage in negotiations or international competition. While we cannot impose any restraints on China's modernization of nuclear weapons, it is still necessary to keep a close eye on China's development in nuclear weapon modernization and extract the

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possible trends regarding Taiwan's national security and national defense in order to prepare and minimize potential conflicts. The following section explains the factors relevant to China's development of nuclear weapons by focusing on China's nuclear policy, the current inventory of nuclear warheads, and the R&D direction on warheads. These three elements constitute China's nuclear weaponry strengths in the future. Analyses and judgments are conducted on China's number, types, and deployment methods of warheads in due course.

II. China's Nuclear Policy

To this date, the Chinese government has not yet released a whitepaper or provided policy debates for its nuclear weapon policy. Therefore, we can only analyze and synthesize the talks from China's leaders, the contents of China's military strategies, and the official documents ever published to establish an overall understanding of the core elements of China's nuclear policy. This information will be quite useful in examining China's development of nuclear warheads.

In theory, China's nuclear policy should not deviate from its current military strategy. The fundamental driver is to use nuclear weapons to strengthen and achieve military goals. Since the establishment of the New China, China has made multiple adjustments to its guidelines on military strategy in different time periods—from the initial "to lure the enemy in deep" to the current "victory in the local war in intelligence". Even so, "proactive defense" has always been part of China's military strategy, in which its fundamental spirit is robust self-defense and readiness for attacks.[1] In this context, China's nuclear policy is undoubtedly hinged on the spirit of proactive defense. For instance, in the white paper entitled, "China's National Defense in 2008", the "PLA Second Artillery Force adheres to the national strategy of no prioritization in the use of nuclear weapons and ensures self-defense in the nuclear strategy...PLA Second Artillery Force's nuclear missiles

[1] On the formation and development of China's proactively defensive military strategy, please refer to *Military Strategy Research Department of PLA Academy of Military Science, Strategics* (Beijing: Military Science Press), December 2013, pp. 41-50.

are not aiming at any country at normal times. When the country is under the nuclear threat, Nuclear Missile Force will enhance the status of alert and prepare for a nuclear strike, to deter the energy not to use nuclear weapons against China."[2] "China's Military Strategy" published in 2015 says that "... no use or threatening to use nuclear weapons without conditions to the country without nuclear weapons and the areas without nuclear weapons. No engagement in the nuclear arms race with any country. Nuclear weaponry is always maintained at the minimum level required to protect the national security."[3]

The above statement indicates that China adopts a defensive strategy for its nuclear policy, where the use of nuclear weapons is not prioritized, and there will be no nuclear strike on countries without nuclear weapons. That said, the most important part and the part in need of clarification in its nuclear policy is the idea of "minimum deterrence". The current proposition of China's nuclear policy is to fight back after being hit by the first strike. If the target of deterrence is the U.S., the balance required to achieve deterrence is extremely significant. Without a large number of warheads and launch devices with high survivability, it is impossible to establish credible deterrence required for this strategy. As China understands the limitation of the "minimum deterrence" in its nuclear policy, the most direct and reasonable approach is to deploy more nuclear warheads on the PLA Navy's nuclear ballistic missile submarines to ensure its nuclear deterrence without disrupting the existing political statement. In the foreseeable future, and

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[2] State Council Information Office of the People's Republic of China, "China's National Defense in 2008," January 2009, https://web.archive.org/web/20090123104120/http://www.gov.cn/jrzg/2009-01/20/content_1210075.htm.

[3] State Council Information Office of the People's Republic of China, "China's Military Strategy," May 2015, http://www.scio.gov.cn/zfbps/ndhf/2015/Document/1435161/1435161.htm. In April 1995, China issued a statement and commitment of no use or threatening to use nuclear weapons, without conditions, to the countries without nuclear weapons or to the regions without nuclear weapons. It is currently the only country announcing security assurance for nuclear weapons among the permanent members of the United Nations Security Council. Please refer to the *People's Republic of China's national report in the performance of Treaty on the Non-Proliferation of Nuclear Weapons*, published by Permanent Mission of the People's Republic of China to the United Nations Office at Geneva and Other International Organizations in Switzerland, April 29, 2019, http://www.china-un.ch/chn/dbtyw/cjjk_1/Bj_1/ t1665265.htm; "List of countries in possession of nuclear weapons," *Wiki*, https://www.wikiwand.com/zh-mo/%E6%A0%B8%E6%AD%A6%E5%99%A8%E6%93%81%E6%9C%89%E5%9C%8B%E5%88%97%E8%A1%A8.

as China continues to strengthen its nuclear weaponry, it may discard the strategy for "minimum deterrence" and adopt a more agile and flexible nuclear policy. For instance, the U.S. adopted a "flexible response" strategy in the 1960s. The tenet of this strategy is to respond with the same weapon the enemy uses. If it is impossible to use traditional weapons for deterrence, the use of nuclear weapons may be prioritized. In this way, China can revert its disadvantage of a passive response in the use of nuclear weapons and obtain dominance in force through "vertical escalation". With appropriate political control, traditional weapons and nuclear weapons can be effectively combined to properly respond to a wide range of military threats.

III. Assessment of China's Warhead Inventory

In general, there are two most direct and most commonly used indicators in the review of a country's nuclear military power: the number of warheads and the quantity of all types of warhead launch devices. Warheads are small in size and easy to hide. When the military is unwilling to disclose relevant information for confidentiality, it is difficult for outsiders to come up with an accurate estimate. Warhead launch devices are large in size, and outside parties can easily find out the construction process. Hence, the gap is not too wide between the estimated number and the actual number. Furthermore, China is a totalitarian regime and exercises far more strict control on confidential data than democratic countries. It is only possible to conduct an analysis based on open information from governments and private think tanks. A preliminary understanding of China's nuclear strengths and weaknesses can be established by guesstimating its inventory of nuclear warheads and combing through these warheads' types, numbers, payloads, ranges, and launch devices.

Currently, there is a large divergence among authoritative institutions in different countries regarding the estimated number of China's warheads. For instance, the U.S. Department of Defense thinks it is less than 200. Meanwhile, the Stockholm International Peace Research Institute (SIPRI) and the Research Center for

Nuclear Weapons Abolition (RECNA) estimate it to be 350. On the other hand, the Federation of American Scientists (FAS) approximates it to be 272. It is possible that the U.S. Department of Defense applies a higher standard in the estimation of warhead numbers; hence, its guesstimate is lower than the numbers produced by other sources. Given its long-term observation of the PLA's military development and the professional caliber of the personnel, this number should not deviate too much from the fact. Hence, the general approximation of China's number of nuclear warheads ranges between 200 and 300. Table 4-1 summarizes the projected value of China's number of warheads and launch devices in 2020.[4]

Table 4-1 shows that the less than 20 warheads owned by China have the explosive power of megatons of TNT equivalent, and its remaining warheads have yielded the explosive power equivalent to 200k to 300k TNT each. Based on the explosive power of these warheads, the PLA may only have two or three types currently in service. As far as the deployment methods are concerned, most of China's warheads are land-based. Examples are the missile launch facilities or transporter erector launchers (TELs), with the latter better in mobility and less likely to be detected or targeted by enemies. China's number of submarine-launched ballistic missiles is too small. Even if they all survive the enemy's first strike, they cannot constitute credible deterrence for the second strike.[5] The PLA's

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[4] Office of the Secretary of Defense, *Military and Security Developments Involving the People's Republic of China 2020* (Washington, D.C.: Department of Defense, 2020), p. ix; "World Nuclear Forces," *Stockholm International Peace Research Institute*, https://sipri.org/sites/default/files/2021-06/yb21_10_wnf_210613.pdf; "Chinese Nuclear Weapons Capability," *Research Center for Nuclear Weapons Abolition*, https://www.recna.nagasaki-u.ac.jp/recna/bd/files/03_china2021_ en.pdf; Hans Kristensen and Matt Korda, "The Pentagon's 2020 China Report," *Federation of American Scientists*, September 1, 2020, https://fas.org/blogs/security/2020/09/the-pentagons-2020-china-report/.

[5] Currently, there are a total of 48 submarine-launched ballistic missiles (SLBMs) deployed by the PLA Navy. In comparison, the U.S. Navy's each Ohio class submarine is equipped with 20 Trident II submarine-launched ballistic missiles (SLBM) and each missile can carry up to 14 nuclear warheads. In theory, a single Ohio class missile submarine can carry nuclear warheads equivalent to China's total number. In practice, the ballistic missile submarines currently in service in the U.S. Navy has deployed over 200 submarine-launched ballistic missiles (SLBM), carrying 900 warheads or so. The difference is day and night between the U.S. Navy and the PLA Navy in the number of warheads carried by each submarine or the nuclear strike capability of ballistic missile submarines fleets. See Hans Kristensen, "US SSBN Patrols Steady, But Mysterious Reduction in Pacific in 2017," *Federation of American Scientists*, May 24, 2018, https://fas.org/blogs/security/2018/05/ssbnpatrols1960-2017/.

number of air-based nuclear warheads is even lower. Currently, there are only air-delivered nuclear warheads. The air-launched ballistic missiles and cruise missiles are still under development. Given a constantly expanding scope covered by sensors, it is impossible to use bombers to launch nuclear warheads by going through the enemy's anti-aircraft network. Hence, the PLA's R&D of air-based nuclear warheads will likely focus on air-launched ballistic missiles and cruise missiles. As the latter is rather mature in technology, air-launched nuclear cruise missiles should be one pillar of China's strategic triad.

Table 4-1 Estimates of China's Number of Warheads and Catapults (2020)

Catapult No.	Payload (No. of warheads x explosive power)	No. of catapults	No. of warheads
DF-4	1 x 3.3 mt	6	6
DF-5A	1 x 4-5 mt	10	10
DF-5B	5 x 200 – 300kt MIRV	10	50
DF-5C	5 x 200 – 300kt MIRV	0	0
DF-21A	1 x 200 – 300kt	20	20
DF-21E	1 x 200 – 300kt	20	20
DF-26	1 x 200 – 300kt	200	20
DF-31	1 x 200 – 300kt	6	6
DF-31A	1 x 200 – 300kt	36	36
DF-31AG	1 x 200 – 300kt	36	36
DF-41	3 x 200 – 300kt MIRV	0	0
JL- 2	1 x 200 – 300kt	48	48
JL- 3	3 x 200 – 300kt	0	0
H- 6K	1 x bomb	20	20
H- 6N	1 x ALBM	0	0
H- 20	2 X ALCM	0	0
Total		412	272

Source: Hans Kristensen and Matt Korda, "The Pentagon's 2020 China Report," *Federation of American Scientists*, September 1, 2020, https://fas.org/blogs/security/2020/09/the-pentagons-2020-china-report/.

Almost all of China's nuclear warheads are launched by ballistic missiles, covering short, medium, long, and intercontinental ranges. Ballistic missiles return to the earth extremely fast, and the countermeasures are difficult. If the maneuverable reentry vehicle (MaRV) is deployed for warheads on DF-21 missiles, it is even more challenging for the enemy to implement anti-missile interception. While China has made a breakthrough in the multiple independently targetable reentry vehicle (MIRV) technology, its number of warheads stays within 300. It is possibly because of the inability to achieve warhead miniaturization, as mentioned extensively in the "Cox Report" published in 1999. Therefore, China needs a holistic approach and a comprehensive analysis in its modernization of nuclear weapons, especially when it comes to enhancing the performance and range of ballistic missiles and issues related to nuclear warheads, such as the types, functions, deployment, mobility, and survivability. For the purpose of deterrence, the Chinese military should not pursue a large inventory of nuclear artillery. It should rather focus on the maintenance and deployment of the sufficient number and survivability of warheads, which reduces the prohibitive costs of nuclear warhead deployment and maintenance. In this way, it also allows for the allocation of resources on the structural optimization of nuclear army forces and the survivability increase of nuclear warheads.

IV. Future Development of China's Nuclear Warhead

In December 2015, Xi Jinping instructed in the ceremony for the PLA Ground Force's establishment of Rocket Force and Strategic Support Force (SSF) to prepare the strategic requirement for the new force to carry out "comprehensive deterrence and warfighting" operations with "both nuclear and conventional" capabilities and enhance "credible and reliable nuclear deterrence and counterstrike capabilities", "medium- and long-range precision strike capabilities", and the ability to contribute to the "strategic balance" between China and its main strategic

competitors."[6] Compared with the previously released white paper entitled, "The Diversified Employment of China's Armed Forces", the PLA Rocket Force is given the additional strategic requirement for "comprehensive deterrence and warfighting".[7] This means that the PLA Rocket Force should be equipped with a broad spectrum of capabilities in tactical deterrence, limited nuclear wars, and all-out nuclear wars. The section below explains China's potential development in nuclear warheads to ensure "comprehensive deterrence and warfighting" capabilities. Only nuclear warheads are adequate in supporting all of the Rocket Force's missions and the effective implementation of the strategic goals of "comprehensive deterrence and warfighting".

1. Miniaturization

In the early days of nuclear weapon development, all countries competed in large equivalent warheads. However, the heavy weight, complexity in launch and support systems, and high costs in operation and maintenance have turned different nations to the R&D of nuclear warhead miniaturization. Nuclear warhead miniaturization offers many benefits, including a significant increase in the number of warheads a ballistic missile can carry. When combined with the MIRV warhead technology, it can strike a larger number of targets and make it more difficult for the opponent's anti-missile defense. Most importantly, the rapid advancement of technology has empowered miniaturized nuclear warheads with huge destruction capabilities. The W-88 nuclear warhead deployed on the U.S. Navy Trident II ballistic missile is only c. 800lb in weight. However, its explosive power is 475k tons of TNT equivalent. For the nuclear bomb drop in Hiroshima, the U.S. used 50 kg (110 lb.) to generate the explosive power of 15k tons of TNT equivalent. In keeping up with this trend, China's top priority is centered on the R&D and the deployment of miniaturized nuclear warheads to strengthen the strike capability and maximize the number of nuclear warheads each platform can carry.

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[6] "Xi Jinping Presented PLA Ground Force, Rocket Force, and Strategic Support Force was Flags, and Gave Speeches," *cpcnews.cn*, January 2, 2016, http://cpc.people.com.cn/BIG5/n1/2016/0102/c64094-28003839.html.

[7] State Council Information Office of the People's Republic of China, "The Diversified Employment of China's Armed Forces," April 2013, http://www.gov.cn/zhengce/2013-04/16/content_2618550.htm.

2. Multiple models

In the foreseeable future, the variety of China's platforms for carrying nuclear warheads will dramatically increase. These platforms include intercontinental ballistic missiles (ICBMs), submarine-launched ballistic missiles (SLBMs), aerial bombs, air-launched cruise missiles, and ballistic missiles. The methods used by platforms to launch nuclear warheads are not necessarily the same. There are also significant differences in weights, ranges, and payloads. Different nuclear warhead models must be designed to effectively accommodate the various requirements of these platforms. For instance, submarine-launched ballistic missiles (SLBMs) cannot launch a thermal nuclear warhead with the power of megatons TNT equivalent, given the size and the weight of the warhead. To meet the strategic goal of "comprehensive deterrence and warfighting", China needs to develop and deploy different types of nuclear warheads for different missions and platforms to achieve tactical deterrence and engage in limited nuclear wars and all-out nuclear wars. On the other hand, China may simplify the large variety of ballistic missiles to reduce the cost of operations and maintenance of nuclear warheads. It may also launch platforms and develop different models of nuclear warheads and ballistic missiles that can launch multiple types of nuclear warheads.

3. Specialization

The specialization of nuclear warheads is the integration of miniaturization and variety in the types mentioned above, designed to strike specific targets. During the Cold War, the Soviet Union and the U.S. developed and deployed many specialized nuclear warheads, such as neutron bombs and nuclear landmines against tanks and armored units; nuclear torpedoes, nuclear mines, and nuclear depth bombs against the targets on the water surface and beneath waters; and nuclear electromagnetic pulse (NEMP) warheads to neutralize the enemy's communication system with a nuclear blast in the air. While these warheads come with smaller equivalents, they still cause lethal damages to the targets. Noteworthily, there are no significant collateral damages; hence, no heavy casualties of innocent civilians, which translates to a greater possibility of practical use in real battles. The PLA Rocket

Force has about 1,200 short-range ballistic missiles (SRBM).[8] The development of various specialized nuclear warheads to be deployed on these missiles can greatly boost the flexibility in utilizing nuclear warheads and empower various nuclear warheads with wider strategic and tactical capabilities.

V. Conclusion

Based on the above analysis of China's nuclear policy, types, and the number of nuclear warheads, a summary can be drawn regarding China's shortcomings in nuclear weaponry and its areas for improvement. In reference to the achievements by the U.S. and Russia in the nuclear warhead technology during the Cold War, a comparison and an inference can be established on China's possible directions and long-term trend in the R&D of nuclear warheads. Each nuclear warhead may not be large in size, but its quantity, model design, and deployment method are tied to a nation's nuclear policy and military strategy and may even have a profound influence on the nuclear arms race between superpowers. In the examination of China's nuclear warheads, the following developments and trends can be summarized:

In line with the modernization of traditional military strengths, China is also enhancing the performance of its nuclear weaponry, including ballistic missiles and nuclear warheads.

"Comprehensive deterrence and warfighting" is currently a strategic goal for the PLA Rocket Force. To prepare for nuclear wars in different scenarios, China needs multiple types of nuclear warheads.

China is expected to pursue miniaturization, variety, and specialization in the R&D and deployment of nuclear warheads going forward to ensure across-the-board and highly flexible nuclear strike capabilities for the PLA Rocket Force.

Miniaturized and specialized nuclear warheads serve a wide range of purchases

[8] Defense Intelligence Agency, *China Military Power: Modernizing A Force to Fight and Win* (Washington, D.C.: Defense Intelligence Agency, 2019), p. 91.

and are extremely likely to be used in real battles. The abuse of nuclear weaponry may cause vertical escalation and breach the nuclear threshold, eventually leading to total nuclear war.

As China's number of nuclear warheads and ballistic missiles continues to increase, the U.S. may ask China to engage in nuclear arms talks. If China's assets of nuclear weaponry exceed those of the U.S., it will be required to limit and reduce both. Furthermore, strategic arms may be the main battlefield between China and the U.S. in the foreseeable future.

Chapter 5

China's Nuclear Triad: Delivery Capabilities of New-Generation Strategic Nuclear Forces

Tzu-Yun Su*

I. Introduction

It is clear from China's rapid increase in military budgets that Beijing seeks to compete globally in navy power and nuclear balance. Based on public information, China's military spending totaled USD 203 billion in 2021, twice the 2012 national defense budget of USD 100.3 billion when Xi Jinping took power. As far as the navy capabilities are concerned, publicly available pictures show that the PLA Navy added 106 large surface vessels since 2012 during Xi Jinping's term. During the past two years, the focus was on aircraft carriers and Type 075 landing helicopter docks, not only to target Taiwan but also to control the oceans.

Meanwhile, China's North Pole policy, disguised as a commercial policy, is aimed at deploying the new strategic submarine ballistic nuclear (SSBN). The submarine-launched ballistic missiles launched from the North Pole can hit the conterminous United States. Similar to the South China Sea, attacks can be initiated against the West Coast of the United States with SSBN entering the Philippine Sea, to the east of Taiwan, from the Bashi Channel.

Therefore, the Taiwan Strait problem is essentially due to China's military expansion. Taiwan's safety matters not only to its own survival but also to

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Japan's and Korea's maritime, marine lifelines and the U.S.'s missile defense for its mainland. Hence, why the U.S.-Japan Joint Leaders' Statement, U.S.-ROK Leaders' Joint Statement, and G7 Summit Communique all emphasized the importance of security and peace of the Taiwan Strait.

The nuclear triad of China's strategic nuclear weapons consists of nuclear warheads, new missiles (e.g., DF-41, DF-26, and JL-3), and launch capabilities (e.g., Type 094A tactical nuclear submarines and H-20 bombers). This nuclear balance may seem unrelated to Taiwan, but it can change the world and influence the power structure of international politics.

This article analyzes the center point of China's strategic nuclear weapons—the DF-41 missiles, Type 094 tactical nuclear submarines, and H-20 stealth bombers under development.

II. Ground-based Nuclear Force — DF-41

The main elements of China's intercontinental ballistic missiles (ICBM) are the DF-5 Series and DF-41 intercontinental missiles. The DF-5 is powered by liquid fuels, injected before launch, which takes a while to spot its presence and take countermeasures. The DF-41 is solid-fueled, capable of prompt launches. It can be deployed on missile launch facilities and from launch vehicles for mobility. With its high survivability, it is considered China's newest ground-based missiles. Based on the geophysical survey of latitude and longitude and the atmosphere, DF-41's range can cover the Lower 48 of the United States from an appropriate location. Hence, also the backbone of China's new generation of nuclear strike capabilities. Its equipment with multiple independently targetable re-entry vehicles (MIRVs) is seen as a capability to initiate the first strike. Although the actual performance is unknown to the outside world, it is possible to reasonably estimate its likely functionality according to the assessment of its core elements.

Based on the publicly available data, the DF-41 is estimated to have a weight of c. 63.5 tons, a body length of 16.5 meters, and a caliber of 2.78 meters. With

the adoption of third-stage solid propellant rocket engines, the maximum range is as long as 13,000-14,000 kilometers. It can also carry ten nuclear warheads of over 100,000 tons TNT equivalent. Its circular error probable (CEP) is about 100 meters.[1]

Figure 5-1 Possible Firing Data on DF-41 Intercontinental Missiles
Source: *China Central Television (CCTV)*, cited from: https://www.sohu.com/a/475570671_260616.

1. Range

The key to the effective range of a ballistic missile lies in the fuel capacity and the engine design. However, these two are inherently conflicting with each other. Large size comes with a greater aerodynamic drag and demands more energy from the engine, limiting the range. Therefore, all the countries are focusing on improving fuels (i.e., the increase in the energy density of solid propellants). It is estimated that each 5% increase in the impulse of propellants can boost the range by 45%.[2]

In the context of the history of missile technology development, the current mainstream solid propellants can be divided into two groups: HTPB (hydroxyl-terminated polybutadiene) and NEPE (nitrate ester plasticized polyether). The

[1] "DF-41 Key Data Exposed! Range of 14,000 Kilometers, 10 Warheads. Who Is the Strongest vs. US and Russia," *Tencent*, November 24, 2020, https://new.qq.com/omn/20201124/20201124A00OXN00.html.

[2] Cheng, Tianze, "Review of Novel Energetic Polymers and Binders - High Energy Propellant Ingredients for the New Space Race," *Designed monomers and polymers*, Vol. 22, pp. 54-65, March 2019, doi: 10.1080/15685551.2019.1575652.

NEPE's specific impulse of 2,685N.s/kg and the density of 1.86g/cm3[3] are both superior to those of the HTPB propellants.

It is generally believed that the DF-41 missiles are powered by N15/N16 Series solid propellants newly developed in China—possibly by Academy No. 42 of the China Aerospace Science and Technology (CASC) Academy No. 4,[4] dedicated to the R&D of solid propellants produced by China Aerospace Science and Technology's Jianghe Factory and responsible for the manufacturing of high-energy propellants.[5] While there are questions about the statement of Chinese media regarding the formula and performance of the propellants surpassing the U.S. and Russia, it is less likely different from world-leading NEPE propellants. The reasonable range should be around 13,000 kilometers.

2. Precision

According to the open data from the Chinese official media, a DF-41 can carry ten nuclear warheads of over 100,000 tons TNT equivalent. The circular error probable (CEP) is approximately 100 meters.[6] This precision level is adequate for nuclear warheads to hit area targets such as cities. However, it may fall short of aiming for point targets such as the enemy's underground missile launch facility. Given the lack of guarantee in destroying reinforced underground bunkers, its ability to strike the opponent's nuclear power is undermined.

According to the technological evolution of ballistic missiles, its navigation system is probably based on laser gyroscope as inertial navigation for the climb

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[3] Fang C, Li S-f. 2001. Experimental Studies on Effects of AP Content and Particle Size in NEPE Propellant. J. Journal of Solid Rocket Technology. 24 (3). Cited in Xiao-ting YAN, Zhi-xun XIA, Li-ya HUANG, Yun-chao FENG, Xu-dong NA, "Experimental Study on Combustion Process of NEPE Propellant," 7 TH EUROPEAN CONFERENCE FOR AERONAUTICS AND SPACE SCIENCES (EUCASS), DOI: 10.13009/EUCASS2017-324.

[4] *Xinhua News Agency*, "Revealed for the First Time: Confidential R&D of Solid Propellants for Strategic Guided Missiles," *Xinhua Net*, December 7, 2016, http://xinhua-rss.zhongguowangshi.com/425/4660762653476101656/1370657.html.

[5] Ai-min Wang, "Towards High Energy: the Development of High-energy Solid Propellant in Jianghe Factory," *China Aerospace Science and Technology Corp. (CASC)*, December 8, 2006, http://www.spacechina.com/n25../n2014789/n2014809/c76748/content.html.

[6] "Official Disclosure: How Far and How Accurate Is DF-41's Range?," *Sina Military Section*, July 9, 2021, https://mil.news.sina.com.cn/blog/2021-07-09/doc-ikqcfnca5935434.shtml.

and flight stages to control the missile's position and direction.

Furthermore, the warhead re-entry vehicle can be combined with the BeiDou Navigation Satellite System for precise positioning and terminal guidance, with directions modified by the vector nozzle. However, this will depends on whether the wireless communications of the re-entry vehicle can break through the ionosphere shielding of the blackout zone when entering the atmosphere. A possible solution is to reduce the speed of the re-entry vehicle below 8 Mach or receive signals at the vehicle tail from the BeiDou Navigation Satellite System in order to maintain the controllability of the re-entry vehicle. Meanwhile, judging from China's current deployment of the BeiDou Navigation Satellite Constellation, the designs from military companies, and the production of 28nm TianQin II satellite-based augmentation processors for BeiDou Navigation Satellites and various vehicles,[7] the installation of a satellite signal receiver model at the tail of the re-entry vehicle is the most likely solution. This solution will greatly enhance the warhead position and establish its role as a counterforce, capable of hitting cities or striking the enemy's nuclear missile launch facility, thereby significantly boosting nuclear deterrence.

III. Naval-based Nuclear Force — Type 094 submarine

Strategic submarines are considered the main tool for tactical deterrence because they can carry submarine-launched ballistic missiles (SLBMs) and boast their launch capability with mobility and stealth. Mobility and stealth are important indicators of well-performing nuclear weapons because they imply the ability to initiate nuclear assaults—the most important component of the tactical nuclear triad.

In addition to the first-generation Type 092 submarines launched in 1981, Type 094 submarines are currently the main force of China's tactical nuclear submarines.

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[7] "Ramp-up of 100% China-Made 28nm Chips for BeiDou-3 Satellite Core Components," *Electronic Engineering Times*, August 8, 2020, https://www.eet-china.com/news/202008040957.html.

The publicly available pictures show that Type 094 submarines have three remodels.[8] According to the estimates by the U.S., China needs to have at least five tactical nuclear submarines to maintain the minimum nuclear deterrence and the second-strike capability.[9] This estimate was primarily based on maintenance, training, and strategic cruise flow routes.

The most important performance indicators of tactical nuclear submarines are nuclear reactors and submarine-launched ballistic missiles, as they determine the acoustic quieting performance of the submarines and the strike range of the missile.

1. Evaluation on the Propulsion of Nuclear Submarines

Nuclear reactors determine the underwater speed and—most importantly—the acoustic quieting of submarines. China's fleet of nuclear submarines mainly includes Type 093 nuclear attack submarines and Type 094 nuclear tactical submarines. These two submarine types are similar in design, with Type 094 as a larger version of Type 093 and both adopting pressurized water reactors. The underwater noise level is generally estimated to be about 120 decibels.[10] While the actual power is not openly announced, the publicly available information regarding the ACP100 "Advanced Pressurized Water Reactor 100 MW"—the commercial version transferred from the military[11]—sheds light on the possible design architecture and the 100 MW power range of the submarine nuclear reactor.

As the shaft horsepower is approximately 20% of the reactor's power,[12] it can be estimated that China's nuclear submarines have a shaft horsepower of 27,192.[13]

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8 The difference in the appearance of Type 094 submarines is primarily with the shape of its sails, scuppers and sonar on the side, and turtle backs.

9 Defense Intelligence Agency, *China Military Power: Modernizing A Force to Fight and Win*, (Washington, D. C.: DIA, 2019), p. 73.

10 "Type 094 Jin-class Design," *Global Security*, https://www.globalsecurity.org/wmd/world/china/type_94-design.htm

11 "SMR (Small and Medium-Sized Reactors) May Flourish at Multiple Locations. Purposes Determine Site Selection," *China Energy News*, November 30, 2011, http://www.nea.gov.cn/2011-11/30/c_131278758.htm.

12 U.S. Ohio-class tactical submarine uses S8G reactors, thermal power at 220MW, shaft horsepower at 45MW, about 20% of thermal power. See "Nuclear-Powered Ships," World Nuclear Association, in September 2021, https://world-nuclear.org/information-library/non-power-nuclear-applications/transport/nuclear-powered-ships.aspx.

13 The thermal power of a reactor at 100 MW is equal to 100,000 KW, or 135,962 in metric horsepower. However, the conversion for shaft output is usually 20% of thermal power. Hence, it is 27,192 shaft horsepower.

In 2016, the QL-1 Lead-cooled Fast Reactor (LFR) prototype developed by the FDS Team of the Chinese Academy of Sciences Nuclear Safety Technology Research Institute successfully completed the trial run,[14] indicating the readiness of the technological groundwork in the new generation of high power reactors. It is worth noting that the disclosed information about the development team included China Shipbuilding Industry Group Co., Ltd. It also mentioned that the same technology is used in Russian submarines and has obtained the numerology security certification of the Chinese Academy of Sciences.[15] Therefore, it can be determined that this is the reactor for China's new nuclear submarines.

Figure 5-2 PLA's Early Configuration of Submarine Nuclear Reactors
Explanation: PLA's early configuration of submarine nuclear reactors. Based on the diameter, this should be for submarines, possibly during the late 1960s.
Source: China Nuclear Information Site: https://reurl.cc/L7MxE9.

These new-generation nuclear reactors are called the "ADS Lead-Bismuth Eutectic Project" (or CLEAR-I, "Qilin-1"). It was initiated by the 863 Plan and included in the Seventh Five-Year Plan in 1986 and the 973 Plan under the Ninth

[14] "China Achieves Major Breakthrough in Coolant for Lead-cooled Fast Reactors," *Hefei Regional Center of Strategy Energy and Physical Science Instrument of Chinese Academy of Sciences*, September 8, 2016, http://sepsc.kjtj.cas.cn/xwdt/zxdt/201609/t20160920_348648.html.

[15] "China Achieves Major Breakthrough in Coolant for Lead-cooled Fast Reactors," the same as the previous note.

Five-Year Plan as the focus of the R&D project for new energy.[16] This project lasted thirty years and was completed in 2016. The critical operation of the first reactor finally started in 2019.[17]

This type of reactor, known for its high thermal efficiency, was first adopted by Russian submarines. However, Russia experienced nuclear submarine safety accidents due to materials and technological limitations in the 1970s. Subsequently, pressurized water reactors were used in Russian submarines for better safety. As technology progressed, liquid-metal-cooled nuclear reactors became one of the options for the fourth generation nuclear reactors listed in China's 863 Plan and 973 Plan, which achieved preliminary success in operation. If the subsequent commercialization went well, it would likely be transferred for military use in the next-generation submarines for larger tonnage, higher underwater speeds, and greater strategic benefit in nuclear deterrence.

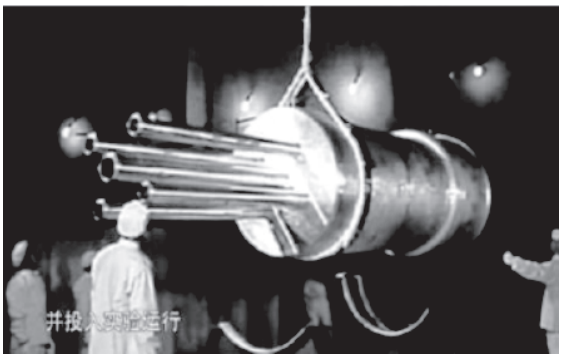

Figure 5-3 PLA's Early Configuration of Control Rods for Submarine Nuclear Reactors

Explanation: PLA early configuration of control rods for submarine nuclear reactors, likely during the late 1960s.

Source: *China Nuclear Information*, https://reurl.cc/L7MxE9.

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[16] The full name of the 973 Plan is "National Key Research and Development Program Based on the Former National Key Fundamental Research and Development Program," The full name of the 863 Plan is "National High-tech R&D Program".

[17] "Ccongratulations! China's Lead Bismuth Eutectic (LBE) Zero Power Reactor Achieves First Critical. Electricity from Mobile Small-Sized Reactors Within Sight," *Sina News*, October 12, 2019, https://news.sina.com.tw/article/20191012/32923338.html.

2. Submarine Launch and Strike Capability

Type 094 tactical submarine, which adopts the turtle back design, can carry 12 JL submarine-launched ballistic missiles (SLBM). This type of submarine is equipped with JL-2 SLBMs which have the third stage solid rocket design in the length of 13-14 meters and a caliber of 2 meters.[18] The range is generally estimated to be 8,000 kilometers.[19]

The JL-2 missile is equipped with a composite guidance system consisting of the strap-down inertial navigation system, ballistic computers, laser gyroscopes, and celestial navigation. Its guidance precision is 90 meters.[20] Some data suggests that it has the direct strike capability against intercontinental missile launch facilities,[21] which means the strike precision should be in the 10-meter range in order to destroy reinforced underground shelters.

That said, based on the production years and the range and primary design requirements of second strikes for tactical nuclear submarines (i.e., to hit the enemy's cities and not missile launch facilities), the precision is probably in the 100-meter range.

The possible deployment of JL-3 submarine-launched ballistic missiles is worth mentioning. Based on the publicly available information, its deployment is surely a go-ahead. Firstly, according to its technological development of submarine-launched ballistic missiles, China seeks a full replacement for the next generation to meet the requirements for the next 30 years. Secondly, the deployment is aimed at meeting China's pursuit of a new nuclear weapon strategy (i.e., the ownership of projection power with greater deterrence effects).

Hence, JL-3 is likely to be powered with the new N-15/16 solid propellants in

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[18] "With a Range of Mere 8000 kilometers, JL-2 Guided Missile Debut at Military Parade a Leader or a Lagger," *Tencent*, December 27, 2019, https://new.qq.com/omn/20191227/20191227A0F9V300.html?pc.

[19] Hsiao Han, Dong Cui, "Expert: JL-3 Guided Missile Equipped with Many Advanced Technologies for Advanced Performances," *Science and Technology Daily*, August 17, 2017, http://military.people.com.cn/BIG5/n1/2017/0817/c1011-29476356.html.

[20] "China's Ballistic Missiles," *China Laobingwang*, September 21, 2021. http://www.laobing.com/jsht/jbz/erp/jsht-zldd-22.htm.

[21] "What does JL-2 Missile Has "First Strike Potential" Mean?," *SciMall*, November 17, 2020, https://www.scimall.org.cn/article/detail?id=4785007.

order to achieve a farther range. The possible ranges are estimated below:

(1) Basic model: If the JL sizes stay the same, the new fuel with high-energy density can extend the range by 15-20%; that is, up to 10,000 kilometers.
(2) Completely new configuration: In general, the pressure shell of a submarine reactor comes with a diameter of 12 meters or so. Hence, the Type 094 submarine adopts the turtle back design to accommodate longer ballistic missiles. Judging from the technical limitation of shipbuilding engineering, maintaining a 14-meter length can increase the caliber of JL-3 to accommodate more propellants and adopt more composite materials and carbon fiber engines. The combination of a fuel increase, weight reduction, and engine efficiency enhancement may extend the range up to 14,000 kilometers.

In this way, the Type 094 submarine in the future or the subsequent Type 096 submarine may attack the contiguous United States from China South Sea. This is strategically significant because such an attack is only possible now from the Philippine Sea in the east of Taiwan, the Kuril Islands in the northern Sea of Japan, or even the Aleutian Islands.

IV. Air-launched Nuclear Force — H-20 Bomber

China's aviation industry received some assistance from the U.S.S.R. However, the transfer of technology was stopped after China and the U.S.S.R. went separate ways. Nevertheless, China conducted research and reforms with reverse engineering and gradually achieved the localization of all fighters. It is worth noting that research and improvement through imitation is an R&D route often adopted by countries with less advanced military technology, which does not warrant over-stigmatizing. In addition to the learning curve, there is also substitute research in fundamental sciences such as material science.

After the reforms and opening up and the ensuing economic development, the progress in civil aerospace and electronic technology has made achievements in engine design, materials science, and avionics.

1. Indirect Official Confirmation for H-20 Bombers

Although China's current main bombers are an imitation of the former U.S.S.R.'s Tu-16 H-6 bombers, their survivability is rather low in today's air defense system. In addition, it has reached the engineering limitation in terms of performance enhancement. Therefore, the H-20 bombers under development by the Xi An Aircraft Industry Group Co. are expected to become the mainstay of China's next-generation strategic air force, given its stealth characteristics.

Assessment on the reasonability of the technology roadmap: after the successful development of the J-20 stealth fighters and the improvement of the domestic engines, China's subsequent launch of the H-20 has a credible technological basis. Obviously, China also adopted generation-hopping as its development strategy for strategic bombers. Unlike the roadmap of the U.S.'s or Russia's strategic air forces—from B-52 and Tu-95 subsonic bombers to B-1 and Tu-22 supersonic bombers, respectively—China directly jumps to the forefront of the new-generation stealth platform.

This can be proven by the open comment in 2016 from Ma Xiao-tian, the former Air Force Commander, that "China's air force is developing the next generation long-range bombers".[22] On the other hand, the PLA Air Force spokesperson, Colonel Shen Jin-ke, announced in August 2021 that "the PLA Air Force has entered the historical threshold of the strategic air force".[23] These statements explain the possibility of the H-20.

2. Stealth Capability

When flying in the atmosphere, aircraft avoid radar waves by staying low along with the earth's curvature. Due to the natural conditions for stealth, it is necessary to reduce signals, such as electromagnetic waves and infrared thermal with means of body configurations and radar-absorbent coatings to avoid being detected. The

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[22] "Air Force Commander Ma Xiaotian: "China's Air Force Is Developing the Next Generation Long-Range Bombers," *people.cn*, September 2, 2016, http://military.people.com.cn/BIG5/n1/2016/0902/c1011-28686929.html.

[23] "Debut of H -20 on National Day? China Air Force Declares: Stepping into Threshold of Strategic Air Force," *Douwei News*, September 2, 2021, https://blog.dwnews.com/post-1462249.html.

radar cross-section (RCS) control decreases radar-reflected signals.

Although China has not formally published the look of its H-20, the publicly available information shows a blended wing body (BWB) design, basically in the flying-wing configuration,[24] which effectively reduces the area of laser reflection. The possible stealth capability may be benchmarked against the roadmap of the U.S. Armed Forces bombers. The possible RCS values for the U.S. Armed Forces' backbone strategic bombers are 100 m2 for B-52, 0.75 m2 for B-1, and below 0.1 m2 for B-2.[25]

In summary, based on the overall consideration of the experience from the U.S. Armed Forces and the technological levels in China, it is possible to control the H-20's area of laser reflection to below 0.5 m2, compared to the RCS of 16 m2 for the current mainstay model, H-6 bomber.[26]

Figure 5-4 One of H-20's Possible Configurations
Source: China Central Television (CCTV), from Business Insider.

[24] Yun Chen, "H-20 Coming Up Soon? Picture of Imagination Published by Weapon Magazine Triggers Heated Discussions," *Voice of America*, May 29, 2021, https://www.voacantonese.com/a/is-bomber-h20-going-to-show-up-china-weapon-magazine-s-blueprint-for-h20-s-appearance-draws-hot-discussion-20210529/5909149.html.

[25] Radar Cross Section, *Global Security Org*., https://www.globalsecurity.org/military/world/stealth-aircraft-rcs.htm.

[26] Global Investment Center, *Indonesia Air Force Handbook Volume 1 Strategic Information and Weapon Systems* (Washington, D.C.: International Business Publication, 2013), p. 86.

3. Overall Performance

The U.S. Department of Defense estimates that the H-20 may have a flying range of 8,500 kilometers and a payload of 10 metric tons.[27] With in-flight refueling capability, it will be able to strike across states. Further, there is greater survivability through the opponent's air defense system, given its stealth features.

Meanwhile, the strategic thinking of the PLA Air Force for "airland battles, both offensive and defensive operations" will be integrated into the pillar of the "integrated information–firepower warfare". In particular, the BeiDou Navigation Satellite System and the Gaofen and Fengyun Series Satellite Systems can provide China with a complete picture of battlefield weathers, images, and positioning information, which will help the schedule planning and precise projection of the strategic air force and strengthen the capability of nuclear strikes. In this way, Beijing will have a nuclear triad of more credible deterrence.

V. Conclusion

Despite China's keen pursuit of a rapid boost to its nuclear strike capabilities, the nuclear projection in the 2020s will remain dependent on ground-based intercontinental missiles due to technological limitations and overall deployment experience. The up-and-coming stealth bombers and tactical nuclear submarines will gradually grow in numbers, thereby constructing a comprehensive nuclear deterrent power. Possible developments, in general, are described below:

1. Intercontinental Strike

The more mature ballistic missile DF-5 is equipped with liquid fuels; hence, not set up for quick responses. However, it has a range of 15,000 kilometers[28] and can cover entire North America. This strategic implication will keep it in service for

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[27] Office of the Secretary of Defense, *Military and Security Developments Involving the PRC 2018* (Washington, D. C., Department of Defense, 2018), p. 70.

[28] Hsiao Ke,"DF-5 as Bright Spot of the Military Parade, with a Range of Over 15,000 Kilometers and Multiple Warheads," *Sina Military Section*, September 2, 2015, http://mil.news.sina.com.cn/2015-09-02/1220838272.html.

another while. The DF-41 has a slightly short range, but it can be launched quickly and deployed on roads or railways. Its better survivability is complementary to the DF-5—together, they constitute China's main power of nuclear deterrence. With at least three naval-based JL-2 and Type 094 submarines or subsequent Type 096 submarines, China will be able to conduct military cruises regularly in the Philippine Sea, to the east of Taiwan, enhancing the deterrence and credibility for second strikes.

2. Regional Strike

In targeting the countries in the Indo-Pacific, China also relies on the mainstay force, such as DF-21, 26, and 31 Series medium-range ballistic missiles. The H-6 bomber troops also play a role, although its survivability in today's air defense system is not high due to flight performance. Hence, H-6 serves as an aerial and mobile platform, working in conjunction with CJ Series cruise missiles for attacks. The H-6's operating radius is about 2,800 kilometers based on the publicly available data. When combined with the CJ missile's range of 2,500 kilometers, it is possible to cover a strike range of 5,000 kilometers. Hence, the ground-based and air-launched regional deterrence capability can be established with medium-range missiles.

3. Theatre Strike

China's third level of a nuclear strike is its theater and tactical nuclear projection capabilities. The main force at this level is the DF-15 and DF-16, consisting of medium- and short-range ballistic missiles at a range of 1,500 kilometers. Meanwhile, the JH-7, J-15, and J-16 fighter planes also have the capability to project tactical nuclear warheads, which can initiate tactical nuclear attacks on ground targets and submarines in the sea and serve as a nuclear delivery vehicle in warzones.

4. Overseas Bases

This section is related to the first point mentioned above about China's

dependence on ground-based ballistic missiles. The projection capability of the PLA Navy and Air Force is constrained by the lack of overseas bases. If there are sufficient overseas bases, China's bombers and tactical submarines will be able to operate in a wider area with the support of logistics resupply points, which will boost its survivability and credibility. For example, China currently has a base in Djibouti for the Red Sea coastal area in Africa. Although it is located at the northeast corner of Africa, China can still directly strike at the North Atlantic Treaty Organization (NATO) with H-20 bombers and threaten India by moving eastward. Similarly, after taking over Kiribati, an island country with diplomatic ties with Taiwan, about 3,000 kilometers from Hawaii and 8,000 kilometers from the mainland United States, China plans to invest and repair Kanton Airport used by the U.S. Armed Forces during the Second World War.[29] If this plan comes true for Beijing, the deployment of H-20 will pose a direct nuclear threat to the west coast of the United States.

In conclusion, China has been increasing its nuclear force rapidly in recent years by strengthening its coercion and enhancing strike capabilities, which implies that China has substantial abilities to initiate nuclear strikes. It is also necessary to note that, apart from nuclear military and delivery vehicles, Beijing also integrates in-depth a geostrategic strategy, including scientific research in the North Pole, which is often overlooked by outside parties. The collection of information about ice sheets, water temperatures, and currents helps the deployment of tactical nuclear submarines. The launch of submarine-launched ballistic missiles (SLBMs) in the Arctic Ocean can quickly arrive at the Lower 48 of the United States and shorten the response time to the U.S.'s missile defense system. This may affect both the United States and Russia, change the global nuclear balance, and influence international politics. Furthermore, while Beijing may obtain power, it risks the countermeasures from all countries—a military and strategic dilemma China is putting itself into.

[29] "China Plans to Modernize 2km Airstrip in Centre of Pacific Ocean," *Global Construction Review*, May 7, 2021, https://www.globalconstructionreview.com/news/china-plans-modernise-2km-airstrip-centre-pacific-/.

Chapter 6

China's Missile Defense Capability

Hsiao-Huang Shu*

I. Introduction

On February 4, 2021, the P.R.C. Ministry of National Defense announced the successful trial of ground-based midcourse anti-ballistic missile technology, which achieved expected goals. This accomplishment attracted international attention to China's development in anti-ballistic missile systems. The trial was China's fifth test of anti-ballistic missiles, with the preceding four tests in 2010, 2013, 2014, and 2018.[1] The U.S. Department of Defense supposed that the 2018 test was for the DN-3 interceptor while the 2021 test was for HQ-19 missile systems, both already in service and are considered anti-satellite (ASAT) weapons.[2]

II. China's Anti-Ballistic Missile Technology

1. Anti-ballistic Missile System

Midcourse anti-ballistic missile technology requires the interceptor missile to destroy ballistic missiles, usually in the atmosphere, before the latter fly midcourse

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1 "China Declared the Success of the Ground-based Midcourse Anti-ballistic Missile! Department of Defense: not Targeting Any Country," *Xinhua Net*, February 5, 2021, http://www.xinhuanet.com/mil/2021-02/05/c_1211012765.htm.

2 "China Testing the Ground-based Midcourse Anti-ballistic Missile U.S.: Anti-satellite Weapon," *Want Daily*, March 9, 2021, https://www.chinatimes.com/newspapers/20210309000712-260301?chdtv.

and when ballistic missiles reach the highest point in flight before arriving at the target zone. If struck down, the debris will not fall on the homeland. The longer early warning and response time means a larger defensible geographic area. However, the early warning system must be able to detect invading missiles as early as possible, which relies on long-range early warning radar, space early warning radar, or X-band radar, sufficient to identify missiles from decoys. The great height and speed for interception mean booster rockets of the high thrust are required for interceptor missiles—usually two-staged missiles—which are rather technologically challenging.

China began testing its anti-ballistic missile system as early as 2010. Some people say China used the interceptor missile based on the improved modeling of the DF-31 ballistic missile, which the U.S. thinks is the DN-1. However, the military media clarified that it was the HQ-19, with effects between Terminal High Altitude Area Defense (THAAD) and Standard Missile 3 Block II. On January 27, 2013, the P.R.C. Ministry of National Defense reannounced its successful testing of the ground-based midcourse anti-ballistic missile system. It is believed that China has demonstrated in its early warning satellite and early warning radar technology in this test, as its HQ-19 missile may have the capability to identify decoys. In 2014, China conducted another inception test, which the U.S. thinks may be a test on anti-satellites (ASAT).[3]

According to the U.S. website "Global Security", China's anti-ballistic system has multiple missiles, including HQ-9B, HQ-19, HQ-26, HQ-29, DN-1, and DN-2. The HQ-19's campaign capability is comparable to that of the U.S.'s THAAD. Nothing much is known about HQ-26 from the outside world. It is approximately equivalent to the U.S.'s Standard Missile 3 or PAC-3 Missile.[4] The HQ-29 is

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[3] "Beijing Released the News on the Ground-based Midcourse Anti-ballistic Missile What are the Differences of the Five Tests?," *HK 01,* February 10, 2021, https://www.hk01.com/%E5%9C%8B%E9%9A%9B%E5%88%86%E6%9E%90/584380/%E5%8C%97%E4%BA%AC%E6%B7%B1%E5%A4%9C%E7%99%BC%E5%B8%83%E9%99%B 8%E5%9F%BA%E4%B8%AD%E6%AE%B5%E5%8F%8D%E5%B0%8E-%E8%A7%A3%E6%9 4%BE%E8%BB%8D%E4%BA%94%E6%AC%A1%E8%A9%A6%E5%B0%84%E6%9C%89%E 4%BD%95%E4%B8%8D%E5%90%8C.

[4] "HQ-26 Anti-Ballistic Missile Interceptor," *Global Security.org*, https://www.globalsecurity.org/space/world/china/hq-26.htm.

considered equivalent to the PAC-3 Missile, DN-1, and DN-2 (i.e., the U.S.'s ground-based midcourse defense system). In 2018, China may have deployed the newly modeled DN-3 missiles, deemed the best-performing kinetic hit-to-hill midcourse interceptor missiles.[5]

2. China's Anti-Missile Defense Network

These different types of missiles consist of China's anti-missile defense network. The midcourse interception net as the first level comprises the D.N. Series missiles, responsible for missile interceptions outside the atmosphere. On the other hand, the second level is for the edges of the atmosphere, handled by the HQ-19 and HQ-26. The third level is the terminal interceptions within the atmosphere, performed by HQ-9B and HQ-29.[6] Table 6-1 summarizes China's types of anti-missiles and anti-satellites (ASATs) and the test timetables based on the publicly available information.

Table 6-1 China's Types of Anti-missiles and Anti-satellites (ASAT)

Model No.	Function	Height	Comparable U.S. system
Outside the atmosphere			
SC-19	ASAT		
DN-1	ASAT		Ground-based defense system
DN-2	ASAT		Ground-based defense system
DN-3	ASAT		
On the edges of the atmosphere			
HQ-19	Anti-missile		THAAD
HQ-26	Anti-missile		Standard Missile 3
Low levels			
HQ-9B	Anti-missile		THAAD
HQ-29	Anti-missile		PAC-3

[5] "Beijing Released the News on the Ground-based Midcourse Anti-ballistic Missile. What are the Differences of the Five Tests?," op. cit. 3.

[6] "Beijing Released the News on the Ground-based Midcourse Anti-ballistic Missile. What are the Differences of the Five Tests?," op. cit. 3.

Model No.	Function	Height	Comparable U.S. system
S300PMU2	Limited anti-missile capability		
S400	Limited anti-missile capability	Low altitude	

Source: Compiled by the author.

Table 6-2 China's Timetable of Anti-satellite and Anti-satellite (ASAT) Tests

	Date	Target	Type	Test
1	2005.07	None	SC-19	Rocket test
2	2006.02	Satellite	SC-19	Failed
3	2007.01	Satellite	SC-19	Successful interception
4	2010.01	Missile	SC-19	Successful interception
5	2013.01	Missile	SC-19	Successful interception
6	2013.05	None	DN-2	Experiment
7	2014.07	Missile	SC-19	Successful interception
8	2015.11	None	DN-3	Flight test
9	2018.02	Missile	DN-3	Successful interception
10	2021.02	Missile		Successful interception

Source: Compiled by the author.

(1) *HQ-19*

The test in February 2021 was suspected to be for HQ-19 missiles, with the target missiles being DF-21 medium-range ballistic missiles. Russia's reports stated that the HQ-19 might be in the early deployment stage, which can intercept India's Agni-2, Agni-3, or the more powerful Agni-4 and Agni-5 missiles. This progress will significantly undermine India's nuclear threat. While the U.S. withdrew from the Intermediate-Range Nuclear Forces Treaty (I.N.F.), its deployment of medium-range missiles is unlikely to be too speedy. Hence, China's missile defense system will be able to effectively counter the U.S. missiles.[7]

[7] "Expert: China is Approaching the Goal of Building Own Anti-missile Systems," *Sputnik*, February 8, 2021, https://big5.sputniknews.cn/opinion/202102081033053161/.

HQ-19 missiles were developed by China Aerospace Science & Industry Corp. Academy No. 2 in the late 1990s. They are two-stage missiles with N-15B solid-propellant rockets, carbon fiber-made missile bodies, and kinetic hit-to-kill warheads. The full HQ-19 system includes solid phased array radar for early warning. Its X-band radar is said to have a detection range of 4,000 kilometers, covering the vast area from the South Asian Subcontinent to the Tibetan Plateau. The tests in 2013 and 2014 successfully completed the interception of a simulated missile at a height of over 200 kilometers and a relative speed of 10,000 meters per second. In 2016, it seemed that the HQ-19 was first seen on China Central Television (CCTV). On that occasion, the media coverage disclosed for the first time the images of its ground-based midcourse anti-ballistic missile system and warhead. The HQ-19 adopts kinetic hit-to-kill warheads, with the infrared homing system on the side, similar to the THAAD, to reduce the influence of atmospheric friction and high heat on sensors and enhance the precision of attacks. This mechanism also accommodates lighter warheads to increase firing height. In 1999, China successfully completed the test flight of kinetic hit-to-kill warheads and became the world's second country to own the kinetic hit-to-kill technology.[8]

(2) *SC-19*

China uses similar missiles for anti-missile and anti-satellite (ASAT) tasks. Some reports indicate that China's tests for the development of missile defense systems are actually for anti-satellite (ASAT) weapons. The SC-19 missile may have multiple identities; for one, it is suspected as the DN-1 missile. The U.S. media "Popular Mechanics" indicated that the SC-19 is an anti-satellite (ASAT) missile developed from the DF-21C ballistic missile with five completed tests. China is developing at least three anti-satellite (ASAT) missile systems, and the SC-19 is already deployable.[9] The SC-19 missile uses KT-1 solid-propellant rockets, developed based on DF-21 medium-range ballistic missiles. China has

[8] "HQ-19 Anti-Ballistic Missile Interceptor," *Global Security.org*, https://www.globalsecurity.org/space/world/china/hq-19.htm.

[9] "Anti-Satellite Weapons Are Becoming a Very Real Threat," *Popular Mechanics*, April 1, 2020, https://www.popularmechanics.com/military/weapons/a32008306/anti-satellite-weapons/.

conducted at least six anti-satellite (ASAT) experiments. In 2007, it successfully destroyed a space satellite. Meanwhile, it successfully hit ballistic missiles in 2010 and 2017.[10]

The name "Shuangcheng" (S.C.) is probably from the launch of the Shuangchengzi Space and Missile Center in Gansu Province. The SC-19 is powered by a two-stage solid rocket, gyroscope inertial navigation, and radar navigation. The warhead is equipped with kinetic hit-to-kill technology and high-explosive ammunition for accurate destruction. Further, the SC-19 can also intercept satellites or other space vehicles in low or medium earth orbits.

According to the U.S.'s detection data on the 2010 test, an SC-19 launched from the Korla Missile Test Complex in Western China successfully intercepted the CSS-X-11 missile (i.e., B611 short-range ballistic missile [SRBM] for export) launched from the Shuangchengzi Space and Missile Center about 1,100 kilometers to the east of Korla. In January 2007, China used the SC-19 as a direct-ascent anti-satellite (DA-ASAT) weapon to intercept an invalid FY-1C weather satellite.[11] In the past, nothing much was known about China's anti-missile experiments. In January 2013, the second ground-based midcourse missile interceptor successfully completed the interception trial. It was also China's second official announcement of this type of experiment. The following experiments were conducted in July 2014 and December 2018.[12]

However, the outside world remains skeptical about China's relevant experiments. The space debris caused by the SC-19's destruction of a satellite in its first test attracted complaints from the international society. Hence, subsequent tests targeted ballistic missiles. U.S. expert Richard Fisher pointed out that China is carrying out anti-satellite (ASAT) and anti-missile experiments simultaneously, possibly with SC-19 serving as both an anti-satellite (ASAT) and an anti-missile.

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[10] "Foreign Media: SC-19 Succeeds in Six Consecutive Strike-Back Experiments. Hurray for Our Country," *kknew.cc*, January 24, 2017, https://kknews.cc/zh-tw/military/omlx3ko.html.

[11] "SC-19 Anti-Ballistic Missile Interceptor," *Global Security.org*, https://www.globalsecurity.org/space/world/china/sc-19-abm.htm.

[12] Hsi-fu Ou, "Comparison of China's and US's Missile Defense Systems," *National Defense and Security Bi-weekly*, Vol. 24, March 19, 2021, https://indsr.org.tw/Content/Upload/files/biweekly/24/6_SiFuOu.pdf.

If China possesses the anti-satellite (ASAT) capability, it will severely affect the U.S.'s freedom in space utilization and capability in military deployment. Further, the missile type used in the subsequent tests remains a question. U.S. experts think the third test was perhaps on a new missile—HQ-26 with a new solid rocket.

(3) *DN-3*

The U.S. think tank, "United States-China Economic and Security Review Commission", pointed out that China's SC-19 and DN-2 are both anti-satellite (ASAT) weapons. The tests in 2010, 2013, and 2014 were all on anti-satellite (ASAT) weapons in the guise of missile defense. The DN-1 was developed based on the C-19 and DN-2, while the ND-3 was developed from the DN-1. China's newest carrier rockets are the KZ-1 and KZ-11, and the DN-3's rocket was probably developed from the KZ-11. U.S. expert Richard Fisher mentioned that the U.S. currently does not have an anti-satellite (ASAT) system that can reach the same height as the DN-2 and DN-3.[13]

The first test on the DN-2 was carried out in April 2013—also China's third test on anti-satellite (ASAT). In October 2015, many people observed unusual flight trails in Korla City (Xinjiang), which looked like the final stage of a missile interception, airborne at the edge of the atmosphere. It was suspected to be the first test on the DN-3 missile, considered China's best performing hit-to-kill midcourse anti-ballistic missile system. In addition, the HQ-19 may have been deployed in service. As shown in the 2018 test, the DN-3 missiles may be gradually replacing the HQ-19 as the main force for midcourse interceptions.

(4) *HQ-26*

U.S. experts speculated that China is simultaneously developing a number of anti-satellite (ASAT) and anti-missile weapons. In addition to the aforesaid systems, the HQ-26 is a navy version of the missile defense system similar to the U.S.'s Standard Missile 3. It is aimed to be equipped on large surface vessels

[13] "US Media Says China Tests DN-3 Anti-Satellite (ASAT) Weapon, Ahead of the U.S.," *Global Times*, November 12, 2015, https://news.qq.com/a/20151112/038565.htm.

(possibly Type 055 destroyers) in the future.[14]

(5) *Low altitude: HQ-9B, S300, and S400*

The HQ-9B is a terminal missile defense system developed based on the HQ-9. China also purchases the S300 and S400 long-range anti-aircraft systems from Russia, with limited missile defense capabilities. It also constructs a massive missile defense network with these systems, including satellites, early warning radar, long-range and anti-aircraft missiles, possibly short-range anti-aircraft missiles, fighter aircraft, and anti-aircraft guns. A complex and multilevel air and space defense system is established by integrating all these anti-aircraft systems.

China's missile defense system primarily aims to protect the Bohai Sea Economic Zone centered on Beijing and later extends to other regions or key targets such as Shanghai or the Three Gorges Dam.[15] The HQ-9 is on a fully automated engagement, with target information from early warning radar. The search radar of the missile system searches for the target according to the directions shown by the early warning radar. The target is tracked as soon as it is captured. After the issuance of firing command, the fire-control radar provides relay homing to guide the missile seeker into the target range. When near the target, high-explosive fragment warheads are fired to destroy the target missile.[16]

III. Early Warning System (E.W.S.)

1. Early Warning Radar

In the past, China did not have early warning satellites dedicated to the missile defense system and could only rely on long-range early warning radar. After years of hard work, China has established a comprehensive anti-missile defense system

[14] "U.S. Media Says China's Anti-Missile Tests Are Perhaps for Multiple Anti-Missile Systems Based on HQ26," *Sina News*, January 28, 2013, http://mil.news.sina.com.cn/2013-01-28/1136714089.html.

[15] "Foreign Media Says China Creates a Defence Network by Imitating US's Anti-Missile System," *Sina News*, November 2009, http://mil.news.sina.com.cn/2009-11-04/0811572489.html.

[16] "Foreign Media Says China Creates a Defence Network by Imitating US's Anti-Missile System," *Sina News*, November 2009, http://mil.news.sina.com.cn/2009-11-04/0811572489.html.

by integrating satellites, early warning radar, and a midcourse and terminal anti-ballistic missile system. In the 2013 anti-missile test, China showcased its early warning satellites, early warning radar, and interceptor missiles for rapid response capabilities.[17]

In 1986, China started to deploy its first-generation over-the-horizon radar (O.T.H. radar). Currently, China has six early warning radar systems in operation. Among them, four extremely high-frequency O.T.H. radars face Taiwan, of which three systems are bistatic radars. These O.T.H. radar systems operate in different frequencies, with a detection distance of over 3,000 kilometers. China's O.T.H. radar usually detects long-range targets on the water surface to assist anti-ship ballistic missiles in identifying targets early and detecting targets in the air.[18] In 2017, China Central Television (CCTV) introduced a new large-scale phased array radar, known as "Chinese Pave Paws". Working in P-band, it is a meter wave radar that spots, tracks, and identifies targets in an extremely far distance. China's newly built P-band phased array radar adopts 12,000 T/R (transmitter/receiver) modules, the largest number in the world for phased array radar.

Meanwhile, China has built a number of large early warning radar systems, including X-band radar in Heilongjiang. It is based on single-sided fixed antennas, primarily to provide early warning in the direction for Alaska and feed accurate early warning information to the HQ-19 and DN-3 missiles. In addition, China has established large S-band phased array radars in Fujian and Xinjiang. The systems are on rotatable radar consoles for 360° detection capability, capable of detecting stealth planes.[19] The P-band radar was developed by China Electronics Technology Corp. (CETC) Academy No. 14 (Nanjing Academy). The unit electricity consumption is low for phased array radar operating in P-band. It can detect a long distance due to high wavelengths and low atmospheric attenuation, which provides

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[17] "Beijing Released the News on the Ground-based Midcourse Anti-ballistic Missile. What are the Differences of the Five Tests?," same as the previous note.

[18] "Eyes Gaze upon the Skies: China Builds Missile Early Warning Radar System 2," *MP News*, September 20, 2021, https://min.news/zh-tw/military/097c3143ad776c64f7cf4c10e3ae2cb9.html.

[19] "China's First high-profile Exposure of World-class Anti-missile Early Warning Radar, Previously Known to Anybody," *kknew.cc*, October 9, 2017, https://kknews.cc/military/rqaekrr.html.

great detection capabilities for stealth targets at the expense of some accuracy. Therefore, it is necessary to rely on more accurate X-band radar to detect decoys.[20]

China and Russia also work together for early warning. In 2019, Russian President Vladimir Putin indicated the assistance to China's development of missile early warning systems to improve China's early warning capabilities. This development assistance included Russia's Tundra early warning satellites and China's own early warning system based on Voronezh-DM long-range high-frequency early warning radar stations. Early warning radar provides the trail, speed, estimated flight time of the invading missile, and other data necessary for an interception. The Voronezh-DM radar detects a distance of up to 4,000-6,000 kilometers. If deployed in the Russian Far East, it will not have adequate detention depth. However, when deployed in China's coastal area, the radar spots targets early for both China and Russia.[21]

2. Early Warning Satellite

China began the development of early warning satellites as early as 2013. It started the launch of communications technology experiment satellites in 2017, also known as "FireEye", likely to serve as ballistic missile early warning and similar to the U.S.'s Infrared Astronomical Satellites. FireEye-2 was launched in January 2017, while FireEye-3 in December 2018. In 2020-2021, China launched FireEye-5, FireEye-6, and FireEye-7. While these satellites were claimed to be for the testing of communications technologies, it is believed that they are related to the detection of ballistic missile attacks. FireEye-2 is equipped with synchronous-orbit highly-sensitive infrared detection technology. If positioned above the Western Pacific, its detection covers the vast area from the Midway Atoll to East Africa and from the Arctic Ocean to the South Pole. Both the U.S.'s submarine-

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[20] "China's P-band Phrased Array Early Warning Radar can Spot Ballistic Missiles Thousands of Kilometers Away," *Sina Military Section*, February 8, 2021, https://mil.news.sina.com.cn/zhengming/2021-02-08/doc-ikftssap4752743.shtml.

[21] "China and Russia Cooperate in Early Warning, to Eliminate the Threat of U.S. First Nuclear Strikes," *BBC Chinese*, November 24, 2020, https://www.bbc.com/zhongwen/trad/world-55065435.

launched ballistic missiles and India's ballistic missiles are detection targets.[22]

IV. Conclusion

While China has constantly criticized the U.S.'s missile defense systems development, it has also been developing its own ballistic missile defense systems, anti-satellite (ASAT) capability, and midcourse anti-ballistic missile capability. Its anti-satellite (ASAT) capability has perhaps surpassed that of the U.S. In this competition of strong powers, China does not only want to reinforce the traditional military force but also to strengthen nuclear deterrence. Compared to the U.S.'s and Russia's nuclear triads, China still needs to enhance its deterrence force. Although "China's National Defense in the New Era" does not mention the tactical role of the PLA Air Force, the strategic requirement for the Rocket Force is to be prepared in carrying out "comprehensive deterrence and warfighting" operations with "both nuclear and conventional" capabilities, enhancing "credible and reliable nuclear deterrence and counterstrike capabilities" and "medium- and long-range precision strike capabilities", and contributing to "strategic balance" between China and its main strategic competitors". Meanwhile, the PLA Navy should "accelerate the transformation from near seas defense to far seas protection and strengthen tactical deterrence and counterstrike capabilities".[23] These suggest that the PLA Navy and Rocket Force are still the mainstays of China's nuclear deterrence. Compared to the U.S. and Russia, its strategic strike capability is still an underdog. Hence, China continues to enhance its strategic military power by developing new ballistic missiles and new missile launch facilities and constructing the missile defense

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[22] "China Successfully Launches FireEye-4, Possibly Related to Orbital Missile Early Warning," *HK 01*, October 18, 2019, https://www.hk01.com/%E5%8D%B3%E6%99%82%E4%B8%AD%E5%9C%8B/3 87504/%E4%B8%AD%E5%9C%8B%E6%88%90%E5%8A%9F%E7%99%BC%E5%B0%84%E9%80%9A%E4%BF%A1%E6%8A%80%E8%A1%93%E8%A9%A6%E9%A9%97%E8%A1%9B%E6%98%9F%E5%9B%9B%E8%99%9F-%E7%96%91%E8%88%87%E5%A4%A9%E5%9F%BA%E5%B0%8E%E5%BD%88%E9%A0%90%E8%AD%A6%E6%9C%89%E9%97%9C.

[23] "Expert: China Is Approaching the Goal of Building Own Anti-Missile Systems," *Sputnik*, February 8, 2021, https://big5.sputniknews.cn/opinion/202102081033053161/.

system to avoid the rapid destruction of its fragile nuclear strike system by the enemy in case of a war.

After completing the test in February 2021, China is close to accomplishing the goal for its own anti-missile system, which not only counters the U.S.'s deployment of medium-range weapons in Asia but also offsets India's threat of nuclear strikes. As the U.S.'s current development of medium-range missiles is not going too fast and there are many challenges in its Asian deployment, even the beginning of the hypersonic weapons is unlikely to intimidate China in the immediate future. Hence, China's anti-missile defense network should be able to effectively counter the U.S.'s military threats.

PART THREE

Strategic Support Equipment

Chapter 7

Development and Assessment of PLA's Electronic Reconnaissance Capability

Chen-Yi Tu*

I. Introduction

Modern electronic warfare can be divided into electronic attacks (EAs), electronic support (ES), and electronic protection (EP). Electronic support consists of electronic intelligence (ELINT) and communication intelligence (COMINT). While the former is based on radar signals with a frequency range from 1.2 to 40 GHz, the latter usually covers 80 to 3,000 MHz used in radio communications. These two detect, intercept, identify, and position electromagnetic and radiation data and collect information about the characteristics of emission sources to facilitate further analysis. There is some overlap between signal intelligence (SIGNIT) and electronic support. However, electronic support emphasizes tactical applications. For example, the receipt and comparison of signals onsite are directly forwarded to Radar Warning Receiver (RWR) for radar early warning intelligence. Signal intelligence is more focused on long-standing surveillance, interception, and analysis for long-term strategic planning.[1]

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1 "Advanced Trigger Based Multichannel Pulse Analysis to Characterize Radar Warning Receivers," *Rohde and Schwarz*, https://www.rohde-schwarz.com/ph/applications/advanced-trigger-based-multichannel-pulse-analysis-to-characterize-radar-warning-receivers-application- card_56279-1039004.html; Mario LaMarche, "Electronic Support: An Overview of Electronic Warfare Part 3," *Mercury Systems Blogs & Podcasts*, November 2018, https://www.mrcy.com/ company/blogs/electronic-support-overview-electronic-warfare-part-3.

Analyses are performed on the electronic parameters and data collected from electronic surveillance ships, aerial reconnaissance aircraft, and ground reconnaissance vehicles for direction-finding. Electronic reconnaissance, which provides electronic protection and data required for attacks, is also part of electronic support. However, ships, aircraft, or vehicles are limited to platforms and usually cannot carry out large-scale and continued reconnaissance for long. Nonetheless, there is no limitation for electronic reconnaissance satellites/ ELINT satellites in outer space. Access to this intelligence source becomes the most critical element in common operating pictures of the C4ISR system.

During the Cold War, the U.S. and Russia embarked on many secret programs in the development of electronic reconnaissance satellites/ ELINT satellites to obtain electronic intelligence (ELINT). For example, the U.S. Naval Research Laboratory carried out the Galactic Radiation and Background (GRAB) experiment in the 1960s in the guise of observing solar radiation to obtain the Soviet Union's anti-aircraft radar information.[2] It is said that the Soviet Union launched over 200 electronic reconnaissance satellites/ ELINT satellites in 1967-1991 to stay on top of the U.S. Armed Forces and aircraft carriers of its allies. While there have been vibrant commercial activities by using signal intelligence in Europe and the U.S. from electronic reconnaissance satellites/ ELINT satellites in recent years, the development of the PLA's electronic reconnaissance capability has been relatively overlooked.

This report intended to examine the development, utilization, and R&D of the PLA's electronic reconnaissance equipment in order to assess the PLA's potential capability going forward. It also focuses on the influence of the increasing number of electronic reconnaissance satellites/ ELINT satellites.

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[2] John Pike, "Project Tattletale: GRAB Galactic Radiation Background Experiment," *Federation of American Scientists Space Policy Project*, February 20, 2000, https://fas.org/spp/military/program/sigint/grab.htm.

II. Development and Employment of PLA's Electronic Reconnaissance Equipment

In recent years, China has been keen to demonstrate its electronic reconnaissance on land, at sea, and over the air by aggressively developing electronic confrontation (i.e., electronic warfare) capabilities. On December 31, 2015, China formally established its Strategic Support Force (SSF) by including Technical Reconnaissance Department and Electronic Confrontation Department, previously under the General Staff Department. Meanwhile, China also set up the Network System Department and Aerospace System Department by including the Jiuquan Satellite Launch Centre (JSLC) and Satellite Maritime Monitoring & Control Department, previously under the General Equipment Department. The integration of functions on land, at sea, over the sky, and even in space into a single system speaks volumes about its ambition to expand electronic reconnaissance and enhance control over the electromagnetic environment.

At the military parade on October 1, 2019 for the 70th Anniversary of the Founding of the People's Republic of China, four information operations parade formations drew out from the Strategic Support Force (SSF) and Electronic Confrontation Brigade of the Ground Force were inspected. One of the square formation from the Strategic Support Force emphasized: "system neutralization by breaking nodes, victory at the first strike". The other square formation from the Electronic Confrontation Brigade labeled itself for "integrated reconnaissance and strike operations, integrated network and electronic warfare, software and hardware integration, airland operations" by focusing on "battlefield network-electronic power" and joining by artillery units in the operations. These indicates that the two has distinctive roles.[3]

In the next year of the military parade, National Defense Channel of China Central Television (CCTV) showed the training images of the PLA Northern Theatre's 78th Group Army on May 10, 2020. In this footage, the two armored

[3] See *Chinese People's Liberation Army Daily*, October 2, 2019, http://www.81.cn/jfjbmap/content/2019-10/02/node_2.htm.

vehicles, remodeled from 6x6 Dongfeng Mengshi CSZ181, looked rather similar to the 2nd Information Warfare Formation in the military parade. One of the vehicles had two antenna. Judging by the appearance, it should be capable of monitoring and direction-finding over VHF/UHF/SHF; hence, it is likely to be an electronic reconnaissance vehicle. These training images also indicate that equipment displayed at the military parade has already been in service (Figure 7-1).

Figure 7-1 PLA's Electronic Reconnaissance Vehicle

Source: National Defense Channel of China Central Television (CCTV).

Electronic surveillance ships, such as Type 815 and follow-up models, have entered service since 2014 and carried out far-sea reconnaissance missions. There are currently nine known ships, with three each for East Sea Fleet, South Sea Fleet, and North Sea Fleet. It is worth noting that the Type 815 Series has been under continuous improvement during the construction process. Hence, it is known to come in two batches: the first to the fourth ships are the Type 815G (Figure 7-2); and the fifth one "Kaiyangxing" (Mizar, pennant number 856), which was launched in 2017, changed the radome in front of the mast into a cylinder. This subsequent batch is called the Type 815A for differentiation with the prior model (Figure 7-3).[4]

[4] "China's New Electronic Surveillance Ship Enters Service. U.S. Media Says It is World-class," *People's Daily*, February 22, 2017, http://military.people.com.cn/BIG5/n1/2017/0222/c1011-29099699.html; "Photo Feature Today's Chinese Warship," *Ships of the World*, 945, April 2021.

Figure 7-2 Types 815G Electronic Surveillance Ship "Uranus"

Figure 7-3 Type 815A Electronic Surveillance Ship "Zeta"

Source of photo: Global Times, Sina Military Section.

In addition, the public release from Japan's Joint Staff Office and the R.O.C. Ministry of National Defense provide timely information of PLA air activities. It reveals that the remodeled Y-8 and Y-9 electronic intelligence aircrafts, also known as GX Series, are not only participating training exercise over the East China Sea but also continue to violate Taiwan's southwestern air space. The J-16's electronic warfare model (J-16D) first showcased in 2021 China International Aviation & Aerospace Exhibition. It is equipped with a wingtip pod, with appearance like the AN/ALQ-218 radar warning/ electronic support (ES)/ electronic intelligence receiver (RWR/ESM/ELINT sensor) used by the U.S. Navy's EA-18G Growler, may possesses similar function. The payloads mounted beneath the intake on both undersides and the two stations for underwing pylon tanks may have the

same function as Growler's AN/ALQ-99 jamming pods. However, it is unclear whether China has overcome the technical challenge of AN/ALQ-99 in mitigating interference to the aircraft's own AESA radar for better operational effectiveness.

Figure 7-4 Static Display of J-16D at China International Aviation & Aerospace Exhibition

Source: The Paper.

III. R&D Capacity of China's Electronic Reconnaissance

Despite the limited information disclosed by China regarding the R&D of its electronic reconnaissance, the operational requirements should be identified by the Strategic Support Force (SSF). Based on the publicly available information, the PLA's research and validation in "electronic confrontation" (電子對抗) and "cyberspace security" (網絡空間安全) are in charged by Unit 32802 of SSF – which is also part of the Systems Engineering Research Institute of PLA Academy of Military Science in Beijing.[5] In addition, the Electronic Confrontation Institute under National University of Defense Technology in Hefei, Anhui, formerly known as Electronic Engineering Institute of PLA, was integrated into the National

[5] "Announcement (2021) No. 2 | PLA 32802 Brigade 2021 Announcement for Recruitment (Table of Positions Attached)," *hongshi81*, January 27, 2021, https://mp.weixin.qq.com/s?_biz=Mzg4ODA1ODE0NA=&mid=2247529640&idx=5&sn=b8771d32b5b7a025fe36ede84ca95b4d&chksm=cf82cce7f8f545f1f2b19b6c19b3781459d24611d00dd99742a3d73b2c032d68c73b5a61ad29&scene=21.

University of Defense Technology (NUDT) in Changsha since the military reforms in 2017. The latter is also a hub for technology R&D and the talent cultivation of senior experts in military technology. Further, the equipment testing was conducted at Luoyang Electronic Equipment Test Center of China in Luoyang City, Henan Province. This center is also know as the PLA's 33rd Experimental Training Base (Unit 63880).

In 2012, the Luoyang Electronic Equipment Test Center of China and Electric Engineering Institute of the National University of Defense Technology (presently Electronic Confrontation Institute) joined forces and established the State Key Laboratory of Complex Electromagnetic Environment Effects on Electronics and Information System (CEMEE). The complex electromagnetic environment refers to the aggregation of anthropogenic electromagnetic fields and multiple electromagnetic phenomena. All the electronic information systems are subject to the influence of different electromagnetic signals in the complex electromagnetic environment. Consequently, this affects the information links through many levels, such as acquisition, transmission, and utilization, and affects the normal functioning of electronic information systems. These changes are known as the complex electromagnetic environment effect. Understanding the complex electromagnetic environment effect is critical to the testing and validation of electronic warfare equipment. By working with the National University of Defense Technology, the Luoyang Electronic Equipment Test Center of China can establish and expand its own capabilities in equipment testing and validation.

According to recent publications, the Luoyang Electronic Equipment Test Center of China also has capacity to conduct original research while performing key mission in equipment testing and validation. For example, it followed the China-India conflicts in 2021 closely and performed analysis to such current event. The co-authorship also demonstrates its close cooperation with the military industry (Figure 7-5). China Aerospace Science & Industry Corp. Research Institute No. 8511 in Nanjing (known with role of "Headquarter for Information Confrontation" in China Aerospace Science & Industry Corp.) is focused on research of electronic engineering and specializes in field of "aeronautical electronic confrontation." It

is currently responsible of many national key engineering and related programs. According to the publicly available information, its R&D results have already become a series of products in electronic-infra red confrontation equipment and general electronic warfare equipment.[6]


節點文獻

印軍電子戰裝備及其山地作戰使用特點分析

Analysis on Indian army's EW equipment and the characteristics of its use in mountain warfare

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【摘要】電子戰貫穿現代戰爭的全過程,對戰局乃至戰爭結果影響巨大。中印加勒萬河谷沖突后,中印雙方雖然達成協議在沖突地區建立緩沖區,暫時完成"脫離接觸",但是印軍卻大幅增兵沖突地區,并將主戰武器裝備配置到相關區域,同時向美國、以色列、俄羅斯和歐洲國家大量購買先進武器,與各國進行聯合軍演,積極備戰,中印沖突升級的可能性一觸即發。簡要介紹了印三軍主要電子戰裝備,并對其山地作戰使用特點進行了歸納總結。

【Abstract】Electronic warfare runs through the whole process of modern war and has a great influence on the situation and even the result of war. After the conflict in the Kalwan valley between China and India,although the two sides reached an agreement to establish a buffer zone in the conflict area and temporarily complete the"disen-gagement",the Indian army has substantially increased its troops in the conflict area,deployed its main combat weapons and equipment to relevant areas,purchased a large number of advanced weapons from the United States,Israel,Russia and European countries,conducted joint military exercises with other countries,and active-ly prepared for the war. The possibility of escalation of Sino-Indian conflict is imminent. The main electronic war-fare equipment of the Indian army is briefly introduced,and its operational characteristics in mountainous areas are summarized. 還原

【關鍵詞】印軍；電子戰；山地作戰；無人機；

【Key words】Indian army；EW；mountain warfare；UAV；

【文獻出處】航天電子對抗 ,Aerospace Electronic Warfare , 編輯部郵箱 ,2021年01期

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Figure 7-5 Recent Publication from Luoyang Electronic Equipment Test Center of China

Source: CNKI.

The 10th and 29th Research Institute are among the many other research institutions under China Electronic Technology Corp. (CETC). The 10th Research Institute, founded in Beijing on May 25, 1955, is China's first all-inclusive electronic technology research institute. It is also a National Tier-1 science and research organization in China. Meanwhile, 29th Research Institute is located in Chengdu City of Sichuan Province and widely known as Southwest Institute of Electronic Equipment. It is specialized in "electronic information control technology," R&D and production of related equipment. Furthermore, 29th

[6] "China Aerospace Science and Engineering Corp—Information Technology Research Institute," *Baidu Baike*, January 27, 2021, https://baike.baidu.hk/item/%E4%B8%AD%E5%9C%8B%E8%88%AA%E5%A4%A9%E7%A7%91%E5%B7%A5%E4%BF%A1%E6%81%AF%E6%8A%80%E8%A1%93%E7%A0%94%E7%A9%B6%E9%99%A2/1303764.

Institute offers master degrees in "signal and information processing," as well as in "electromagnetic fields and microwave technology." The affiliated company, Chengdu Tian'ao Electronics Co., Ltd., serves as a host for post-doctoral research.[7]

Judging by industrial corporations' immense collaboration between PLA, their actively recruiting efforts, and even offering postgraduate degrees, the PLA's development in electronic warfare equipment is an exemplification of the Military-Civil Fusion (MCF).

IV. Development of Electronic Reconnaissance Satellite/ ELINT Satellite

China's development of electronic reconnaissance satellites/ ELINT satellites is basically under the guise of scientific research program and civilian application. For instance, the first satellite, "ZH-1," from the China Seismo-electromagnetic Satellite (CSES), monitors the earth's outer electromagnetic fields, the ionosphere, the plasmasphere, and physical phenomena such as Energetic Particle Precipitation (ERP). The monitoring covers geophysics, the seismic mechanism, and the environment. The results suggest a significant correlation between electromagnetic disturbances and earthquakes hence, it is possible to explore new methods to predict earthquakes via electromagnetic monitoring.[8] While the ZH-1 claims to be primarily used for seismic observations, the detected data also provide key support to geophysics research. However, the establishment of the ZH-1 electromagnetic monitoring system suggests its electronic reconnaissance missions in space and value in military application.

This is particularly the case because geophysics research uses of ultra-low frequency (VLF, 3 kHz-30 kHz) radio waves . It can be transmitted to an extremely far distance via reflection from the ionosphere and penetrate seawater by at least 10 to 40 meters. This frequency is also used in the communications of nuclear

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7 China Electronic Technology Corp. (CETC) 29th Research Institute, http://www.cetc29hr.com/.

8 Guo-li Li and Hsiao-fan Li "China Successfully Launches Yaogan-32 01 Satellite," *Xinhua Net*, October 9, 2018, http://www.xinhuanet.com/politics/2018-10/09/c_1123533360.htm.

submarines. Further, such electromagnetic monitoring may enable tracking of submarines from different countries with satellite data. Chief Scientist of CSES Satellite mission, Sheng Xuhui Ph.D., is also involved in electromagnetic satellite working groups with France, Italy, and Europe, and the gravity satellite working groups with Europe by serving as China's team leader, thereby opening the door for China's improvement of its monitor system via international academic exchanges.[9]

The gradual completion of the Yaogan series satellites may expand China's exploration of the electromagnetic environment and assets in space. On October 9, 2018, Jiuquan Satellite Launch Centre (JSLC) successfully launched the Yaogan-32 Satellite 01 into the intended orbit with Chang Zheng 2C carrier rocket (along with YZ-1S carrier rocket). The Yaogan-32 Satellite 01 is produced and operated by the Aerospace Dongfanghong Satellite Company under China Aerospace Science and Technology Corp. (CASC) Fifth Academy (known as China Academy of Space Technology). It is primarily used to surveillance in electromagnetic environment and relevant technological experimentations.[10] In 2021, the Yaogan-31 Satellite 02, also developed by the Fifth Academy, was successfully launched with the CZ-4C Yao-40 carrier rocket on January 29 into the intended orbit.

The Yaogan-30 satellite series, developed by the Innovation Academy for Microsatellite of the Chinese Academy of Sciences, is based on the constellation model. From the released images, it is most likely to be a unit with three CubeSats. By calculating the time difference on arrival (TDOA) (Figure 7-6), it can obtain signal strength and therefore use for positioning. The Yaogan-30 Satellite 08 and Yaogan-30 Satellite 10 were also launched successfully on May 7 and July 19, respectively, into the orbits. According to the Chinese official media, the launch

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[9] Chu-ching Chao, "China Successfully Launches 'ZH-1', Its First Electromagnetic Aatellite for Monitoring and Testing," *people.cn*, February 2, 2018, http://scitech.people.com.cn/BIG5/n1/2018/0202/c1007-29803460.html; "National Institute of Natural Hazards' Chief Engineer Sheng Xuhui Invites to Make an Academic Report," Institute of Geology and Environment of Jiangxi Normal University, May 25, 2021, https://dlxy.jxnu.edu.cn/2021/0525/c1910a217802/page.htm.

[10] Huai-yu Liu, "Yaogan-32 Satellite 01 Successfully Launched," *Space China*, October 9, 2018, http://www.spacechina.com/n25/n2018089/n2018131/c2019368/content.html.

of Yaogan-30 Satellite 10 was described as the final stage of the current battle.[11] Based on the experience of the U.S. company Hawkeye 360 in providing signal intelligence services with CubeSats constellation, as each Yaogan-30 set consists of three CubeSats, it should be technically feasible to conduct around-the-clock radio frequency surveillance on specific regions in the world. This will help the vessel tracking of PLA in the region.[12]

Figure 7-6 Yaogan-30 Satellite 02

Source: China Central Television (CCTV) news channel.

V. Conclusion

In the preliminary introduction of the PLA's electronic reconnaissance capability from this chapter, it can be concluded that PLA already possess electronic reconnaissance capabilities at multiple temporal and spatial scale. Such capabilities continue to expand, with the goal of conducting 24/7 global surveillance. Therefore, these capabilities will greatly enhance their early warning capability and

[11] Chu-ching Chao, "China Successfully Launches Yaogan-30 Satellite 10 Tianqi to Complete the First Stage of the Internet-of-Things Constellation," *People's Daily*, July 19, 2021, http://finance.people.com.cn/BIG5/n1/2021/0719/c1004-32161846.html.

[12] Gunter Krebs, "Yaogan 30-01,..., 10-10 (CX 5), " *Gunter's Space Page*, August 3, 2021, https://space.skyrocket.de/doc_sdat/yaogan-30-01.htm.

complete the common operating picture for the C4ISR system with the final piece of puzzles. In the light of future great power competition, these will prepare PLA for the new "electromagnetic (operation) first" form of warfare.

Chapter 8

Cyber Warfare Capabilities of the PLA Strategic Support Force (SSF)

Tsung-Han Wu, Chia-Ling Hung*

I. Introduction

The PLA Strategic Support Force (SSF) is responsible for military informationization construction and the defense in cyberspace. According to Xi Jinping's New Three-step Development strategy on the national defense and military development for the era on the 19th National Congress of the Chinese Communist Party, October 18, 2017, it is necessary for the PLA to ensure the realization of basic mechanization and high-degree informationization by 2020, basic modernization of China's national defense and military services by 2035, and the transformation of China's military into a world-class military by the mid-21st century.[1] Regarding cyberspace, on the first Central Cyberspace Affairs Commission meeting in 2014, Xi Jinping has said, "Without cybersecurity, there is no national security. Without informationization, there is no modernization."[2] In July 2019, a white paper entitled "China's National Defense in the New Era" says cyberspace is part of China's sovereignty and major interest in national security; it

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1 "How to Accelerate National Defense and Military Development? Xi Jinping Emphasizes New Three-steps Strategy," *cpcnews.cn*, March 11, 2021, http://cpc.people.com.cn/xuexi/BIG5/n1/2021/0311/c385474-32049007. html.

2 "Xi Jinping in Charge of China's Cybersecurity," *BBC Chinese*, February 27, 2014, https://www.bbc.com/zhongwen/trad/china/2014/02/140227_china_xi_web_security.

also listed nuclear power and space as high points of China's military strategy. The white paper also indicates that the SSF is importantly responsible for new types of war capabilities. Based on the strategic requirements for system integration and Military-Civil Fusion (MCF), the development of a new type of war capability should be sped up and integrated.[3] All these statements speak of the importance of the SSF.

For a long time and due to data sensitivities, not much was known about the true face of the SSF. While many researchers have put piecemeal information together, knowledge was still fragmented, let alone the whole landscape. Occasional reports or articles published in academic journals focused on the organization, yet many of them were with few details on technologies or techniques.[4] This paper seeks to add to this gap. It examines the SSF by focusing on cyber warfare and cyber operation capabilities. Recent examples of possible operations are provided, and the most updated research literature is summarized.

II. The SSF and its Cyber Warfare Department

The PLA SSF was founded on December 31, 2015, as the PLA's fifth force along with other ground force, navy, air force, and rocket force. The establishment of this additional force signals the PLA's integration of space, cyber, electronic, and even psychological elements into a same battlefield framework. According to the introduction of the Chinese Communist Party's media, the SSF provides the PLA with the "guarantee for information support and strategic support" by serving as an

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3 "China's National Defense in the New Era (full text)," *The State Council Information Office of the People's Republic of China*, July 24, 2019, http://www.scio.gov.cn/ztk/dtzt/39912/41132/41134/Document/1660318/1660318.htm.

4 John Costello and Joe McReynolds, China's Strategic Support Force: *A Force for a New Era* (2018, Washington: National Defense University Press); Rachael Burton and Mark Stokes, *The People's Liberation Army Strategic Support Force Leadership and Structure* (2018, Project 2049 Institute); Elsa Kania and John Costello, "The Strategic Support Force and the Future of Chinese Information Operations," *The Cyber Defense Review (2018)*, pp. 105-121; Adam Ni and Bates Gill, "The People's Liberation Army Strategic Support Force: Update 2019," *China Brief*, Vol. 19. No. 10, May 2019, https://jamestown.org/program/the-peoples-liberation-army-strategic-support-force-update-2019/.

"information umbrella" for the whole PLA. It will "integrate into the operation of ground force, navy, air force, and rocket force throughout the war". To be specific, the core mission of the SSF is to engage in battles (strategically) and assist (as support) different forces in joint operations via the cyber and electromagnetic approaches. These operational tasks include reconnaissance, prewarning, communications, command, control, and navigation to achieve victory in warfare.[5]

While the SSF is set up as a military force at the same level as China's ground force, navy, air force, and rocket force, given that it is under the Central Military Commission (CMC) Joint Battle Command Center and also framed by the concept of "the CMC exercising overall leadership, the TCs [Theater Commands] responsible for military operations and the services focusing on developing capabilities," its actual role in the leadership system would change according to the nature of tasks.[6] On the surface, the SSF only provides support and protection. In reality, the initiation of attacks from its intelligence personnel and troops of hackers is rather impressive. Due to the PLA's increasing emphasis on information warfare, psychological warfare, and cognitive warfare, the SSF undertakes relevant tasks.[7] It is worth noting that the SSF is also one of China's cyber warriors, along with the Ministry of Public Security, the Publicity Department of the Communist Party of China, and the Militia of China.

The foundation of the SSF involved the consolidation and integration of the PLA's multiple departments and personnel before and after Xi Jinping's initiation of military reforms. Referring to the media reports and the previous

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5 Yue Chiou, "Expert: Strategic Support Force (SSF) Throughout the Warfare as Key to Victory," *people.cn*, January 5, 2016, http://military.people.com.cn/BIG5/n1/2016/0105/c1011-28011251.html; Guang-hui Ni, "Unveil the mystery of China's Strategic Support Force (SSF) (perspective and deepening of national defense and reforms of the military)," *people.cn*, January 24, 2016, http://military.people.com.cn/BIG5/n1/2016/0124/c1011-28079245.html.

6 Ying-Yu Lin, "Mission and Scale of China's Strategic Support Force (SSF)," *Prospect & Exploration*, 15(10), 2017, p. 105.

7 Ching-an Wang, "Development of Chinese Cyber Warriors as Threat to Our Military," *Journal of Army Communication Electronic Information*, 127, April 2017, pp. 4-26; "Exploration of PLA Strategic Support Force's Capability in the Context of China's Integrated Network and Electronic Warfare," *Navy Professional Journal*, 54(3), June 2020, pp. 81-92; Changhee Park, "Evaluation of Informatized War Capabilities of the People's Liberation Army: A Scenario of Taiwan," *National Defense Journal*, 36(2), June 2021, pp. 1-50.

studies, the SSF consists of the Aerospace System Department, Network System Department, Electronic/ Electromagnetic System Department, and Military Intelligence Department. Under these departments there are sub divisions which work individually and cooperate with each other. In general, the purpose is to use information technology to link all battle forces for a comprehensive warfare system. Currently, the PLA considers the pursuit of the commanding elevation in cyberspace and across the electromagnetic spectrum an important means of obtaining military advantages. Therefore, the SSF is essential for the PLA's integration of network and electronic warfare.

The Network System Department, formally established in July 2017 as part of the SSF, is responsible for military defense and offense in cyberspace. This department is an integration of the General Staff Department (GSD) Technical Reconnaissance Department (GsD 3rd Department) previously in charge of radio surveillance and reconnaissance, GSD Electronic Confrontation Department (GsD 4th Department) in charge of radar systems, and GSD Informatization Department (GsD 5th Department), whose "information security bureau" was in charge of military defense and offense in cyberspace. In line with this, it is believed that the 12 operational units and troops previously under the Third Department of the People's Liberation Army's GSD are now part of the SSF. According to prior reports by the Kanwa Defense Review, the unit "information warfare force directly under the headquarters" is responsible for gathering the PLA's hackers to develop viruses and logic bombs for cyberattacks. In brief, the Network System Department's activities include R&D, reconnaissance, defense, and offense as a complete link.[8] The basic structure of the SSF and other cyber troops is shown in Figure 8-1.

Neither of the first two commanders in chief of the SSF (i.e., Gao Jin and Li Fengbiao) comes from the information or communications backgrounds, whose appointments may be due to tenures or the PLA's overall planning. However, this is no longer the case. Ju Qiansheng, the commander in chief since July 5, 2021, has

[8] Jun-jie Yin, "On Cyberwars, Kanwa: more hacker troops," *Central News Agency*, January 4, 2016, https://www.cna.com.tw/news/acn/201601040303.aspx.

a technical background, who previously served as the deputy head of the Technical Reconnaissance Department and commander of the Network System Department of the SSF. Highly proficient in cyberwars, his appointment arguably signals the SSF's increasing focus on professional leadership and further integration of internal resources to strengthen concerted battle actions and establish battlefield advantages.

<table>
<tr><td colspan="9">Central Military Commission of the Communist Party of China</td><td>Other departments</td></tr>
<tr><td colspan="9">Army Strategic Support Force</td><td rowspan="3">Other cyber warriors including the Militia, Internet commentators and opinion leaders, and cyber police</td></tr>
<tr><td colspan="2">Aerospace System Department</td><td colspan="2">Network System Department</td><td colspan="2">Electronic/ Electromagnetic System Department</td><td colspan="3">Military Intelligence Department</td></tr>
<tr><td colspan="8">12 bureaus under the Third Department of the People's Liberation Army's General Staff Department</td><td>Others</td></tr>
<tr><td>Unit 61398 (the U.S. as the main target)</td><td>Unit 1486 (western countries as the main target)</td><td>Unit 661419 (Japan as the main target)</td><td>Unit 78020 (Southeast Asia as the main target)</td><td>Unit 61726 (Taiwan as the main target)</td><td>Unit 61786 (Russia and Central Asia as the main target)</td><td>Unit 69010 (Central Asia and Southeast as the main target)</td><td>Other units</td><td>(Such as information war force under the headquarters, Base 311)</td><td></td></tr>
</table>

Figure 8-1 Structure of Strategic Support Force and other Cyber Warriors

Source: Compiled by the author.

III. SSF's Cyber Warfare Techniques and Recent Cases

Cyberwarfare might engage in a series of techniques and tactics that works with physical battles. It can be an influential determinant of victory or defeat in modern warfare. Cyberattacks may come at different intensities for different purposes—it may be for intelligence gathering, restricting the target's activity, or creating more advantages by cutting off the opponent's ability to access networks and information

systems. With horizontal integration of the intelligence, electronics, and cyber divisions previously under the General Staff Department, the PLA SSF has mastered different cyberattack techniques and can mix and match these techniques. These capabilities have posed a grave threat to Taiwan's government agencies, key infrastructure, and industry supply chains.

In the military domain, the PLA's threats to Taiwan's cyberspace, electromagnetic spectrum safety, and military C4ISR must not be understated, given its growing digitalization of platforms, equipment, and weapon systems. In the meantime, the SSF is also tasked with information warfare, psychological warfare, and cognitive warfare. Disinformation has recently become a highly emphasized element of cyber defense.[9]

The ways the SSF initiates cyberattacks are not dissimilar to most cybersecurity and information security incidents. The major approach involves identifying possible vulnerabilities by collecting relevant information of the targets and then acquiring important and confidential intelligence according to requirements. It may also be the invasion of the target's system by implanting malware or direct attacks on the software loopholes previously detected to destroy the system. Below are some examples of the techniques:

Phishing: This is a type of social engineering. It is the acquisition of the target's confidential emails by cheating with electronic communications, usually via emails or fake websites.

Ferry: This attack is primarily done by entering the physically isolated networks via mobile devices to steal data or engage in other malicious activities. Ferry is often accompanied by Trojan horses.

Distributed denial-of-service attack (DDoS): The purpose is to disable the target from continuing to provide services. Attackers use a large number of computers (invaded in advance) for simultaneous connection and send a hefty number of

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[9] Gui-hsiang Wen, "Disinformation Seeks to Tear Taiwan Apart. President: Everybody Stays Alert of Cognitive Warfare," *Central News Agency*, April 16, 2021, https://www.cna.com.tw/news/aipl/202104160089.aspx; Kai-hsiang You, "Ministry of Justice Investigation Bureau's Video Deliberately Distorted. Scholars: PLA ups Its Cognitive Warfare Techniques," *Central News Agency*, April 18, 2021, https://www.cna.com.tw/news/firstnews/202104180076.aspx.

packets to block and paralyze the network to overload the system and make normal functioning impossible.

Great Cannon: Derived from the Great Firewall, this initiates distributed denial-of-service attack (DDoS) mainly by hijacking web traffic.

Advanced persistent threat (APT): This attack is based on prior observation and analysis of the target over a long period in order to stay on top of the target's dynamic information and initiate customized attacks. Attackers often resort to multiple and complicated techniques, including social engineering, by invading and penetrating possible loopholes. APT attacks may be a long, secretive process in multiple stages.

The process of initiating psychological warfare or cognitive warfare is also similar to that of general cyberattacks. The difference is that the former aims to influence the audience's psychological status or change the audience's perception by collecting information with specific disseminating techniques. As far as the SSF is concerned, network, electronic, and psychological warfare are interrelated and can work in conjunction.

Psychological warfare	Target the objective	Lurking and intelligence stealing from the objective	Release disinformation (/ true) information	To influence the target audience
Cyberattacks	Target the objective	Lurking and intelligence stealing from the objective	Various types of cyberattacks	To influence the target audience

Figure 8-2 The Path Diagram of Psychological Warfare and General Cyberattacks

Source: Compiled by the author.

Limited by data source, this paper does not intend to pinpoint the techniques and steps and specify the victims, incidents, and objects targeted by the attacks from the SSF. On the other hand, below we provide a list of cyberattacks that the SSF might have been possibly involved in since 2020 based on relevant information security reports or media coverage. It is worth mentioning that these cyberattacks may not all be operated by the SSF alone. Instead, these may be joint attacks from

mercenary hackers for hire or other state-owned or -sponsored cyber warriors. The final section provides a summary of the advanced persistent attack (APT) groups possibly related to the Strategic Support Force.

The first case in point was the ransomware attacks in May 2020 on CPC Corporation Taiwan and Formosa Plastics. The timing was sensitive because it was close to the presidential inauguration ceremony dated on May 20. After the probe by the Ministry of Justice Investigation Bureau, it was believed to be the work of the Chinese hacker organization APT 41 (also known as Double Dragon; Barium; Winnti; Wick Panda; Wicked Spider). This organization is thought to be highly related to the Strategic Support Force and meant to demonstrate the capability in neutralizing Taiwan's essential services to create panic. It was very much of a show of muscle and warming.[10] In June 2020, Prime Minister of Australia, Scott Morrison, openly said that Australia had been under complicated, large-scale cyberattacks from "national" hackers for months, where both government agencies and private companies were targeted. While Mr. Morrison did not specify the name of the attacking country, most reports believed it was China.[11] In October 2020, the media reported that the Chinese hacker organization RedEcho attacked India's electric grids and caused a blackout in Mumbai. It was when the border row turning to tense between China and India, and there was a standoff between the Chinese and the Indian armies. Further, it was generally believed that the hacker organization was meant to intimidate the Indian government. The reports by information security companies indicate that there are many similarities in the behavior of RedEcho and APT41.[12]

In March 2021, Microsoft exposed the initiation of a zero-day attack by the Chinese hacker organization Hafnium on the loopholes of the Microsoft Exchange Server. In the middle of July, the U.S. and its allies, including the Five Eyes,

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[10] Qian-ru Weng, "Ministry of Justice Investigation Bureau Discloses the Full Results of the Probe into Ransomware Attach on Formosa Plastics," *iThome*, August 12, 2020, https://www.ithome.com.tw/news/139331.

[11] "Australia Cyberattacks: PM Morrison Warns of 'Sophisticated' State Hack," *BBC NEWS*, June 19, 2020, https://www.bbc.com/news/world-australia-46096768.

[12] "China-Linked Group RedEcho Targets the Indian Power Sector Amid Heightened Border Tensions," *Recorded Future*, February 28, 2021, https://www.recordedfuture.com/redecho-targeting- indian-power-sector/.

European Union (EU), North Atlantic Treaty Organization (NATO), and Japan, condemned the China government's irresponsible and malicious cyber activities around the world. Subsequently, four Chinese hacker suspects were prosecuted. The U.K.'s National Cyber Security Centre said in a statement that the State Council of China is related to the hacker organization Hafnium that attacked the Microsoft Exchange Server. It was also specified that China's Ministry of State Security is behind the two hacker organizations, APT31 and APT40.[13]

Numerous psychological and cognitive warfare cases attempt to sabotage Taiwan's image or its diplomatic relations by manufacturing international incidents. In April 2020, many fake accounts tweeted about the Taiwanese people's apology to Tedros Adhanom Ghebreyesus, Director-General of the World Health Organization. It was later proven to be a plot and a scam by Chinese netizens. In December 2020, there was a fake official document pretending to be a request from the Ministry of Justice Investigation Bureau to the Office of the President for cooperation with the U.S. to drive a democratic revolution in Thailand. This request was then later proven to have come from Mr. Liu, who went to China for training by the Internet Water Army. In September 2021, the information security company TeamT5 was said to have been instructed by the Taiwan government to illegally collect the personal data of the Japanese people and confidential information of important business figures, proven to be online disinformation propaganda from China.[14]

The number of information security incidents in the world broke records again and again during the past year, and it seems that the attacks from China's cyber warriors have become more frequent and aggressive. As the world is caught in the

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[13] John Hudson and Ellen Nakashima, "U.S., Allies Accuse China of Hacking Microsoft and Condoning Other Cyberattacks," *Washington Post*, July 19, 2021, https://www.washingtonpost.com/national-security/microsoft-hack-china-biden-nato/2021/07/19/a90ac7b4-e827-11eb-84a2-d93bc0b50294_ story.html.

[14] Yen-fen Huang, "China's New Trick in Cognitive Warfare! Targeting Taiwanese Information Security Company and Manufacturing Fake News to Incite Disharmony between Taiwan and Japan Governments," *iThome*, September 23, 2021, https://www.ithome.com.tw/news/146834; Bo-wen Hsiao, "Taiwanese Distributes Fake News from Chinese Cyber Warriors. First Cyber Case in National Security," *Central News Agency*, December 11, 2021, https://www.cna.com.tw/news/firstnews/202012110028.aspx; Bo-wen Hsiao, "Chinese Netizens Pretend to be Taiwanese Apologizing for Attacking Tedros Adhanom Ghebreyesus," *Central News Agency*, April 10, 2020, https://www.cna.com.tw/news/firstnews/202004100033.aspx.

competition between China and the U.S., cyberspace has been already a heated battlefield.[15]

Table 8-1 APT Groups Possibly Associated with the SSF

Name	Target Areas or industries	Target Profiles	Attacks to Taiwan
APT1 (61398)	Government, national defense, NGOs, academics, critical infrastructure, entertainment, high-tech	Multi-disciplinary but mostly focusing on political, economic, and military intelligence	Yes
APT2 (61486)	Government, academics	Focusing on satellite and aviation industries	
APT3	National defense, aviation, space, architecture, manufacturing, high-tech, telecommunication, transportation	Focusing on companies in cutting edge domains	
APT10 (menuPass)	Government, national defense, aviation, space, energy, finance, medicare, pharmaceuticals, high-tech, media, telecommunication	Mainly targeting governments and corporates, particularly Japanese	Yes
APT18	National defense, aviation, space, architecture, engineering, education, medicare, high-tech, telecommunication, biotech	Mostly targeting governments, corporates, and human rights groups	
APT19 (a.k.a. Deep Panda)	Government, national defense, energy, education, finance, telecommunication, manufacturing, high-tech, and medicare	Focusing on governments and national defense domains. Mostly targeting at advisory groups and political dissidents	

[15] Nicole Perlroth, "How China Becomes the Main Cyber Threat to the U.S.," *NY Times Chinese*, July 20, 2021, https://cn.nytimes.com/technology/20210720/china-hacking-us/zh-hant/.

Name	Target Areas or industries	Target Profiles	Attacks to Taiwan
APT26	Government, NGOs, aviation, space, national defense, energy, finance, telecommunication, food & agriculture, medicare and healthcare	Focusing on competitive companies in aviation, national defense, and energy	
APT40	Government, national defense, engineering, manufacturing, shipping, logistics	Focusing on domains related to maritime technologies. Thought to be closely associated with the Chinese navy	
APT41 (a.k.a. Barium, Winnti, Wicked Panda, Wicked Spider Group)	Government, national defense, architecture, education, energy, medical science, high-tech, manufacturing, petrochemicals, retail, telecommunication, transportation, entertainment	Multiple disciplines. Noted rather active when the Anti-ELAB Movement was ongoing in Hong Kong	Yes
Blacktech	Government, architecture, finance, media, medicare & healthcare	Mostly focusing on East Asia	Yes
Tonto Team	Government, national defense, finance, media, information technology	Mostly targeting Korea, Russia, and Japan before 2019. Later targeting Mongolia and Russia	Yes
Mustang Panda	Government, NGOs, aviation	Mostly targeting non-government organizations. Often using the Mongolian language	Yes

Name	Target Areas or industries	Target Profiles	Attacks to Taiwan
RedDelta	Government	Mostly targeting government agencies. Found in 2020 to frequently attack Vatican and Catholicism related organizations	

Source: Compiled from Gulshan Rai, "Cyber DNA of China-Deep," Focused and Militarized, *Vivekananda International Foundation*, March 23, 2021, https://reurl.cc/1oeR7W; Adam Hlavek, "The China Threat, In Brief," *IronNet*, January 10 2021, https://reurl.cc/r1LWAk; "Groups," *MITRE/ ATT & CK*, https://reurl.cc/95V8qn; "Advanced Persistent Threat Groups," *MANDIANT*, https://reurl. cc/EZGdvR; APT list, CYBER INTEL MATRIX, https://reurl. cc/NZqe8Q.

IV. Conclusion

Cyberwarfare is taken by the PLA as a key to victory in information warfare. According to the Taiwanese Ministry of Defense's 2021 China Military Power Report, the PLA is now able to initiate soft kill, hard kill, and electronic attacks on the western region of the First Island Chain, blocking communication and blanking signals. The PLA traditional troops can also work with the cyber warriors to attack the global networks wireline and wireless. These capabilities have been sufficient to neutralize the R.O.C. Armed Force's air defense, command of the sea, and countermeasure capabilities. The SSF is obviously among the key contributors to the PLA's rapid development in terms of its capabilities. Thus, Taiwan's national defense is under serious challenge.[16]

The frequency of cyberattacks and the variety of attack techniques have risen since 2020. There is also an increasing wave of psychological attacks. Further, this paper found many incidents which attempted to damage the image of Taiwan's government and its relationship with its allies. To counter the challenges, Taiwan's

[16] Ching-lyu Yang, "National Security Crisis! Ministry of National Defense'2021 China Military Power Report' Revealed that PLA Has Already Had a Complete Grasp of Taiwan's Military Dynamics," *Newtalk*, September 1, 2021, https://newtalk.tw/news/view/2021-09-01/629400.

government units in national security are urged to respond carefully and embark on in-depth research on the Strategic Support Force.

Chapter 9

Review of China's New Space Warfare Capability

Yi-Shuo Tzeng*

I. Introduction

In 2021, the PLA's Strategic Support Force achieved major milestones in the development of space technology by launching the Tianhe core module into the earth's orbit on April 29. The astronauts of the Aerospace System Department entered the Tianhe core module on June 17, successfully launched from the space station on July 14, and returned safely to the earth on September 17. During this period, China continuously demonstrated its national power in space. It is now the only country in the world operating a space station. Its astronauts completed the operation of going in and out of the space capsule, showcasing China's strong capabilities in precise launching, targeting, communications, and anti-satellite (ASAT).

Furthermore, in 2021, China completed the first-stage development of its communications relay satellite and successfully supported the functioning of the space station and the audio/video communications between the space station and the earth.[1] China's achievements in space development go beyond space stations and space communications. On May 15, the Mars exploration led by the China National Space Administration declared good news. After the thrilling nine minutes, Tianwen-1 successfully landed by itself on the surface of Mars, making

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1 "Chronicle of the Success of China's First Generation of Data Relay Satellites Developed by CASC," *China Space News*, July 16, 2021, http://m.spacechina.com/n2014789/n2014809/c3274335/content.html.

China the world's second country that has successfully landed on Mars.[2] With these accomplishments, the Chairman of the Central Military Commission, Xi Jinping, visited the satellite base in Xian on September 15 and vowed to protect China's assets in space.[3] This means China will enhance its resilience in terms of space and military technological development. It also means China is comparable to the U.S., with strengths and vulnerabilities, given its military dependence on space assets.

In the second version of the white paper "China's National Defense in the New Era" in 2019, China stated that it would accelerate the development of technology, the integration of satellite information and resources and the command of Space Situational Awareness (SSA) to enhance the abilities in accessing and utilizing the space.[4] Given China's achievements in space development in 2021, this chapter focuses on the military implications by focusing on the PLA Strategic Support Force's relevant activities in 2021. The purpose is to examine how the Aerospace System Department under the Strategic Support Force combines cyber and electronic warfare units and utilizes the space development plans and relevant warfare capabilities to support the PLA's information warfare or establish information advantages through gray-area conflicts.

Below is a summary of the PLA Strategic Support Force's progress in its space station, satellite communications network, and anti-satellite (ASAT) capabilities. The section also provides an analysis on the implications of the military's strengthening the access and utilization of the space, enhancement of Space Situational Awareness (SSA), and countering the enemy's use of space to achieve information advantages.

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[2] Steven Lee Myers and Kenneth Chang, "China's Mars Rover Mission Lands on the Red Planet," *New York Times*, May 14, 2021, https://www.nytimes.com/2021/05/14/science/china-mars.html?_ga=2.146445553.455917626.1632233103-1542753318.1629218292.

[3] "A Space Dream Built with Precision and Ingenuity," *people.cn*, September 20, 2021, http://politics.people.com.cn/BIG5/n1/2021/0920/c1001-32232002.html.

[4] "China's National Defense in the New Era (full text)." *Ministry of National Defense of the People's Republic of China*, July 24, 2019, http://www.mod.gov.cn/big5/regulatory/2019-07/24/content_4846424.htm.

II. Leverage of space development to establish information advantages on multiple warfare fronts

In response to Russia's and China's deployment of anti-satellite (ASAT) activities possibly beyond the detention scope of 20,000 km covered by existing space radars, it was heard in July 2021 that the U.S. intended to work with the U.K. and Australia in the establishment of three radar stations to detect the space weaponry from Russia and China up to 36,000 km from the surface of the earth. China threatened to collaborate with Russia to impose countermeasures. Like the U.S., the U.K. and Australia are also members of the Five Eyes, allowing them to share intelligence closely. The distribution of monitoring activities enhances the accuracy of the information, improves the survivability of the command and control systems, and strengthens the flexibility and resilience of backup deployment.[5]

In addition to the Five Eyes, the Japan Ministry of Defense stated the importance of the stability of Taiwan's situation to Japan for the first time in the 2021 annual white paper "Defense of Japan" released on July 13, 2021. It also emphasized the necessity of constructing multi-domain defense forces to cope with the challenge of new warfare in space and cyber and electromagnetic power. Noteworthily, the U.S. Armed Forces are much even faster. Given the trend for integrating the cyber and electromagnetic spectrum, all the military forces are starting to combine the command and control systems for space and cyberspace. It is expected that the cross-disciplinary integration between military branches can boost the flexibility and resilience in all-domain warfare.[6]

As the U.S. utilizes space assets to enhance information advantages for the defense of the First Island Chain in the Indo-Pacific, China is also proactively using its space assets to enhance C4ISR and ensure partial information advantages

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[5] Edited and translated by Hsin-yu Shih, "U.S. Intends to Build Three Radar Stations, to Counter China's Space Expansion," *Youth Daily News*, July 19, 2021, https://www.ydn.com.tw/news/newsInsidePage?chapterID=1426358.

[6] Japan Ministry of Defense, *2021 Defense of Japan*, July 13, 2021, p. 13, https://www.mod.go.jp/en/publ/w_paper/wp2021/DOJ2021_Digest_CH.pdf.

in the future battlefield of informationization. To this end, the Strategic Support Force is constructing its own space information advantages mainly by deploying reconnaissance, navigation, and communications assets in space for surveillance, positioning, and Space Situational Awareness (SSA). The establishment of space communications with satellite constellations enhances the satellite communication speed, quality, and resilience of military forces and networks on land, at sea, over the air, and underwater.

To offset the enemy's information advantages with the use of space assets, the Strategic Support Force has been proactively developing anti-satellite (ASAT) weapons, robot arms for grabs, kinetic energy weapons (e.g., space objects or debris), and the capability to initiate non-kinetic attacks on space satellites or ground stations, such as lasers directed towards the ground or the space to cause blindness or damages, microwave interference, electromagnetic pulse shocks with an explosion nearby or cyber viruses.[7] For gray-area conflicts of a non-war nature, the techniques are limited to recoverable measures and non-kinetic attacks. Thus, the Strategic Support Force must ensure its information advantage in cyberwar and electromagnetic spectrum war against strategic opponents.[8] Moreover, going up against the U.S. Armed Forces remains a huge challenge for the Strategic Support Force.

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[7] Todd Harrison et al., "Space Threat Assessment 2021," *Report of the CSIS Aerospace Security Project*, April 2021, pp. 3-7, https://csis-website-prod.s3.amazonaws.com/s3fs-public/publication/210331_Harrison_SpaceThreatAssessment2021.pdf?gVYhCn79enGCOZtcQnA6MLke Klcwqqks. Also see Fu-yu Tsai (trans), "Increasing Space Security Threats Become an International Concern (part 1)," *Youth Daily News*, May 4, 2021, https://www.ydn.com.tw/news/newsInsidePage?chapterID=1364439.

[8] Chris Dougherty, "Confronting Chaos: A New Concept for Information Advantage," *War on the Rocks*, September 9, 2021, https://warontherocks.com/2021/09/confronting-chaos-a-new-concept-for-information-advantage/.

III. China's Progress in Space Reconnaissance and Communications

1. Acceleration in the Deployment of Gaofen Reconnaissance Satellites

After launching multiple high-resolution remote sensing reconnaissance satellites from the end of 2015 to 2020, the PLA Strategic Support Force continued its rapid deployment of Gaofen Series dual-use optical remote sensing reconnaissance satellites in 2021 to detect offshore stealth fighter aircraft and hypersonic weapons for early warning and deterrence purposes. The speed of deployment seems to be accelerating, given the maturity of the multiple carrier rockets. In September alone, the Taiyuan Satellite Launch Center (TSLC) used the CZ-4C Yao-40 carrier rocket and successfully launched a hyperspectral observation satellite (Gaofen 5 Satellite 02)[9] on September 7. On the other hand, the Jiuquan Satellite Launch Centre (JSLC) launched Jilin-1 Gaofen-02D on September 27[10] to fast-track the construction of reconnaissance satellite constellations. China claims its hyperspectral observation satellite is equipped with seven detection instruments covering ultraviolet and long-wave infrared—an integration of imagining technology and hyperspectral sensing to achieve the all-in observation of space, light spectrum, and radiation data. This fusion of multiple observed data with the perspectives of hyperspectral, in full-spectrum polarized with performance, is likely to be internationally cutting edge.[11]

2. Significance of Tiangong Space Station to the Space Force

Back in 2013, when the crewed spacecraft Shenzhou-10 was launched, Xi Jinping expressed his desire to speed up the space development to realize the

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[9] Chu-ching Chao, "Successful Launch of the Hyperspectral Observation Satellite to Ensure the Data for Environmental Monitoring," *people.cn*, September 7, 2021, http://finance.people.com.cn/BIG5/n1/2021/0907/c1004-32220053.html.

[10] "Jilin-1 Gaofen-02D Successfully Launched," *China Daily*, September 28, 2021, https://jl.chinadaily.com.cn/a/202109/28/WS615273b9a3107be4979f0263.html.

[11] Op. cit. 9. Chu-ching Chao, "Successful Launch of the Hyperspectral Observation Satellite to Ensure the Data for Environmental Monitoring," *people.cn*, September 7, 2021, http://finance.people.com.cn/BIG5/n1/2021/0907/c1004-32220053.html.

"aviation dream of the Chinese people". At that time, China was already planning to build its own crewed space station in 2020 and said it wanted to catch up with Russia and the U.S. in 2030 to become a space power.[12] Noteworthily, the Tiangong Space Station's Tianhe core cabin module is one realization of China's space ambitions.

On April 29, 2021, the Tiangong Space Station launched its Tianhe core cabin module. On June 17 of the same year, Shenzhou-12, carrying three PLA astronauts (i.e., Nie Haisheng, Liu Boming, and Tang Hongbo), was successfully docked with the Tianhe core cabin module.[13] This launch is China's 19th flight mission of crewed spacecraft and the first human-crewed mission in the space station stage.[14] On July 4, 2021, Liu Boming and Tang Hongbo went out of the capsule for the first time for six to seven hours,[15] inspected the performance of the new generation of spacesuits in space, installed equipment for the space station, enhanced the panoramic camera, and tested the robot arm of the space station. On August 20, the astronauts went out of the capsule again and completed tasks like installing pumping sets and lifting the panoramic camera. According to the field tests, China has achieved breakthroughs in robot arms for core cabin modules, extravehicular maintenance and support tools, and air-space-ground communications. All these are powerful supports to extravehicular operations of the space station.[16]

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[12] Tzong-han Mu, "With Exploration of the Moon and Mars and Establishment of the Space Station, China Surpasses Russia and Catches up with the U.S. in Its Space Ambitions," *Central News Agency*, July 29, 2021, https://www.cna.com.tw/amp/topic/newsworld/153/202107290004.aspx.

[13] Yue Yang, Pu-chung An, Kang Chan, Ching-ching Tan, "Out on a Mission! Chinese Astronauts Fly to the Home in Space," *Chinese People's Liberation Army Daily*, cited from the website of Ministry of National Defense of the People's Republic of China, June 17, 2021, http://www.mod.gov.cn/big5/topnews/2021-06/17/content_4887501.htm.

[14] Op. cit. 8. Tzong-han Mu, "With Exploration of the Moon and Mars and Establishment of the Space Station, China Surpasses Russia and Catches up with the U.S. in Its Space Ambitions," *Central News Agency,* July 29, 2021, https://www.cna.com.tw/amp/topic/newsworld/153/202107290004.aspx.

[15] China's first space walk was in September 2008 on an extravehicular task from Shenzhou-7. That walk only lasted about 20 minutes. Thirteen years on, China's space walk has been extended to six to seven hours. Tze-han Lin, "Perfect Extravehicular Activity Demonstrates China's Strengths in Aviation," *People's Daily(Overseas Edition)*, August 30, 2021, http://finance.people.com.cn/BIG5/n1/2021/0830/c1004-32211570.html.

[16] Op. cit. 10. Tze-han Lin, "Perfect Extravehicular Activity Demonstrates China's Strengths in Aviation," *People's Daily(Overseas Edition)*, August 30, 2021, http://finance.people.com.cn/BIG5/n1/2021/0830/c1004 32211570.html.

The Tiangong Space Station will consist of the Tianhe core cabin module, namely the Wentian and Mengtian modules. There will be a total of ten space missions in 2021-2022 for the construction of the space station. According to Wang Wei, Director of the General Research Office of the Space Station, the General Design Department of China Aerospace Science and Technology Corporation (CASC) Academy No. 5, the Wentian and Mengtian modules will be launched to dock with the core cabin module to form a T-shaped three-cabin structure via configuration repositioned. Meanwhile, four cargo spaceships will be launched for living and working in space, and four human-crewed spacecraft will transport the astronauts to the space station for living and working.[17] These four flight missions will require a stay at the space station for three to six months.[18]

Even with continued scalability, the Tiangong Space Station's technical capabilities remain significantly behind those of the International Space Station as China still does not have the large orbital segments as those in U.S. space shuttles. Each of the Tiangong Space Station's Tianhe core cabin modules—the Wentian and Mengtian modules—is approximately 16.6 meters in length for the long stationing of three people. Together with the cargo spacecraft and the human-crewed spacecraft, this adds to a total of 80 to 100 metric tons, equivalent to Russia's third-generation space station Mir. Meanwhile, the International Space Station, jointly constructed by the U.S. and Russia since 1998, is 109 meters in length, 73 meters in width, 20 meters in height, and 419 metric tons in weight. Its internal capacity is 916 m3, equivalent to a seven-story small stadium and capable of providing seven astronauts for long-term living and working.[19]

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[17] "400 km in Space – How is China Building a 'Home in Space'?," *China News Services*, April 29, 2021, https://www.chinanews.com/gn/2021/04-29/9467173.shtml.

[18] Op. cit. 8. Tzong-han Mu, "With Exploration of the Moon and Mars and Establishment of the Space Station, China Surpasses Russia and Catches up with the U.S. in Its Space Ambitions," *Central News Agency*, July 29, 2021, https://www.cna.com.tw/amp/topic/newsworld/153/202107290004.aspx.

[19] "Is the Gap Big between International Space Station and China's Epitome in Aviation Technology, Tiang?," *Our China Story*, July 3, 2021, https://www.ourchinastory.com/zh/1148/%E4%B8%AD%E5%9C%8B%E8%88%AA%E5%A4%A 9%E7%A7%91%E6%8A%80%E7%9A%84%E4%BB%A3%E8%A1%A8%20%E3%80%8C%E5%A4%A9%E5%AE%AE%E3%80%8D%E8%88%87%E5%9C%8B%E9%9A%9B%E5%A4%AA%E7%A9%BA%E7%AB%99%E5%B7%AE%E8%B7%9D%E5%A4%A7%E5%97%8E%EF%BC%9F.

While China designates the Tiangong Space Station as its "national space laboratory", it is independently maintained and operated by China. On the other hand, the International Space Station is maintained by more than ten countries.[20] Whether China's Tiangong Space Station provides military service is an issue of great concern. Despite the limitation in hardware scalability, the Tiangong Space Station continues to install state-of-the-art communications and electronics technology and update software with artificial intelligence to achieve the extension of functions.[21] The two extravehicular activities by astronauts from the Tianhe Core Module showcased China's capability to manufacture, repair, and maintain space robot arms, spacesuits with life-support and communications systems, and real-time communications in space and between space and the ground with Tianlian relay satellites for the space station.

Furthermore, it is worth noting that the Tiangong Space Station will serve as a space harbor by providing maintenance and supplies to spacecraft in space and upgrading the spacecraft equipment and software accordingly. Neither the Mir space station in the past nor the International Space Station has this function. After completing the Tiangong Space Station, China will launch the XunTian CSST Chinese Synoptic Survey Telescope on its own and put it in the same orbit as the Tiangong Space Station, with short stops over at the Tiangong Space Station for the refilling of propellants, repair, maintenance, and upgrade.[22] In this way, the Tiangong Space Station will become part of China's space target acquisition and reconnaissance capability.

3. Military significance of Tianlian Communications Satellites

While the world is watching Musk's low-orbital Starlink to connect with 6G, autonomous driving, and solar energy generation in 2021, China is also proudly

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[20] Op. cit. 12. "400 km in Space—How does China Build a 'Home in Space'?," *China News Services*, April 29, 2021, https://www.chinanews.com/gn/2021/04-29/9467173.shtml

[21] Op. cit. 12. "400 km in Space—How does China Build a 'Home in Space'?," *China News Services*, April 29, 2021, https://www.chinanews.com/gn/2021/04-29/9467173.shtml.

[22] Op. cit. 12. "400 km in space—How does China Build a 'Home in Space'?," *China News Services*, April 29, 2021, https://www.chinanews.com/gn/2021/04-29/9467173.shtml.

demonstrating its Tianlian communications satellite group deployed in the geostationary orbit, 35,786 km above the ground at a cost lower than Starlink and with a technology higher than Starlink for satellite-to-earth communications. On July 6, 2021, the Xichang Satellite Launch Center (XSLC) used the CZ-3C carrier rocket to send Tianlian 1-05 into the intended orbit and join the global network involving Tianlian 1- 01, 02, 03, and 04,[23] and Tianlian 2-01.[24] This successfully included China's first generation of tracking and data relay satellite (TDRS) program, making China the world's second country with a relay satellite system of global coverage. Consequently, this development opened a new chapter for space exploration and data transmission.[25]

Since the launch of Shenzhou-7 in 2008, each crewed flight by Tianlian satellites has been rendering services in communications relay. Currently, the second-generation Tianlian relay satellites (i.e., the human-crewed Shenzhou Series), the space station (Tiangong-1 target spacecraft and Tiangong-2 space lab, Tianhe core cabin module), low-to-mid orbit spacecraft, and low-orbit high-resolution remote sensing satellites provide in-orbit high-speed data relay and monitoring services. This has established the capabilities of global surveillance and high-speed data real-time transmission and became the backbone of China's space communications. In addition, Tianlian provides the monitoring capability from space with the Chinese carrier rockets, greatly enhancing the capability to launch overall surveillance and data relay services by increasing the monitoring and communications coverage of Chinese human-crewed spacecraft from less than 20% to over 98%. Moving forward, the user group will extend from spacecraft to

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[23] Tianlian 1- 01, 02, 03, and 04 launched in April 2008, July 2011, July 2012, and November 2016, respectively. Tianlian 2-01 also successfully launched on March 31, 2019. Note 1: Chu-ching Chao, "BeiDou-3, the Last Satellite in the BeiDou Navigation Satellite System, will be Launched at 9:43 today," *people.cn—Technology channel*, June 23, 2020, http://scitech.people.com.cn/BIG5/n1/2020/0623/c1007-31756155.html.

[24] Cheng Fan, Hsia-qun Chen, Yi-fei Fu, "Tianlian 1-05 Liftoff! Let's Get to know Relay Satellite Group," *Science and Technology Daily*, July 8, 2021, https://www.chinanews.com/gn/2021/07-08/9514973.shtml.

[25] Challey, "How Fast is China's Tianlian? Which One is the Future? The Comparison between Starlink and 6G," *Electronics Engineering Times*, June 24, 2021, https://www.eet-china.com/news/12095.html.

users at sea, on land, and over the air—a tremendous boost to C4ISR.[26]

Tianlian Series satellites are built based on the Dongfanghong series satellites. By 2021, China has launched a total of 41 DFH-3 platform satellites for communications, navigation, and relay purposes. China-made satellites possess the all-phase three-axis attitude stabilization, advanced track control technology, and a control system over the core circuit box. Its liquid bipropellant technology is capable of multiple ignitions and switching on/off at any time. With continued efforts for its technology, the local content of Tianlian 1- 05 is as high as 92%.[27]

On top of the technological foundation of Dongfanghong satellites, the Chinese research team has achieved key breakthroughs in the closed-loop autonomous precision capturing and tracking in relay satellites. This development resolves the challenge of capturing and tracking satellites in high-speed motion, enabling high-quality link communication among satellites. Information on ground conversations arrives at Tianlian relay satellites with satellite-ground links from the ground station. In addition, the research team overcame the difficulty in the R&D of high-performance antennas. The integrated design in mechanics, electrical, and thermal resolves the challenge of design and manufacturing of plane of reflection in high-precision and dual-band band trace antennas. Consequently, microwave high-speed data transmission is enabled and satellite-ground communications empowered.[28]

The communications facilities of ground stations started to look old and worn out in 2017, which were gradually replaced with China's own software. On April 16, 2021, the Tianlian 1-02 ground system completed repair and maintenance and reentered the service to meet the satellite-ground communications required by the

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[26] Chu-ching Chao, "BeiDou-3, the Last Satellite in the BeiDou Navigation Satellite System, will be Launched at 9:43 Today," *people.cn-Technology channel*, June 23, 2020, http://scitech.people.com.cn/BIG5/n1/2020/0623/c1007- 31756155.html; Cheng Fan, Hsia-qun Chen, "China's Tianlian: Gold Bridge between Earth and Sky (Home in space —Constructing the China Space Station," *People's Daily Overseas Edition*, July 19, 2021, http://www.xinhuanet.com/politics/2021-07/19/c_1127668171.html.

[27] Chu-ching Chao, "BeiDou-3, the Last Satellite in the BeiDou Navigation Satellite System, will be Launched at 9:43 Today," *people.cn-Technology channel*, June 23, 2020, http://scitech.people.com.cn/BIG5/n1/2020/0623/c1007- 31756155.html.

[28] Cheng Fan, Hsia-qun Chen, "China's Tianlian: Gold Bridge between Earth and Sky (Home in space — Constructing the China Space Station," *People's Daily Overseas Edition*, July 19, 2021, http://www.xinhuanet.com/politics/2021-07/19/c_1127668171.html.

space station. This marks the achievement of integrated operation and management for the Tianlian first- and second-generation relay satellite system. In addition, it also enhances the reliability, maintainability, and automation of the Tianlian relay satellite system.[29]

The conversation on June 23 between Xi Jinping from the ground station and the astronauts in Shenzhou-12 was relayed through the satellite-ground communications with links from the Tianlian 2 satellite to its core cabin module. It was first through the precision-tracking of the space station with the linked antenna among Tianlian relay satellites. Upon receiving conversations from the ground station, Tianlian relay satellites transmitted data via their own linked attentions to the space station so that astronauts received the conversations from the ground station. On the other hand, the conservations from the astronauts to the ground are transmitted from the relay terminal of the space station, then the Tianlian relay satellite via satellite-ground downlinks to the ground station.[30]

Tianlian relay satellites operate in the S/Ka-band, with Kameter wave radar in 26.5G-40GHz for high-speed data communications. This frequency band is in the middle of FR2 (Frequency Range 2) for 5G at 24250MHz-52600MHz (vs. FR1 at Sub-6GHz: 450MHz-6000MHz). It is also the millimeter wave (mmWave) band advocated by Qualcomm.[31] Tianlian's speed is at least comparable to 4G communications on the ground. Meanwhile, the downlink rate of up to 1.2G is equivalent to the 5G speed rate. The ground stations for relay satellites receive real-time space data and transmit data to the Beijing Aerospace Control Center. The data is automatically distributed according to identifiers, with second latency. The satellite-ground Internet consists of in-orbit communications exchange networks and satellite-ground gateway systems based on ethernet switches. This satellite-

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[29] Jan Wang, Pu-chung An, "China Completes the Upgrade of First Generation Relay Satellite Ground System," *Chinese People's Liberation Army Daily*, April 17, 2021, http://www.gfdy.gov.cn/big5/information/2021-04/17/content_10028899.htm.

[30] Cheng Fan, Hsia-qun Chen, "China's Tianlian: Gold bridge between Earth and Sky (Home in space — Constructing the China Space Station," *People's Daily Overseas Edition*, July 19, 2021, http://www.xinhuanet.com/politics/2021-07/19/c_1127668171.html.

[31] Challey, "How Fast is China's Tianlian? Which One is the Future? The Comparison between Starlink and 6G," *Electronics Engineering Times*, June 24, 2021, https://www.eet-china.com/news/12095.html.

earth network convergence allows astronauts to connect from WiFi hotspots in the space station for high-speed Internet.[32]

IV. China's Progress in Anti-satellite (ASAT) Capability

It is believed that the PLA already established the kinetic hit-to-kill capability targeting low-earth orbit (LEO) satellites and the anti-satellite (ASAT) capability towards geosynchronous orbits (GEO). The PLA tests any potential dual-use technology of military value, such as space robot arms. However, the information on such technical capabilities was opaque until 2020, and it was difficult for the outside world to keep track of China's real progress.[33] It was not until April 21, 2021, when James Dickinson, commander of the United States Space Command, testified to the United States Senate that China's SJ-17 satellite is equipped with bionic robot arms, which can be used in the future to snatch other satellites and become the PLA's space weapon.[34]

China claimed its SJ-17 satellite is only used for "geosynchronous orbit technology validations" and the peaceful handling of space debris and junks.[35] However, the long-standing tracking by the western world noticed that this satellite

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[32] Cheng Fan, Hsia-qun Chen, "China's Tianlian: Gold Bridge between Earth and Sky (Home in space — Constructing the China Space Station," *People's Daily Overseas Edition*, July 19, 2021, http://www.xinhuanet.com/politics/2021-07/19/c_1127668171.html.

[33] Pratik Jakhar, "China Claims 'Important Breakthrough' in Space Mission Shrouded in Mystery," *BBC News*, September 9, 2020, https://www.bbc.com/news/science-environment-54076895b.

[34] Ken Moriya Su, "China Can' Grapple' US Satellites with Robotic Arm, Commander Says," *Nikkei Asia*, April 21, 2021, https://asia.nikkei.com/Politics/International-relations/US-China-tensions/China-can-grapple-US-satellites-with-robotic-arm-commander-says.

[35] "SJ-17 Satellite is Equipped with Anti-satellite (ASAT) Capability but China Claims that It is a Test of the Technology to Observe Space Debris for Peaceful Purposes. SJ-17 Satellite was Launched on November 3, 2016 from Hainan Wenchang Spacecraft Launch Site with a CZ-5 carrier rocket. It is a geosynchronous orbit (GSO) technology test satellite and developed by China Academy of Space Technology. On the DFH-4S platform, its weight is close to four tons. SJ-17 satellite's missions include tests in new energy and non-toxic propellants. There will also be a test on the high-orbit technology for observation of space debris. Space debris consists of decommissioned or defunct spacecrafts. It is a threat to in-orbit satellites." From Hsi-fu Ou, "Chinese Robot Arms of SJ-17 Satellite," *National Defense Security Real-Tome Assesement*, June 17, 2021, https://indsr.org.tw/tw/News_detail/3401/%E4%B8%AD%E5%9C%8B%E6%A9%9F%E6%A2%B0%E8%87%82%E5%AF%A6%E8%B8%9017%E8%99%9F%E8%A1%9B%E6%98%9F.

has changed operational orbits multiple times and took turns with other Chinese satellites to get unusually close to western satellites.[36] It is determined that China is extremely likely to be validating the co-orbital satellite attack model.[37] According to the judgment from the United States Space Command, this type of technology can grabble or destroy other satellites as a potential space weapon despite the claim of Tianjin University that the R&D of bionic robot arms is only for capturing space debris (the same way the U.K. previously claimed its space net is for capturing space junks). Moreover, similar designs must be very close to spacecraft for Rendezvous Proximity Operations (RPO), which cannot capture space debris or defunct satellites tossing and turning violently and out of control. The capturing design must target the expected maneuvers in known orbits. Further, this is no different from the co-orbital satellite attack model using anti-satellite (ASAT) weapons.[38]

China indicated that it wanted to enhance its ability to access and utilize the space. In addition to the SJ-17 satellite, it proved the ability in July 2021 to successfully reuse space launched vehicles (SLV).[39] Derived and developed from space shuttles, space vehicles are similar to Musk's SpaceX series and can be launched in orbits synchronously with other satellites. Hence, it is considered a co-orbital satellite attack capability.[40] On March 12, 2021, the CZ-7A carrier rocket developed by the China Academy of Launch Vehicle Technology under the China Aerospace Science and Technology Corp. (CASC) successfully completed its first flight from the Hainan Wenchang Spacecraft Launch Site.[41] Soon after, and on July 16, the CZ-7A carrier rocket took off from the Jiuquan Satellite Launch Centre (JSLC), completed the plan first, and landed firmly at Alxa Right Banner Airport.

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[36] Todd Harrison et al., "Space Threat Assessment 2021," *ibid*., p. 10.

[37] Fu-yu Tsai trans., "Increasing Space Security Threats Become an International Concern (part 2)," *Youth Daily News,* May 5, 2021, https://www.ydn.com.tw/news/newsInsidePage?chapterID=1364768&type=forum.

[38] Todd Harrison et al., "Space Threat Assessment 2021," *ibid*., p. 10.

[39] Tze Hu, "Successful First Flight and Validation of China's Reuse of Suborbital Space Vehicles," *Xinhua Net*, July 16, 2021, http://www.xinhuanet.com/tech/2021-07/16/c_1127663488.htm.

[40] Nivedita Raju, "A Proposal for A Ban On Destructive Anti-Satellite Testing: A Role for the European Union?," *EU Non-Proliferation and Disarmament Papers*, No. 74, April 2021, https://www.sipri.org/sites/default/files/2021-04/eunpdc_no_74.pdf.

[41] Op. cit. 14, Tze Hu, "Successful First Flight and Validation of China's Reuse of Suborbital Space Vehicles."

It was China's first successful trial flight, in which it utilized a reused space launch vehicle.[42]

Compared to the CZ-7 Series carrier rockets, the CZ-7A carrier rocket has a booster of half an extra length. The faring is shorter by 2.5 meters and can carry 5.5 to 7 tons of equipment into the geosynchronous orbit. It can also carry out launch missions for lunar orbits and low-inclination orbits.[43] The BeiDou Navigation Satellite System and communications satellites also operate in the geosynchronous orbit. In theory, China's repeated use of space vehicles can transport kinetic or non-kinetic space weapons to the geosynchronous orbit for attacks on communications satellites or navigation satellites in lower orbits from other countries. The CZ-7A carrier rocket is at the preliminary stage of development for reusing space launch vehicles, similar to Falcon 2 of the SpaceX family.[44] Hence, considered by China a milestone as a tier 1 power in space development.[45]

V. Conclusion

2020 was a year of achievements for the BeiDou Navigation Satellite System,[46] and the year 2021 was a year of accomplishing the first stage of development for Tianlian communications relay satellites. Meanwhile, China is still in the process of utilizing increasingly mature carrier rockets and deploying Gaofen Series remote sensing reconnaissance satellites. Moving forward, it will continue to expand the Tiangong Space Station's capabilities in anchoring, supplying, repair, and maintenance, and will soon launch the Xuntian space telescope for target acquisition and reconnaissance by co-orbiting with the space station. The PLA

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42 Chu-ching Chao, "New Member of the CZ Family Revealing CZ-7A Carrier Rocket," *people.cn*, March 12, 2021, http://finance.people.com.cn/BIG5/n1/2021/0312/c1004-32049744.html.

43 Op. cit. 17, Chu-ching Chao, "New Member of the CZ Family Revealing CZ-7A Carrier Rocket".

44 Todd Harrison et al., "Space Threat Assessment 2021," *ibid*., p. 9.

45 Op. cit. 14, Tze Hu, "Successful First Flight and Validation of China's Reuse of Suborbital Space Vehicles".

46 Chu-ching Chao, "BeiDou-3, the Last Satellite in the BeiDou Navigation Satellite System, will be Launched at 9:43 Today," *people.cn-Technology channel*, June 23, 2020, http://scitech.people.com.cn/BIG5/n1/2020/0623/c1007- 31756155.html.

Strategic Support Force's Aerospace System Department is expected to make great progress by enhancing its own support and establishing information advantage in battlefields on multiple fronts. Meanwhile, the Strategic Support Force will also continue to integrate warfare in space, cyberspace, and the electromagnetic spectrum by constantly developing anti-satellite (ASAT) weapons to further offset the advantages of leading countries.

That said, China has its own less obvious worries for space and military development. While China cannot determine the maximum localization of components, vehicles, and software for space equipment, the computation for attitude control and real-time audio/ video transmission and communications require high-performance chips. There are sanctions, embargos, and control arising from the Clean Network initiative in the technological cold war between China and the U.S. Further, there is a shift of supply chains by Europe and Japan with the establishment of their own semiconductor supply chains. Noteworthily, China's unsophisticated but aggressive approach for domestic innovations and own semiconductor supply has not achieved much success. Therefore, how this affects China's space development and military application must be closely watched.

Chapter 10

Review of China's New Carrier Rockets and Solar Orbiters

Ching-Hui Chen, Han-Ming Yen*

I. Introduction

The Chinese official data indicates that the 2021 national defense budget was approximately RMB 1.35 trillion,[1] up by 6.8% from 2020 and primarily for four prioritized areas: 1. assurance of initiation and implementation of major military engineering projects as scheduled in the 14th Five-Year Plan; 2. upgrade and replacement to enhance modernization of military weapons and equipment; 3. improvement of training conditions and construction of a talent development system for nurturing military professionals; 4. alignment of the military personnel's benefits and living standards with the country's economic and social conditions.

The military force modernization is mainly based on the two-pronged strategy of the Military-Civil Fusion (MCF) and Science and Technology (S&T) industrial innovations. First, the boundary between the military force and the livelihood economy is blurred so that economic and social development may be integrated into military development and national security requirements. The implementation measures include the fusion of military and private-sector industrial sites, the integration of military and civil technology and innovation, nurturing versatile talents for military and civil purposes, and mutual conversion of military and civil

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1 "Is China's Military Spending of RMB 1.35 Trillion High? Is it a Threat to the World Peace? In-depth Analysis from German Military Experts," *Storm Media*, March 6, 2021, https://www.storm.mg/article/3519423?page=1.

construction and development. The goal is to include all aspects of the society and the economy into the military system and build a holistic system and capabilities for national military strategy. Second, it is necessary to hunt for potential and critical technologies as the cornerstone of military modernization. Hence, China invests considerable resources in companies and research projects for technologies with strategic potential and proactively promotes the industry-government-academia cooperation in the development of new technologies, such as AI and advanced robotics, semiconductor and advanced computing, quantum technology, biotechnology, hypersonic and directed energy weapons (DEW), advanced materials, and alternative energies.

Based on the aforesaid military development strategy, China has made good progress in modernizing military equipment and important vehicles over the recent years. In its publication, "Military and Security Developments. Involving the People's Republic of China 2020", the U.S. Department of Defense openly says that China has reached the same level as the U.S. or even surpassed the U.S. in certain military areas (e.g., space vehicles). Below is a summary of the space developments internationally considered strategically critical.

II. Development of Key Space Vehicles

Given the high level of commonality in the manufacturing technology between missiles and space vehicles, such as rockets, and the high degree of complexity in space vehicle systems and components to drive the development of relevant industries, China believes that space development is essential to its national security, society, and economy and that "the wealth of the country and for the people does not equate to national power". Even in the past, when China was lagging in technology and poor in fiscal finance, it poured all the resources into its space industry. After more than 50 years, it has established a comprehensive plan for space development. Currently, the PLA Rocket Force manages all of China's space programs, including the development and deployment of ground-

based missiles and cruise missiles and the development of intercontinental ballistic missiles (ICBMs). The number is expected to increase to 200 within five years to create a substantial threat to the U.S. Meanwhile, China invests in a large number of resources on a variety of space projects, both military and civil (such as commercial launches, scientific research, and space exploration). This objective has critically driven the growth and development of China's aviation and space industry. Below is an introduction to a few of its important space vehicles.

1. Rockets

Provoked by the launch of satellites by Soviet Russia and the U.S. in 1958, China embarked on the planning for the launch of satellites (code name: 581 Plan) and started constructing its first spacecraft launch site. In 1959, China adjusted the research tasks for space technology and focused on the development of sounding rockets. In 1960, it successfully imitated the production of short-range missiles and surface-to-air missiles and designed its own medium- and short-range missiles. In 1964, the first biological rocket T-7A with white laboratory mice was launched from the Guangde Rocket Launch Site; this was China's first successful step in the exploration of space biology. Afterward, China began planning for the development of satellites. In the meantime, there has been a solid foundation for the research and production of rockets and the launch of guided missiles. China's extreme emphasis on the development of rocket science is primarily due to the significance of space warfare to its national development. It can be materialized through the development of politics, economy, society, military force, technology, and psychology. Most importantly, as a dual-use technology, rockets can effectively drive the development of the military industry and relevant sectors, such as metal processing, materials, machinery, electronics, electrical machinery, and information technology. For civil purposes, rockets can be used to develop multi-orbit satellite constellations, establish space stations, and conduct extraterrestrial exploration. For military purposes, rockets are directly related to the range of intercontinental missiles. Hence, China has been aggressively developing rockets since the 1950s. The year 2020 saw vibrant activities, with a total of 39 launches, although in global

space warfare, China is only second to the U.S. (with 44 launches during the year).[2]

Currently, China's most prominent launch vehicle is the "Chang Zeng" (CZ) rocket, developed by the Shanghai Academy of Spaceflight Technology (SAST) under the China Aerospace Science and Technology Corporation (CASC). The CZ Series carrier rockets started in the 1960s, and the research and production of four generations of space vehicles have been completed. CZ-1 and CZ-2 are first-generation space vehicles. The first successful launch of the DFH-1 satellite by CZ-1 was in the 1970s. This first-generation rocket was an improvement of strategic weapon models and contained the highly noticeable features of strategic weapon models. Although its creation resolved China's problem of not having a carrier rocket, its overall performance and launch capacity was relatively low, its maintainability poor, and the launch cycle for rocket tests was long. More so, it was controlled with an analogue system. The second-generation space vehicles, represented by CZ-2C, CZ-2D, CZ-3, and CZ-2E, still retained the characteristics of strategic weapon models. There were technical improvements on the foundation of the first-generation rockets. However, the adoption of toxic propellants made with dinitrogen tetroxide and unsymmetrical dimethylhydrazine (UDMH) was not environmentally friendly. The third generation consists of CZ-2F, CZ-3A, and CZ-4. Also built on the prior foundation, the third-generation space vehicles continued to enhance reliability and mission adaptability. In October 2003, the CZ-2F rocket sent China's first astronaut, Li-wei Yang, to space. This mission made China the third in the world to send humans into the orbits. The details of the first three generations of CZ rockets are shown in Figure 10-1.

[2] Bryce Briefing (2020). Global Orbital Space Launches. BRYCETECH.

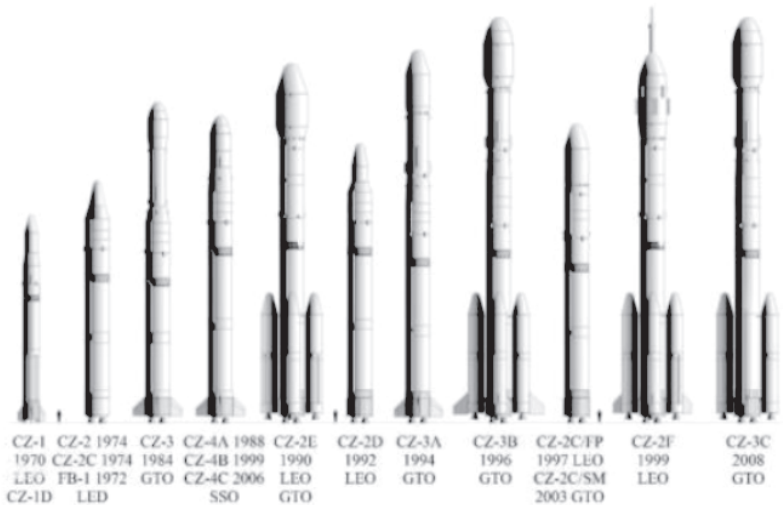

Figure 10-1 CZ Series the First-generation, Second-generation, and Third-generation Carrier Rockets

Source: China Aerospace Science and Technology Corporation (CASC) website.

The fourth-generation space vehicles include CZ-5, CZ-6, CZ-7, CZ-8, CZ-9, and CZ-11. This generation improved the flaws of the previous generations and significantly enhanced the launch capabilities. The CZ-6 with a small-capacity launcher took its first flight in 2015. Both the CZ-7 medium-sized rocket and the CZ-5 heavy rocket had their first flights in 2016. It is worth noting that the newest CZ-11 series rocket is 20.8 meters in length. The maximum diameter of the rocket body is 2.0 meters. It is 57.6 tons in weight and has a takeoff thrust of 120 tons. Its launch capacity is greater than 420 kilograms in the sun-synchronous orbit (SSO) at an altitude of 700 kilometers and 700 kilograms in the low-earth orbit (LEO). Meanwhile, this rocket adopts an international interface for satellites and rockets, can meet the varying mission and loading requirements, and launch in different orbits. CZ-11A is a larger and commercial solid carrier rocket developed and produced by the China Academy of Launch Vehicle Technology based on CZ-11. Its takeoff thrust is 115 tons, and its maximum diameter is 2.65 meters. There are three sizes of fairings available, at a diameter of 2.4, 2.7, or 2.9 meters. The launch

capacity is 2 tons in the low orbits and 1.5 tons in the sun-synchronous orbit (SSO) at an altitude of 700 kilometers. It is on a hot launch system from a simple launch pad. The CZ-11A is China's first rocket designed, produced, and operated with a cost consideration. The launch cost is even the lowest, and the launch cycle is no more than 72 hours. The rocket is a single structure, with machinery and electrical units integrated. It can accommodate the launch requirements for most low-orbit satellites. This rocket is currently under research and production and is scheduled to take its first flight in 2022. The CZ Series carrier rockets currently in service are detailed in Figure 10-2. In addition to the well-known Chang Zeng, the China Aerospace Science and Technology Corporation (CASC) also has carrier rockets, such as Ceres, ZQ-1, and KZ-11, for different tasks.

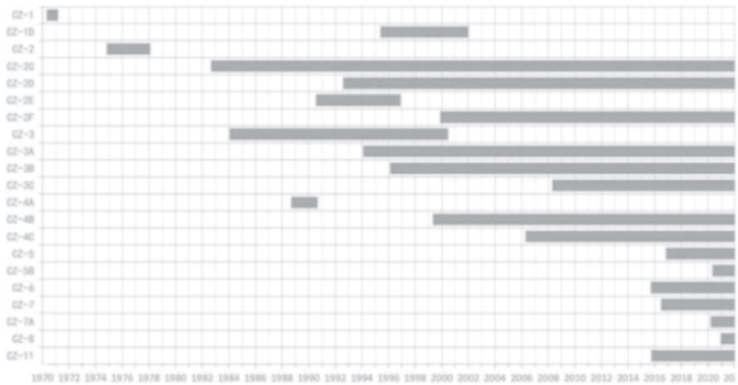

Figure 10-2 CZ Series Carrier Rockets Currently in Service

Source: China Aerospace Science and Technology Corporation (CASC) website.

At present, China's orbital launches are from four launch sites—Taiyuan Satellite Launch Center (TSLC), Xichang Satellite Launch Center (XSLC), Jiuquan Satellite Launch Center (JSLC), and Wenchang Satellite Launch Center (WSLC). China is working on the modernization and remodeling of space launch systems and the design and introduction of environmentally friendly rockets. In the past, Chinese launchers often used toxic hypergolic propellants. However, new designs are starting to use kerosene or hydrogen as fuels for RP-1 and RP-2 motors. It is

worth noting that KZ and CZ-11 on solid propellants are improvements from the Dongfeng intercontinental missiles. In addition to state-owned enterprises, there are also private companies, such as the i-Space, China Rocket, and LinkSpace. The latter has been developing reusable rockets in recent years.

2. Space Station

The International Space Station is located in the low-earth orbit (LEO), operated jointly by the National Aeronautics and Space Administration (NASA), Russian Federal Space Agency (RKA), Japan Aerospace Exploration Agency (JAXA), Canadian Space Agency (CSA), and European Space Agency (ESA). It is a microgravity laboratory for developing biology, medicine, and manufacturing technology. The biological statistics (e.g., bone density and muscle mass) of astronauts are also important data for human migration to space in the future. China's space station project kicked off in 1992 by China Manned Space (CMS). It was a three-stage project: launch of crewed vehicles with space for experiments; activity of astronauts in the space environment; and construction of space stations. After China lost the right in 2011 to use the International Space Station, it launched the space laboratory Tiangong-2 and the crewed vehicle Shenzhou-9 to complete a series of scientific experiments before returning to the earth. This year, China launched Tiangong Space Station's Tianhe core cabin module[3] and will send astronauts and a space station module into orbits for docking. The planned completion of the space station will be in 2022. If the International Space Station is not extended its service life and then decommissioned in 2024,[4] there will be just one space station from China. The space competition has been considered a showcase of national strengths. It is unclear whether China has surpassed the U.S. and Russia in space technology, but its ambition is evident.

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[3] Jones, A., "China Launches Tianhe Space Station Core Module into Orbit," *SPACENEWS*, April 29, 2021.

[4] Xiaoci, D., et al., "China Successfully Launches Core Module for Its Space Station, Kicking off Intense Construction Phase," *Global Times*, April 29, 2021.

3. Other Space Vehicles

In addition to the relative maturity in the development and the utilization of space vehicles, China is also proactively developing vehicles for new requirements, such as space humanoid robots and exploration vehicles for space resources, introduced below.

(1) *Space Humanoid Robot*[5]

In early 2021, the Centre for Advanced Mechanisms and Robotics (CAMAR), Tianjin University released its developed humanoid robot. It looks like an octopus, with soft, thin, long, and stretchable arms. Once launched into an orbit on a satellite, this robot can grab and remove space junks out of the orbit. However, space experts indicate that it is necessary to predict the path of movements for trash cleaning. Otherwise, the robot will lose control due to external forces and cause damages to other satellites. Based on its appearance, it is difficult not to associate it with the possibility of changing paths of the enemy's satellite as an anti-satellite (ASAT) weapon.

(2) *Exploration Vehicles for Space Resources*

China sees the exploration of space resources as one of the important means to global dominance and a major way to demonstrate its economic strengths and technological development. Since its 13th Five-Year Plan, China has conducted multiple space exploration missions, including the exploration and the collection of rare earth on the moon (Yutu lunar rover and Chang'e lunar lander) and the exploration of Mars (Zhurong Mars rover, Tianwen-1).[6] China is likely to leverage its Tiangong Space Station, along with the development of its space resource exploration vehicles and probes, to provide space laboratory resources and connect with countries other than the U.S. This avenue for joint technological breakthroughs is a way to achieve global supremacy.

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[5] Harrison, T., Johnson, K., and Young, M., "Space Threat Assessment 2021," *Center for Strategic &International Studies*, 2021.

[6] "Tianwen-1 and Zhurong, China's Mars Orbiter and Rover," *The Planetary Society*, https://www.planetary.org/space-missions/tianwen-1.

III. Possible Bottlenecks and Challenges

The above summary indicates China's emphasis on the space domain and ambition to compete with the U.S. for global leadership. With the emergence of a plethora of new technologies and materials, the breakthrough of the current capabilities of space vehicles will become the key to space dominance. Given its technological development and international status in politics to date, China is faced with two potential bottlenecks and challenges, as discussed in the following sections.

1. Reliance on Other Countries for Semiconductors

China is expecting to complete the "basic" goals of military modernization in 2035. Its current major technological breakthroughs are achieved with Military-Civil Fusion and industrial innovations in science and technology. However, China still relies on other countries for leading-edge semiconductors in the short term. The development of its hypersonic cruise missile (HCM) is a case in point.[7] It is believed that China obtained the chips designed by the U.S. and manufactured by the Taiwan Semiconductor Manufacturing Company for use in the supercomputer developed by Phytium Technology Co., Ltd. in order to simulate the heat and resistance of passing through the atmosphere. In other words, China still needs to enhance its semiconductor tech prowess. In the short term, it uses Military-Civil Fusion to secretly transfer civil technology for military purposes by concealing private companies' connection with the PLA. In this way, China has obtained key technological breakthroughs in space vehicles.

2. Military-Civil Fusion under International Scrutiny

China deems Military-Civil Fusion as an important strategy to accomplish military modernization to use the civil market in accelerating technological innovations and achieving breakthroughs in military technology. However, China's

[7] "U.S. Failed in Hypersonic Cruise Missile (HCM) Test, but China Achieved Breakthrough by Using U.S. Chips," *Central News Agency*, April 8, 2021, https://www.cna.com.tw/news/aopl/202104080173.aspx.

political status is sensitive in the international community. Many Chinese tech companies are related to the PLA. As a result, the U.S. Department of Commerce and the U.S. Department of Defense have become stricter in naming companies for the entity list, squeezing the profitability of other Chinese firms in the U.S. market. In other words, Military-Civil Fusion constraints China in the international political arena and loses the energy of developing generic technologies for both military and civil use. Huawei and DII are high-profile examples.

IV. Conclusion

China has become a formidable participant in the world's space race after more than 50 years of effort. Starting from the construction of the first launch site for carrier rockets in 1958, China is now accomplishing over 30 launches each year. On top of the foundation built with the Military-Civil Fusion strategy in national defense, China has achieved multiple significant and influential developments in space vehicles over the last 20 years. These developments include the famous CZ Series rockets, carrier rockets for different tasks, the space station, the space humanoid robot, and exploration vehicles for space resources. China's ambition does not end at an equal footing with global powers, such as the U.S. and Russia. It seeks to reobtain the global leadership under the banner of "revival of the Chinese people". The development of space vehicles and relevant technologies effectively enhance physical and non-physical military strengths. Moreover, this advantage is an important means of winning other countries over as a leader. Hence, the technology race between China and the U.S. will continue. With Chinese companies developing at a vibrant pace and stretching reach without constraints, the Military-Civil Fusion for military modernization will remain one of China's essential strategies in military development.

PART FOUR

General Technology and Supporting Policies

Chapter 11

China's Development of Unmanned Vehicles

Hsiao-Huang Shu, Jyh-Shyang Sheu*

I. Introduction

China has established the world's largest UAV (a drone or remotely piloted aircraft [RPA]) industry with extensive exports to other countries for both military and non-military tasks. It has also become the world's largest exporter of military UAVs, with its signature models, the Wing Loong and Rainbow Series UAV. Over 300 UAVs were exported to 15 countries in 2015-2020. Chinese UAVs are used by some countries in the Middle East and North Africa to assassinate rebel armies, guerrillas, and opponents and stabilize political power.[1] Although the precision and warfare performance of China-made UAVs are inferior to U.S.-made UAVs, they are cheap and popular with third-world customers. However, UAVs suffer a heavy toll as any ground troop can strike them down with certain anti-aircraft capabilities.[2]

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1 "China is the Largest Exporter of UAVs, Helping Totalitarian Nations to Suppress Democracy. Expert: Lowering of Threshold for Wars," *Apple News*, April 29, 2021, https://tw.appledaily.com/international/20210429/IO3UC2F7SZDUVKQUKE67YKP42U/.

2 " China is the Largest Exporter of UAVs, Helping Totalitarian Nations to Suppress Democracy. Expert: Lowering of Threshold for Wars," same as the previous note.

II. Development of UAVs in China

1. UAV Development and Problems Encountered

In recent years, China has been investing heavily in developing a variety of UAVs for surveillance, targeting, and attacks and in constructing complex UAV infrastructure facilities. National organizations are responsible for the UAV development and requirement specifications, while industries are tasked with the design, R&D, and manufacturing. The number of UAV users in military forces is also increasing. China's UAV systems enhance its precision strike capability within a long range of 3,000 kilometers. Further, new UAVs come with reduced Radar Cross Section (RCS) for better survivability in high-threat environments.[3]

In developing UAVs, China also uses various civil technologies, such as speedy obstacle avoidance, target identification and tracking, low, slow, and small detection for complex urban environments, agile response, and links for control.

In 2020 when COVID-19 caused multiple lockdowns in China, many local governments (e.g., Chongqing City) purchased UAVs for emergency operations. These UAVs deliver goods with precision in targeted areas and quickly meet the needs for medical supplies under the command of the smart control system. Relevant technologies include UAV position monitoring, automatic task allocation and arrangement, reporting back of onsite situations, flight surveillance, and emergency control. These technologies also help in military tasks, such as warzone logistics and supplies.

China also has reconnaissance- and strike-integrated UAVs and AI-driven UAVs for automatic flights, the Loyal Wingman concept, and swarm UAVs. In addition, it may also combine UAVs with AI. Hundreds of stealth UAVs may initiate attacks even when communication is cut off or interrupted. Further, China is also likely

[3] "The Chinese People's Liberation Army's Unmanned Aerial Vehicle Project: Organizational Capacities and Operational Capabilities," *Project 2049*, March 11, 2013, https://project2049.net/2013/03/11/the-chinese-peoples-liberation-armys-unmanned-aerial-vehicle-project-organizational-capacities-and-operational-capabilities/.

to use UAVs for electronic warfare or equipment of electromagnetic pulse pods.[4] China's massive export of UAVs also raises the concern of whether these drones are used to assist espionage activities. The U.S. Department of the Interior ordered to ground over 800 UAVs in 2019 because they were either made in China or with China-made parts. The U.S. Cyber Security and Infrastructure Security Agency also issued warnings and expressed its concern for the increasing number of China-made UAVs used by U.S. government organizations.[5] The U.S. Army in 2017 forbade the use of DJI UAVs and indicated that it did not use DJI products on the battlefield. The U.S. Department of Defense also authorized 130 military bases to strike down private and commercial UAVs that may pose potential threats.[6] In 2019, the Trump administration ordered the U.S. Department of Defense to ground all China-made UAVs. However, the reliance on Chinese UAVs remains. Although the U.S. Department of Defense already spent USD13 million to develop alternatives, the costs are 8 to 14 times higher than similar-grade Chinese products, while their performance is inferior. Hence, this shows the difficulty of the U.S. in ridding its reliance on Chinese technology, given the absence of U.S.-made substitutes.[7]

2. Development of UAV for Military Use

At the 70th Anniversary of the Founding of The People's Republic of China in 2019, China presented multiple new weapons, including the GJ-11 stealth UAV and WZ-8 supersonic UAV. At the 2021 China International Aviation & Aerospace Exhibition, only the GJ-11 model was displayed to exhibit its configuration. Also showcased at the exhibition was the Tianshao UAV with a flush antenna, whose

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[4] "Did Chinese Scientists Just Bring Down an Unmanned Plane with an Electromagnetic Pulse Weapon?," *South China Morning Post*, August 26, 2021, https://www.scmp.com/news/china/science/article/3146380/did-chinese-scientists-just-bring-down-unmanned-plane.

[5] "Worried about China's Espionage Activities, U.S. Government Grounds 800 UAVs," *BBC Chinese*, November 1, 2019, https://www.bbc.com/zhongwen/trad/world-50258687.

[6] "Why U.S. Military Stops Using Chinese DJI UAVs?," *BBC Chinese*, https://www.bbc.com/zhongwen/trad/chinese-news-40860075.

[7] "Pentagon Drones '8 to 14 Times' Costlier than Banned Chinese Craft," *Financial Times*, July 19, 2021, https://www.ft.com/content/dd2e936e-5934-49f1-8aa6-29dea9a41b18.

sensors are flatly attached to the vehicle body to maintain the stealth design. On the other hand, the Rainbow-6 UAV adopts jet propulsion and comes in a stealth configuration, capable of great heights and speeds. During long flights, UAVs can implement reconnaissance, surveillance, and strike missions.[8]

The GJ-11 is a UCAV (unmanned combat aerial vehicle), likely to be the stealth version in service based on Lijian launched in 2013. It looks like the U.S. X-47B with full wings and a weapon bay and can maintain stealth and attack targets by penetrating the enemy's anti-aircraft defense. The GJ-11 may be equipped on aircraft carriers or amphibious assault ships and automatically take off and land. Manned fighter aircraft, such as the J-20, serve as loyal wingman by supporting highly threatening tasks.[9] The GJ-11 was jointly developed by Shenyang Aircraft Corp., Shenyang Aerospace University, and Hongdu Aviation Industry Group under code 601S. Code 601 refers to Shenyang Aircraft Corp. Academy No. 601, while code S refers to Shenyang Aerospace University.[10]

The Dark Sword, developed by Shenyang Aircraft Corp., is a supersonic UAV with a stealth design and front wings. It is believed to have a super-cruise capability. There was a report in 2016 saying that China was validating the hypersonic UAV with a flight speed of up to 4 Mach.[11] It is unknown whether this has been replaced by the WZ-8 or secretly continued as it was.

The WZ-8 was also displayed at the 70th Anniversary of the Founding of The People's Republic of China in 2019. Its model name is either DR-8 or WZ-8, similar to the D-21 supersonic reconnaissance UAV developed by the U.S. Air Force in the 1960s. The U.S. once conducted reconnaissance with D-21 drones on China's nuclear test but lost one D-21. The complete remains of this D-21 were found by China. The WZ-8 can provide the PLA with a wide range of

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[8] "China's Gigantic Twin-engine, Long-endurance Armed UAV Emerges," *Inceptive Mind*, September 26, 2021, https://www.inceptivemind.com/china-ch-6-gigantic-twin-engine-long-endurance-armed-uav-emerges/21344/.

[9] "J-20 Fighter and GJ-11 UAV as China's Golden Partner of a Stealth Sword," *China Times*, September 5, 2021, https://www.chinatimes.com/realtimenews/20210905003282-260409?chdtv.

[10] "Gongji-11 (GJ-11) Sharp Sword/Lijian," *Global Security.org*, https://www.globalsecurity.org/military/world/china/lijian.htm.

[11] "Dark Sword (An-Jian/Anjian)," *Global Secuity.org*, https://www.globalsecurity.org/military/world/china/anjian.htm.

reconnaissance capabilities. It can track the U.S. carrier battle group in the South China Sea or the Western Pacific to provide target-oriented information for anti-ship ballistic missiles. Its maximum speed is 4,000 km per hour, and its operating radius can reach Guam.[12]

Wing Loong, another Chinese military UAV developed by the Aviation Industry Corporation of China, Ltd., looks like the U.S. MQ-9 Reaper with two tail wings leaning outward. Satellite antennas are installed inside its head fairing. Further, the Wing Loong UAV can carry various reconnaissance and electronic warfare equipment and air-to-surface missiles for attack missions—having both reconnaissance and attack capabilities. In terms of UAV design and R&D competencies, China is only next to the U.S. and Israel, yet better than Russia. Some Chinese UAV performances are even comparable to the major UAVs used by the U.S. Armed Forces. The mass production models may be exported to countries like Uzbekistan and the United Arab Emirates.

The Rainbow series was developed by the China Aerospace Science and Technology Corp. (CASC) Academy No. 11. It shares a similar look with the Wing Loong UAV, with the confirmation resembling the U.S. MQ-9 UAV. The tail wings are in a V shape, and the propellers are at the back in order to free up the head space for the avionic cabin. The Rainbow-4's wingspan is 18 meters. It has the highest payload and the best flight performance among all China-made UAV models. It is said to be even more advanced than Wing Loong, which can loiter for 30 hours for tasks such as border patrols, island protection, anti-terrorist combats, and emergency communications.

China is also using large UAVs for ocean patrols, reconnaissance, and gray-area conflicts by harassing the airspace of neighboring countries. On August 24, 2021, the TB-001 large UAV was found to be on a mission in the East China Sea and above the waters near the Ryukyu Islands. The TB-001, developed by the Tengdeng Technology Company, is the largest UAV publicized by China to this date. Its wingspan is 20 meters, and its range can reach 6,000 kilometers at the cruising

[12] "BZK-008 CH-91 WZ-8 Hypersonic Drone Testbed," *Global Security.org*, https://www.globalsecurity.org/military/world/china/bzk-008.htm.

altitude of 8,000 meters.[13] On August 25, one BZK005 UAV flew from the East China Sea to the Western Pacific. As the PLA's first large and long-endurance UAV, its newest improvement can perform attacks to the ocean and the land and BVLOS (beyond visual line of sight) tasks based on satellite navigation or collection of multiple intelligences.[14]

3. State-operated and Civilian UAV Industries

With the highly competitive Chinese market for UAV system designs and a large number of R&D organizations, the PLA has many options to choose from in developing the best designs according to task requirements. Military UAV tasks include intelligence, surveillance, reconnaissance, precision strike, electronic warfare, communications relays, and target relays for long-range missiles by transmitting data via satellites. Non-war tasks include national security, resource exploration, and ocean patrols. Chinese satellites can also work with various UAVs by navigating long-distance flights and enabling intelligence surveillance and reconnaissance on battlefields, which greatly enhance the use cases of UAVs.

The Chinese UAV is rather sizable, consisting of aviation and aerospace universities, state-owned enterprises, and private companies. Among the leading academic institutions is the Unmanned System Research Institute of Northwestern Polytechnical University (365 Institute), the first organization engaged in the UAV development in China since 1958. It is part of the National Defense Technology Research Institute under Northwestern Polytechnical University. Its UAV products include the ASN-106 and the ASN-209. The Institute of Unmanned Systems of Beihang University is responsible for the BK-005 and Changying projects. On the other hand, the Nanjing University of Aeronautics and Astronautics Unmanned Air Vehicle Institute handle the design of the Chang Kong UAV and the BZK-002

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[13] "China-made Attack UAVs Appear in the East China Sea. Heated Competition among China, the U.S. and Russia in UAV Development," *Tech News*, August 26, 2021, https://technews.tw/2021/08/26/chinese-tb001-ucav-shows-up-at-east-sea-marking-the-increasing-competition-of-large-uav-market/.

[14] "Japanese Miliary Aircrafts Took off for Three Consecutive Days, to Conduct Emergency Interception of Three Chinese Military UAVs," *Voice of America*, August 28, 2021, https://www.voacantonese.com/a/Japanese-fighters-intercept-three-Chinese-drones-in-as-many-days-20210827/6018758.html.

unmanned helicopter.

When it comes to state-owned military companies, the Aviation Industry Corporation of China is closely affiliated with Beihang University. Its subordinates, including Guizhou Aircraft Industry Corp., Shenyang Aircraft Corp., Cheng Du Aircraft Group Co., Ltd., Xi An Aircraft Industry Group Co., and Weifang Tianxiang Airlines Industry Co., Ltd., work on UAV development projects. The China National Aero-Technology Import & Export Corp. (CATIC) overseas the export of UAVs. Meanwhile, the Aviation Industry Corporation of China plays the role of the Chinese UAV industry's leader or system integrator. The Guizhou Aircraft Industry Corp., established in 2011, is a site dedicated to UAV production, testing, and services. It also has a UAV research center in Anshun, Guangzhou.

The Cheng Du Aircraft Group Co., Ltd. is responsible for the R&D of the Wing Loong UAV, as well as large UAVs similar to the U.S. Global Hawk. On the other hand, the Shenyang Aircraft Corp. is tasked with designing large-sized unmanned combat aerial vehicles (UCAVs) by remodeling the J-6 fighter aircraft or developing a new generation of advanced UCAVs. It is also a leader in the R&D of stealth technology, whose stealth UAV product is the Dark Sword. Further, the Xi An Aircraft Industry Group Co. develops and tests the V750 unmanned helicopter for civil and army tactical purposes, with customers including the Chinese navy. The company's most special unit is the Xi'an Automatic Flight Control Research Institute.

The China Aerospace Science and Industry Corporation (CASIC) is another military and industrial organization, whose Academy No. 3 is the R&D and design unit for cruise missiles. However, similar technologies are shared for UAVs. It has developed Haiying, Yaoying, Tengfei, Daofeng, and the WJ600 series, including Yaoying-2 and Tengfei-8 (1-2 kg payload), Yaoying-3 and Tengfei-5 (5 kg payload), Daofeng-460, Yaoying-1, and WJ600 (15-130 kg payload). These series of UAVs come in light, small, and medium sizes to perform tasks, such as national land surveying and mapping, ocean guards, power line monitoring, forest fire prevention, and police patrols. Academy No. 3 has established a complete UAV supply chain from overall design, structure, motor systems to navigation, data

links, and payloads.[15]

Academy No. 9 and No. 11 under the China Aerospace Science and Technology Corp. (CASC) are also UAV development units. Academy No. 9 is responsible for microelectronics and orientation, navigation, and control systems by developing UAV sensors and communications relay technologies. On the other hand, Academy No. 11 is in charge of aerodynamic force tests, and its main product is the Rainbow series. The China Electronic Technology Corporation (CETC) develops electronic subsystems, sensor payloads, and electronic warfare equipment. Its Academy of UAV System Research and Development is responsible for UAVs in electronic warfare by developing platforms for high altitudes and long loitering hours with a stealth design. Academy No. 38 deals with the development of mashed communications and intelligence processing systems in order to handle synthetic aperture radar (SAR) payloads for UAVs. The Electronic Engineering Institute of the PLA is one of the spearhead research organizations for UAV tactics and electronic warfare, whose research projects include the interference of moving targets.[16]

There is also a comprehensive UAV supply chain (including motors, flight control systems, sensors, and servers) for the civil market. The civil market can be divided into the consumer and the industrial segments for aerial photography, logistics & transportation, and environmental monitoring.[17] The best-known private UAV company is DJI—the world's largest producer in 2020, with an 80% market share.[18] Small companies, such as Tenden, AOSSCI, Star, TIM, and Ewatt, also apply many innovative concepts and show the potential in serving military purposes. For example, AOSSCI's X-Shift and X-Chimera are both in a three-piece airframe design with four rotary wings on the exterior and an integrated electric

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[15] "China Aerospace Science & Industry Corp. Launches Haiying UAV Brand," *people.cn-Technology channel*, November 13, 2012, http://scitech.people.com.cn/BIG5/n/2012/1113/c1007-19569150.html.

[16] Ian M. Easton and L.C.Russel Hsiao,"The Chinese People's Liberation Army's Unmanned Aerial Vehicle Project: Organizational Capacities and Operational Capabilities," *Project 2049 Institute*, March 11, 2013.

[17] "2021 Full UAV Supply Chain and Market Analysis in China from Upstream to Downstream," *AskCI*, July 16, 2021, https://www.gushiciku.cn/dl/0zEmp/zh-tw.

[18] "Analysis of DJI in 2020—80% and 70% Market Share in the World and in China, Respectively," *Sohu*, October 19, 2020, https://www.sohu.com/a/425778418_114835.

propulsion. In addition to UAV production, Ewatt also provides ground stations, fleet management, application, and training. Apart from transportation, this type of UAV has a wide range of use cases, including law enforcement, disaster recuses, environmental protection, photography, and surveying/ mapping.

III. Unmanned Systems for Special Purposes

1. Suicide Drones for Attack Missions

It is also necessary to keep a close eye on the development of suicide drones (i.e., loitering munition) in recent years. With similar equipment gradually attracting wide attention, it has highly caught the interest of the PLA. Further, with the launch of the ASN-301 anti-radiation drone in 2017, China successfully copied Israel's Harpy anti-radiation drone[19] obtained in the 1990s. The CH-901 suicide drone has been in the PLA's service for years. This suicide drone at a weight of 9 kilograms was displayed in 2017 at the People's Revolution Military Museum, integrated with a 4x4 Mengshi vehicle. The vehicle was equipped with eight launchers for the CH-901 model and four smaller launchers for fixed-wing drones.[20] In October 2020, a video from the China Electronic Technology Corp. (CETC) showed the likely CH-901 suicide drone further integrated with a 6x6 CTL181A Mengshi motor vehicle. There is a row of 48 UAV launchers on the vehicle. Once launched, the UAVs form into a group to simulate attacks on simulated targets. Similar launch systems can also be used on navy vessels or amphibious warships for different requirements.[21]

As China's UAV industry is highly developed, multiple UAV systems of different concepts often show up at exhibitions. New UAV concepts from other countries usually see Chinese copycats soon after their debut—this is no exception

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[19] Ami Rojkes Dombe, "China Unveils a Harpy-Type Loitering Minution," *Israel Defense*, March 1, 2017, https://www.israeldefense.co.il/en/node/28716.

[20] Jeffrey Lin and P.W. Singer, "Come See China's New Hexacopters and Self-detonating Drones," *Popular Science*, July 31, 2017, https://www.popsci.com/china-new-drones-army-hexacopters/.

[21] Andrew Tate, "China Likely to Deploy New Multiple UAV Launcher in Near Future," *Jane's Defence Weekly*, October 21, 2020.

for suicide drones. The CH-817 micro attack UAV that appeared at the China International Aviation & Aerospace Exhibition in September 2021 is a small dual-propeller drone with a weight of mere 850 grams. Each CH-817 may not be formidable, and the loitering hours are limited. If the swarm technique achieves good progress, this type of light and compact equipment can be released in large numbers in different ways to attack soldiers and important figures or infiltrate and attack high-value but vulnerable equipment such as fighter aircraft. Although whether the PLA adopts this mechanism is yet to be seen, it is still necessary to watch early the potential threat that similar systems may cause in the future.

2. Unmanned Ground Vehicle (UGV)

Unmanned ground vehicles (UGVs) have been increasingly observed in the reports on the PLA equipment in recent years. It is not a new piece of equipment for the PLA, as Chinese military companies have showcased UGV products at many military exhibitions. It also seems that the PLA has been catching up over the past years. On April 13, 2020, the Eastern Theater of the PLA, in its Weibo account, announced the adoption of NORINCO's Sharp Claw I UGV. The report from China Central Television (CCTV) on the same day also indicated that the PLA Rocket Force had started using a large, crane-like robot to assist in the loading of missiles.[22] Sharp Claw I is a crawler-type lightweight UGV used for tracking, reconnaissance, and attacking. It is equipped with optical sensors and a 7.62mm cabin. On January 6, 2021, China Central Television (CCTV), in its video for the "new year opening instructions", also disclosed the footage of the Eastern Theater, showing the PLA's use of UGV and training of infantry troops. The UGV presented is a crawler-type, installed with dual launchers for 35mm grenades and electro-optical/infrared (EO/IR) sensors.[23] This discovery suggests that the PLA ground force is gradually stepping up the validation, training, and application of UGVs. However, the two small UGVs shown to date are both equipped with light

[22] Gabriel Dominguez and Juan Ju, "Norinco's Sharp Claw I UGV in Service with Chinese Army," *Jane's Defence Weekly*, April 15, 2020.

[23] Gabriel Dominguez and Melanie Rovery, "PLAGF Unit in Eastern Theatre Command Deploying New Tracked UGV," *Jane's Defence Weekly*, January 7, 2021.

weaponry and sensor systems, implying that they are probably still serving support roles to ground troops—a contract with Russians who seek to use UGVs as the main battlefield equipment by carrying large weapons.

That said, the footage in 2018 from China Central Television (CCTV) shows that the PLA was remotely controlling a Type 59 Main Battle Tank. It also claimed that the PLA was testing active navigation and positioning, surveillance, machine cognition, deep learning, control drive, and remote control technology. This type of vehicle can be used for reconnaissance by fire or as an unmanned war vehicle.[24] Therefore, it is possible that similar technologies are applied for the R&D of large and unmanned war vehicles, or the unmanned technology is used to enhance the battlefield value of old-fashioned war vehicles in the future.

IV. Conclusion

China's UAV industry is a global leader, with exports and market shares both the highest in the world. Many government agencies and private organizations use China-made products. However, this triggers the concern for data leakage or spy activities in the competition and confrontation between great powers. However, whether it is possible to reduce the overall reliance on Chinese products depends on whether the outside supply chains can replace them. China-made UAVs are exported to third-world countries and used for real battles. In recent years, China has developed many UAVs, such as stealth unmanned combat aerial vehicles (UCAVs), supersonic UAVs, and reconnaissance- and strike-integrated UAVs for special purposes (e.g., Loyal Wingman, swarm tactics, electronic warfare). Thus, China's military use of UAVs poses a new challenge for air defense to Taiwan and other neighboring countries.

[24] Kelvin Wong, "Robot Wars: Asia Pacific Countries Pursue Robotics for Future Ground Combat," *Jane's International Defence Review*, February 22, 2019.

Chapter 12

China's Military Development of Alternative Energy

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I. Introduction

Under the pressure of the international outcry in recent years, China often showcases its activities in carbon reduction and the development of renewable energy. It has pledged to achieve carbon neutrality by 2060 after emissions peak in 2030 and indicated that fossil fuels would account for more than 50% of its energy mix at the end of the 14th Five-Year Plan. On top of its national targets, the military use of alternative energy has the benefit of better energy flexibility and greater battlefield survivability for field operations. In the process of stepping up invasive moves, China has noticed that traditional energy remains the military mainstay, while the increase in consumption and difficulty in transportation to remote areas cause problems in strategy security. The PLA announced in March 2021 the commencement of its first national-level on-site energy demonstration project in the Zhurihe Training Base in Inner Mongolia. Wind and solar will be its main power sources, supported with smart grids and storage and backup electricity from the grids and diesel generation.[1]

Other than the reduction in the reliance on fossil fuels and the enhancement of its application of renewable energy, the ambition to combine new types of weaponry, AI, big data, and cloud computing and to develop smart military energy

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1 Hai-ching Yu, "PLA's First National-level on-site Energy Demonstration Project Comes Online," *Chinese People's Liberation Army Daily*, March 21, 2021, https://reurl.cc/aN5vo7.

sits behind China's transformation in the military energy transition.[2] The bulletin of the fifth plenary session of the 19th Central Committee of the Communist Party of China in October 2020 declared China's intention to realize the centenary goal for its military establishment in 2027 by accelerating the mechanization, informatization, and smartization of its national defense equipment.[3] With the approach of the Military-Civil Fusion, industries, military schools, and key universities develop joint R&D teams and deploy smart energy networks in military bases in remote mountains and on islands. The purpose of China's military energy transformation is to complement equipment revamps and renewals and boost the PLA's new warfare capabilities.[4] Compared to the use of fossil fuels, the PLA's current scale in the use of renewable and low-carbon energy is not big. Nonetheless, it is necessary to keep an eye on the development, achievements, and the trend of moving forward.

II. Development of Key Equipment

1. Smart Grid for Military Use

The PLA has been prioritizing the solution to the insufficient electricity supply and the challenge of transportation for supplies in remote areas and on sea islands. In November 2020, it indicated that more than 500 border defense sentry posts were connected to the state grid during the 13th Five-Year Plan (2016-2020), which previously brought electricity supply around the clock to border sites and was mainly dependent on diesel generation.[5] For instance, after the connection to the state grid, the Kunmujia Post in Tibet, at an altitude of over 4,900 meters, has

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2 Chiang Chang, "Able to Think and Decide, Military Energy is Surely Getting Smarter," *Science and Technology Daily*, March 19, 2021, https://reurl.cc/6DajvZ.

3 Xinhua News Agency, "(release under authorization) Bulletin of the Fifth Plenary Session of the 19th Central Committee of the Communist Party of China," *Xinhua Net*, October 29, 2020, https://reurl.cc/95Zk3O.

4 Wei Liu, Deng-yue Wang, "Prospect of New Energy Applications for Military Purposes," *China Teachers*, February 6, 2021, Cited from *chinaqking.com*, https://reurl.cc/NZr4vn.

5 Hsing-Wei Sun and Shao-Hua Li, "More than 500 Border Defense Sentry Posts Connected to the State Grid," *Chinese People's Liberation Army Daily*, November 29, 2020, https://reurl.cc/Q69YXq.

been expanding its site facilities—even creating a smart greenhouse for growing vegetables.[6]

For the border defense sentry posts on islands and shoals and the western plateau yet to be connected with the state grid, the PLA adopts the case-by-case approach for each post by establishing smart microgrids with solar, wind, and storage complementary to diesel generation.[7] To this day, over 80 new energy smart microgrids have been constructed to enhance border warfare capabilities. Examples are the Shenxianwan Post in Xinjiang at an altitude of over 5,000 meters and the integration of smart microgrids and seawater desalination on the Tree Island of Paracel Islands.[8]

2. Military Applications of Lithium Iron Phosphate Batteries

Lithium iron phosphate batteries have been widely used in green energy storage, unmanned vehicles, electric vehicles, aviation, and communications due to their long service life, superior safety, resistance to both high and low temperatures, and better environmental friendliness.[9] In expanding its civil market for lithium iron phosphate batteries, China is also extending its military use by developing batteries that can function in extremely low temperatures of -40 to -50 degrees. It is hoped that the portability and high power of these batteries enhance the mobility of the military force and its weaponry.[10] Chinese companies, such as Heter Electronics and Hunan Bolt Power New Energy, have received the PLA quality certification for the supply of military batteries and continued to develop the fast charging

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6 Wu-Bin Chen, Yi Chou and Yun-Hong Cui, "How do Soldiers Live at the Sentry Post above 4,000 Meters in Altitude?," *China Veterans Magazine*, 5, 2021, https://www.mva.gov.cn/sy/zzxc/202107/t20210716_48822.html.

7 Hsing-Wei Sun and Hai-Ching Yu, "Over 80 New Energy Microgrids Installed in Border and Marine Defense Troops," *Chinese People's Liberation Army Daily*, February 5, 2021, https://reurl.cc/L7bLl3; Yan-Liang, Da-Hui Liu, "Customized Solutions and Accurate Services to Sentry Posts in the Snow Territory," *Chinese People's Liberation Army Daily*, March 24, 2021, https://reurl.cc/bnXar6.

8 Op. cit. 7; Chao Liu, "Chronicle of Sansha City as the 11th National Double Support Model City," *Hainan Daily*, September 25, 2020, https://reurl.cc/DZgLz5.

9 "Application of Lithium Iron Phosphate (LFP) Battery Packs in Special Industries," *Juda Lithium Battery*, August 14, 2020, https://reurl.cc/2oYg1E.

10 "Introduction to Major Applications of Lithium Iron Phosphate (LFP) batteries," *OFweek Battery*, July 20, 2021, https://reurl.cc/dxnGey; Ryder, "Issues of Attention for Special and Customized Low Temperature Lithium Batteries able to Operate in Low Temperatures," *Rydbatt*, September 2, 2020, https://reurl.cc/NZQrnn.

performance of these batteries.[11]

3. Military Use of Hydrogen Fuel Cells

As one of the alternative energy sources, hydrogen attracted much attention during the oil crisis in the 1970s. As there is almost no carbon emission in the manufacturing process, the surplus of green energy, such as solar and wind, and green hydrogen generated with the electrolysis of water are believed by all countries in the world to be the key to zero carbon emission.[12] With the high energy density of hydrogen, hydrogen fuel cells ensure the continuous working of renewable energy and microgrids.[13] In addition, they have high energy efficiency and longer life than that of lithium batteries. They are also relatively quiet in operation; hence, suitable for unmanned military equipment. Meanwhile, the PLA is currently developing the military use of hydrogen fuel cells, which can be observed from the progression of hydrogen fuel cells for civil purposes during the past few years:

(1) *Multicopter drones powered by hydrogen fuel cells*

In April 2016, the MMC Company launched the world's first multicopter drone, "HyDrone1800", powered by hydrogen fuel cells, which can fly for 273 minutes.[14] Meanwhile, in December 2019, the Innoreagen Company and the Shouhang Guoyi Company jointly developed a six-rotor drone powered by hydrogen fuel cells, claiming that the flight time was even longer; that is, up to 331 minutes.[15]

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[11] "Top Supplier Hunan Bolt Power New Energy: Top-notch Exporter of the First Aluminum-ion Battery Fast Charge Technology for Emergency Energy Storage," *China Battery Enterprises Alliance*, October 7, 2020, https://reurl.cc/n5N5Vv.

[12] Hui-Ling Shi, "Development and Trends of Global Hydrogen Production Methods", *MOEA Department of Industrial Technology*, May 26, 2021, https://reurl.cc/yeEjE8.

[13] Chi-Jun Lin, "Application of Microgrids in Storage Systems," *Newsletter of Taiwan Association of Energy Service Companies*, Vol. 33, August 2018, https://reurl.cc/GbmRgG.

[14] Chuan-Shu Liu, "First Multicoptor Drone Powered by Hydrogen Fuels Takes Flight," *Science and Technology Daily*, April 11, 2016, https://reurl.cc/ARkvnd.

[15] "331 Minutes of Battery Life for Newly Developed Six-rotor Drone Powered by Hydrogen Fuel Cells Sets World Record," *China Hydrogen*, December 17, 2019, https://reurl.cc/Q69Kj2.

(2) *Hydrogen-powered vertical take-off and landing (VTOL) drones and unmanned helicopters*

In October 2020, the Mobility Innovation Company, a member of the Doosan Group from Korea, worked with Chengdu JOUAV Automation to launch "DJ25", the world's first hydrogen-powered vertical take-off and landing (VTOL) drone, with a flight time of up to 303 minutes. In the same year, Mobility Innovation worked with the Ziyan UAS Company to launch "DZ15", the world's first hydrogen-powered unmanned helicopter, with a flight time of 330 minutes.[16]

(3) *Cars powered by hydrogen fuel cells*

In the past five years, many provinces from northern China to southern China, including Hebei, Wuhan, Zhejiang, and Guangdong, have established hydrogen industrial parks, hydrogen stations, and fuel cell car demo sites. In 2021, this trend moved further westward with the development of Hydrogen Valley in Chongqing in order to expand the supply chain of hydrogen fuel cells in China and reduce the cost of application to military equipment in the future.[17]

(4) *Portable hydrogen fuel cells*

These type of cells uses MgH2 as the storage material. As the electricity is generated for immediate use, light and convenient materials can be used for the metal casing for hydrogen storage, reducing the manufacturing cost and the weight of cells. Although the weight can be minimized to 25 g, the generation is up to 25 Wh, higher than that of a smartphone battery.[18] Lightweight and portable batteries

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[16] Ziyan UAV, "World's First Hydrogen-powered Unmanned Helicopter about to Strike," *Zhuhai Ziyan Unmanned Aerial Vehicle's company website*, July 3, 2020, https://reurl.cc/1oYaAG; "Portable Hydrogen Fuel Cells Energize Military Equipment," *people.cn*, January 7, 2019, https://reurl.cc/XlWY8a; Doosan Mobility Innovation, "The 4th Shenzhen International UAV Expo — Review of Hydrogen Power Products," *website on drones*, October 3, 2020, https://reurl.cc/q1gWrn.

[17] "Faster Development of Fuel Cells and Domesticalization of Key Technologies," *people.cn*, May 6, 2018, https://reurl.cc/Gbm0VZ; "Portable Hydrogen Fuel Cells Energize Military Equipment," *Science and Technology Daily*, January 7, 2019, https://reurl.cc/Q69KA2; "First China-made Fuel Cell Generators Come Online and PLA's Use of Fuel Cell Technology for Military Purposes," *kknew.cc*, August 26, 2017, https://kknews.cc/zh tw/military/kaexkpv.html.

[18] "Portable Hydrogen Fuel Cells Energize Military Equipment," *Science and Technology Daily*, January 7, 2019, https://reurl.cc/kLZzrq.

reduce the burden on soldiers and increase the life of electronic equipment, such as portable radio, night vision systems, and single-soldier systems, which boosts an individual's battlefield capabilities.[19]

4. Military Application of Solar Energy Generation

(1) *High-altitude Long-endurance Solar-powered UAV*

The term "near space" refers to a 20- to 100-kilometer distance above the surface—higher than where airplanes fly but below where satellites orbit. High altitude long endurance (HALE) vehicles can fly in near space, 20 kilometers above the earth's surface, for days, months, and even years. Compared to traditional satellites, HALE vehicles are less costly and more mobile. With longer endurance than regular drones, HALE aircraft is deemed one of the new weapons essential to battlefield victory.[20]

In June 2017, the China Aerospace Science and Technology Corp. (CASC) Academy No. 11 launched "Rainbow", the first near space, solar-powered UAV. It has the potential of performing high-altitude surveillance, serving as a portable WiFi station in the air and supporting emergency communications during a disaster. In terms of carrying capacity, endurance, and flight altitude, it also claims to be superior to the Airbus Zephyr solar-powered UAV (which can fly up to 14 days).[21] The PLA's R&D progress in the high-altitude long-endurance solar-powered UAVs has become a concern for countries like the U.S. due to a lower production cost, small size, and high stealth to threaten aircraft carriers.[22]

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[19] Op. cit. 4.

[20] "Future of Unmanned Capabilities: MALE vs HALE," *Defense Systems*, May 27, 2015, https://reurl.cc/pxgE0d.

[21] "China's First Near Space Solar-powered UAV Conducts a Successful Test Flight," *people.cn*, June 14, 2017, https://reurl.cc/oxgGE3; Science, Technology, and Information Technology Bureau, "Application of Near Space Solar-powered Drones in Emergency Communications," *Ministry of Emergency Management*, September 19, 2019, https://reurl.cc/ZjG6GW; "Flying Close to the Sun," *Global Times*, June 21, 2017, https://reurl.cc/35a2LM.

[22] Op. cit. 18.

(2) *New detachable warm barracks*

In May 2020, when the border conflict erupted between China and India, the PLA installed the new detachable warm barracks on the border for camping in the cold highlands. These reusable and easy-to-assemble barracks were developed by the PLA's Army Engineering University. Powered by solar generation, the structure retains the warmth from the sun and is connected to a microgrid with wind and diesel generation. When the outside temperature falls below-40 degrees Celsius, the indoor temperature stays above 15 degrees Celsius, greatly reducing the logistic burden.[23]

III. Battlefield Values and Impacts

Traditional fossil fuels remain the bulk of China's military energy consumption. While the application of renewable and low-carbon technologies is still limited, its progress and potential impacts cannot be ignored. At the end of 2016, the National Energy Administration of China and Logistic Support Department of the Central Military Commission started to promote the "Implementation Plan for Frontier Power Grid Construction", hoping to provide electricity to all of the PLA's and the armed police's border defense troops by 2020.[24] China's installation of smart microgrids on islands and shoals and in remote mountains and plateaus intends to enhance the combat power of border defense sentry posts in inaccessible regions. It is undeniable that some border defense sentry posts need to be connected to the state grid for fundamental solutions to electricity requirements. More so, there are still uncertainties about whether the electricity grid system and relevant facilities built in a harsh environment are resilient enough to weather out the extreme climate on an ongoing basis in the future.

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[23] Hsing-Hsiung Sun, Yan Chao, "China's New Detachable and Self-sufficient Warm Barracks Debut for Highlight Border Defense," Ministry of National Defense of the People's Republic of China, October 8, 2019, https://reurl.cc/73r1pQ; "Solar is on China's Border with India to Protect Warriors in Defense of the Country," *china5e.com*, October 22, 2020, https://reurl.cc/Gbm3eA.

[24] "Border Defense Troops into the New Era of Electricity Consumption," *people.cn*, March 26, 2019, https://reurl.cc/V5EdYN.

In addition to the diversification of the risks associated with overreliance on fossil fuels, all of the aforesaid hydrogen fuel cells and solar energy applications have high energy efficiency, long lives, small sizes, and high mobility. While it is advocating the achievement in the military energy transformation, the most important consideration for China should be the high stealth and stronger distributed killing power (e.g., unmanned weapon stations). As China is expanding its civil market for hydrogen, creating the hydrogen supply chain from upstream to downstream, and developing the hydrogen sources for hydrogen stations, the question on China's military energy transformation remains whether it is propelled towards green hydrogen for net-zero or towards brown hydrogen and blue hydrogen with high carbon emissions from the manufacturing process.[25]

IV. Conclusion

Ultimately, China seeks to combine its military energy transformation with smartization and informatization. The expansion of its domestic market via the Military-Civil Fusion aims to reduce the cost of technology and manufacturing in order to dominate in the new type of warfare. May it be the development of long-endurance solar-powered UAVs, the installation of warm barracks on the highland along the China-India border, or the deployment of renewable energy smart microgrid and desalination plants on the islands and shoals in the South China Sea, these are all part of China's military ambition and invasive moves. Furthermore, it is up for debate whether these activities can reduce carbon emissions and diversify the risks of over-reliance on fossil fuels and whether key renewable energy facilities have the functions and resilience to survive extreme climates.

[25] "New Energy? Hydrogen Could be Worse Than Fossil Fuels," *Taiwan Institute for Sustainable Energy*, August 24, 2021, https://reurl.cc/q1glK3.

Chapter 13

China's Use of Military Propaganda Technology

Shu-Ting Liu*

I. Introduction

Propaganda has always been China's important rule for dominion. To the PLA, propaganda is pertinent to the stability of military morale and the support from the people and to the goal of "the enemy surrendering without even fighting". The PLA has been faced with the challenge of military recruitment and is eager to expand its talent pipeline. Internally, there are generational problems. Military propaganda is an important task in meeting the expectations of society and young soldiers. As communications technology develops rapidly, the PLA emphasizes the importance of "keeping up with the times" by adapting to the internet era and speaking to the heart of youngsters.[1] This chapter seeks to understand how the PLA propaganda uses technology in cyberspace and the effects it creates.

Unlike other chapters that examine state-of-the-art weapons and cutting-edge technological development, this chapter focuses on the use of propaganda technology and highlights the characteristics of technological tools for propaganda. Further, this chapter is founded on the belief that the PLA's internal propaganda emphasizes the use of technology, while its external propaganda is the accumulation and extension of internal propaganda. Hence, the logic of its internal propaganda sheds light on the PLA's direction in external propaganda. The article

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1 For China's military propaganda, see Kristin Huang, "Can Chinese Military's Hip New Propaganda Strike Chord with Generation Z?," *SCMP*, May 30, 2021, https://reurl.cc/q1Zlqp.

also articulates the strategy and the characteristics of China's military propaganda by analyzing its animation, "Demonstration of Concerted Firing on Taiwan", in order to highlight the PLA's direction in the development of external propaganda technology.

II. PLA's Strategy in Internal Propaganda Technology

1. Targeting the Entertainment Culture of the Young Generation

In recent years, the military propaganda of the Chinese Communist Party (CCP) has been focusing on the ACG (animation, comics, and mobile game) industry to grab the interest of young soldiers.[2] By presenting military propaganda in a manner of entertainment through digital imaging technology, military broadcasting attracts public attention and reinforces propaganda effects.

(1) *Fun and eye-catching animation*

The PLA leverages the readability and fun of animation in attracting the target audience and spicing up the storyline for propaganda. In recent years, the PLA also leverages civil technology and resources and works with private production companies or studios for military propaganda animation through licensing, commission, and co-development by tapping into the thriving domestic animation industry. Take "Year Hare Affair" as an example, it started as a hit online as a long-running comic, and the PLA Political Work Department TV Art Center became a co-producer in the fifth season of the said comic. The broadcasting on the 70th Anniversary of the Founding of The People's Republic of China presented the PLA's image in the new era with animation technology and was particularly well-received by the young audience. In particular, it generated more than 60 million views.[3]

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[2] For PLA all fire on ACG propaganda, see "How National Defense Education Integrates into the Two-Dimension? The Right Flavor with a Military Touch," *Xinhua Net*, June 10, 2020, https://reurl.cc/WXEdkD.

[3] For PLA animation propaganda, see "Patriotic Education Campaign in China Under the Era of Xi Jinping," *The Wall Street Journal*, January 4, 2021, https://reurl.cc/xEgZ4b.

Figure 13-1 PLA's Animation "Year Hare Affair"

Source: "Year Hare Affair" season 5, *Bilibili*, October 1, 2019, https://reurl.cc/oxgEpg.

(2) *"Moe" animated figures*

Based on computer animation, the PLA integrates AI facial recognition and interactivity technology to design fictional figures for military propaganda. "Moe" is a concept originated from Japanese anime and denotes to something cute and lovable. The animated and customized "moe" personas are created to reach the young generation. China Military Online launched its first AI anchorperson, "Xiao Jun," in March 2021, showing animation mixing with in-person interviews. While Xiao Jun's going back and forth with the PLA pilots was fun and interactive, the programs also blended with hip slangs and special-effect images, an innovation distinct from previously standardized interviews for propaganda.[4]

[4] For PLA animated anchorperson, see "Debut of Military Media AI Anchorperson Xiao Jun and Interview with Y-20 Pilot Feng Wei," *Ministry of National Defense of the People's Republic of China*, March 8, 2021, https://reurl.cc/Ok0zDv.

Figure 13-2 Interview Conducted by PLA's AI Host Xiao Jun

Source: "Debut of military media AI anchorperson Xiao Jun and interview with Y-20 pilot Feng Wei," *Ministry of National Defense of the People's Republic of China*, March 8, 2021, https://reurl.cc/Ok0zDv.

(3) *Military mobile games with placement propaganda*

The PLA has established a foundation in developing mobile games for placement propaganda. In the early days, the PLA Air Force launched "Golden Helmet," and the PLA Ground Force developed the dual-use version of "Honor of Kings" in training soldiers with war simulation and cultivating military interest among the young Chinese generation. However, as the government mouthpiece, People's Daily started to criticize "Honor of Kings" as addictive for teenagers, the Chinese People's Liberation Army Daily echoed the same message. Consequently, the troops are said to have discontinued the mobile games.[5] In fact, China Military Online has not updated the newest information section about mobile games since early 2019. As this seems contrary to the global trends, the future development of China's military mobile game technology is yet to be observed.

2. Communication for the Internet Era

The PLA propaganda has moved from the traditional paper-based literature to the cyber platform. Various mobile devices now function as propaganda channels.

[5] For PLA prohibits military video games, see "PLA Soldiers Addicted to Mobile Game 'Honor of Kings' Xinjiang Military Base Issues a Ban," *RFI*, October 12, 2017, https://reurl.cc/6DakzO.

Combined with online social means such as short videos, livestreaming, and barrages, they have become the PLA's new way of communicating with the public.

(1) *Short videos close to home*

As short video platforms, such as Douyin and Kuaishou, have become the center of entertainment and social life of the Chinese people, the PLA has been using short videos to enhance internal propaganda. Unlike the long and tedious reports on the PLA's official webpages in the past and unrestricted by the broadcast timeslots of the TV media, each short video is 15 seconds to 5 minutes, providing intuitive audio and video stimulation to the audience on mobile devices and in time confetti. In the example of China Military Online's Douyin account, most releases feature day-to-day military training, military career, and family life, which speaks of the PLA's "close to home and down to earth" strategy in its short video propaganda.

(2) *Engaging via livestreaming*

Livestreaming as the new online social activity emphasizes real-time and reality. The PLA uses livestreaming technology to create an atmosphere of face-to-face communication. For instance, the Network Public Opinion Bureau under the Political Work Department of the People's Republic of China Central Military Commission launched the livestreaming series, "War Drumming Along," without editing or adding special effects to represent the true color of military life. Online connectivity allows instant interactions between the audience and the soldiers. Furthermore, livestreaming is also aired simultaneously via the PLA's new media, China's official media www.cctv.com CCTV.com, the Communist Youth League of China's new media and platforms, such as Toutiao Jinri Toutiao. A single livestreaming of four hours attracted over 43 million viewers, which speaks of its influence on the internet communities.

(3) *Barrages as the technology for interactivity*

Barrages are a new way for interactivity and commenting in the internet era. These are a large number of moving textual comments on videos, similar to the barrage shooting game. It has become an important means of expressing opinions

by the cyber generation in China. Unlike the comments, thumbs up, or sharing on social media, barrages are synchronous and free from the constraints of space, meeting everybody's needs for simultaneous interaction. For instance, the PLA Air Force's airborne troops have set up a Bilibili account, "Our Sky", to publish videos. There is a large barrage of messages, such as "Proud of you" and "Well done", as the audience engages in real-time interactions.

Figure 13-3 PLA's "Our Sky" Barrage Film

Source: "Paratroopers" Parachutes Hit the Ground Running, a Stimulation of Three Days and Two Nights "Thrills on the Battlefield", *Bilibili*, April 2, 2021, https://reurl.cc/oxgEpg.

3. Audio Experience for Voice Propaganda

The "ear economy" in China rose during the pandemic. Audio platforms, such as online music, podcasts, and audiobooks, are gradually becoming the center of Chinese entertainment. Meanwhile, the PLA keeps up with the trend and pursues the possibility of various voice propaganda.

(1) *Music platforms to build cohesion*

Streaming media provides the audience with access to digital music without the limitation to physical equipment, number of downloads, and types of music. Music is available anytime, anywhere, and on demand. In an environment convenient to the audience, online music platforms add features, such as sharing, comments, collection, and customization, for better social interaction. For example, the PLA

News Communication Center launched the military song, "Outset", on the Chinese online music platform, KuGou Music.[6] KuGou Music also introduced the "August 1 Army Day Song List" to enhance the PLA's sense of honor and solidarity by leveraging the reach of music broadcasting.[7]

(2) *Podcasts for subtle and gradual influence*

The podcast market in China has been booming in recent years. Compared to traditional broadcasting, online podcasting is published in lists and available for downloads or streaming on demand. The interface provides features, such as "subscribe" and "push", for better autonomy of the audience. The PLA inspires a patriotic awareness among troops and people and cultivates a sense of national defense with the power of voices on podcasts. For instance, the PLA leverages the influence of podcasts for recruitment by establishing "2021 Bugle Calls to Military Camps" as another use of its propaganda technology.[8]

(3) *Audio reading to entertain and educate*

Audio reading has lately become a new option for the Chinese audience. Audio-sharing platforms use AI technology to push content to users according to voice preferences and listening habits. On Himalaya, China's largest audio sharing platform, over 400 audiobooks feature the PLA. Among them, the Pacific War series from "Modern Military Bar" affiliated with the Chinese government attracts over 20 million hits; the Great Final Battle series on the PLA's warring history generated nearly 2.6 million hits. These numbers show the potential of audio reading to enhance the Chinese people's awareness of national defense.

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6 For Online music platform plays military songs, see "Fighting the Pandemic Song 'Outset' Live on KuGou Music," *Xinhua Net*, April 20, 2020, https://reurl.cc/MkAoVW.

7 For Military propaganda song list, see "Nanfang Daily Joins 'Kuguo' for August 1 Army Day Song List as Salute to Soldiers," *Tencent News*, August 7, 2020, https://reurl.cc/NZroLn.

8 For PLA's podcast platform for recruitment, see "Military Recruitment Via Fingertips," *Ministry of National Defense of the People's Republic of China*, June 8, 2021, https://reurl.cc/l5RbLE.

III. Trends of PLA's External Propaganda Technology

As described above, the PLA's use of internal propaganda technology focuses on the social culture of the young generation and values the broadcasting features of digital audio/video. As a further analysis, this paper examines the simulated animation, "Demonstration of Concerted Firing on Taiwan," published by Warship Knowledge magazine on July 1, 2021.

Figure 13-4 Simulated Animation "Demonstration of Concerted Firing on Taiwan"

Source: "Xi Jinping demonstrates the Chinese people's determination to resolve the Taiwan issue. The film 'Demonstration of Concerted Firing on Taiwan' is now on!" YouTube, July 1, 2021, https://reurl.cc/35aqWV.

1. Application Strategies

(1) *Use of civil technology for military propaganda*

The Chinese military propaganda stays on top of the market trends for the audience and mostly relies on civil technologies and resources. Warship Knowledge is the largest popular science magazine by circulation in China. China CSSC Holdings Limited, the military industry heavyweight, is behind the magazine's publisher, the Society of Naval Architects and Marine Engineers, and is

closely affiliated with the Chinese government. On May 20, 2020, when President Tsai Ing-wen inaugurated, the Warship Knowledge magazine released the film, "Simulation on Firing at Taiwan in 2020,"[9] and in 2021 added a storyline. The use of civil technology for military purposes creates a more immersive experience for the audience in China's narrative of threats.

(2) *Simulated animation for intimation effects*

Based on 3D computer animation, this film simulates the PLA's military equipment and establishes a 3D model of Taiwan's anti-aircraft missiles and combat areas and terrains by adding simulated fighter aircraft, missiles, armored cars, and soldiers. It seeks to create a highly realistic effect with 3D coloring, textures, and lighting. Through the animated simulation, the PLA attempts to exaggerate China's military power and its understanding of Taiwan's military capabilities. The cross-cutting of images of fighter aircraft taking off and ground troops gathering, together with video and audio effects of missile strikes and tank explosion, create an impression of the breaking out of war and aim to put pressure on Taiwan and the international society.

(3) *Mimicked tones as an attempt to speak to the heart*

The voice-over of "Demonstration of Concerted Firing on Taiwan" is in a stable and solemn rhythm, in conjuncture with the string music in allegro tempo and the sound effects, such as airplanes flying and wartime broadcasting, to enhance the sense of presence and sharpen the emotional tension of the simulated animation. The idiomatic expressions and the local accent of Taiwanese soldiers are an important addition. There are conversations mimicking the Taiwanese army under the PLA's attack, such as "What the command is saying?," "Their missiles are here! Damn it!," "Oh no. Anti-aircraft missiles are electromagnetically interfered." These Taiwanese colloquial expressions and tones are meant to highlight the PLA's military advantages by imitating the R.O.C. Armed Force's vocal expression in

[9] *Warship Knowledge magazine* published "Simulation on Firing at Taiwan in 2020", see "Chinese Media Threatens to Neutralize All the Airports in Taiwan in 4 Minutes 'Taiwanese Army Fights Back' 'You Will Know Our Determination in Less Than 4 Minutes'," *Taiwan News*, May 23, 2020, https://reurl.cc/V58qAA.

panic and retreating in defeat and attempting to undermine the confidence of the Taiwan military and its society.

2. Future Trends

(1) *Deepfakes for cognitive warfare*

The above PLA footage shows an increasing sophistication of computer animation technology. In fact, there have been many scandals about the PLA's fakes in propaganda films. For example, the PLA's training images are found to be the patchwork of old propaganda videos. Some of the pictures showing off fighter jets came from Hollywood movies.[10] These indicate that the PLA has strong intention to fake propaganda, but given that its current technical capabilities are inadequate, loopholes are everywhere. Meanwhile, it is expected that the PLA will work on realistic and refined Deepfakes for propaganda purposes. Unlike the traditional post-production of films, Deepfakes use deep learning to create lifelike and natural fake images, which are likely to be used by the PLA for large-scale cognitive warfare.

(2) *Using natural language for simulated emotions*

Deepfakes can be used not only for images but also in voices and texts. The aforesaid propaganda (i.e., imitating accents) reflects the PLA's ambition to manipulate cognition with voices. In fact, the PLA seeks to stir up emotions and control the behavior of targets through various media, of which voice is one of the key applications. The traditional speech synthesis is too rigid and formulaic. Moving forward, the PLA is likely to apply the natural language techniques using machine learning and neural networks after it has built up a sufficient corpus of Taiwanese texts and voices. Once equipped with the capability to finely imitate the speaking style and vocal expression of the Taiwanese people and to synthesize and switch multiple roles, voice-based cognitive warfare will be launched against the

[10] For PLA fakes propaganda films, see "PLA's Intimation not Powerful Enough. Fakes Time and Again and for the Third Time," *Central News Agency*, September 27, 2020, https://reurl.cc/MkAKmX.

Taiwanese society.

IV. Conclusion

This chapter examines the PLA's propaganda technology and use. The results indicate that its internal propaganda and technology focuse on the entertainment culture (e.g., animations, virtual figures, and mobile games) of the young generation and caters to the communication methods in the internet era, such as short videos, livestreaming, and barrages. It also extends its footprint to voice propaganda via music streaming, podcasts, or audiobooks. In sum, China's development of internal propaganda technology keeps up with the trend of the audience market and taps into resources of civil technologies. The development of mobile games is worth watching, given the policy changes and the suppressed industry in recent years.

Furthermore, this chapter is concerned with the PLA's application and the potential development of propaganda technologies. The simulated animation, "Demonstration of Concerted Firing on Taiwan", published by the Warship Knowledge magazine, is used as a case study. This chapter contends that the development of the PLA's external propaganda technology will focus on the continued and extended use of civil technologies for military propaganda, and simulation techniques such as animation and voice to enhance its propaganda effects. Moreover, it is expected that the PLA will carry on with the improvement of promising propaganda technologies (such as Deepfakes and natural language) first in its immense experiment on internal propaganda and then execute more sophisticated external propaganda projects.

Chapter 14

Legal Analysis of the PRC's Defense Industry in Recent Years under the Military-Civil Fusion Strategy

Alice Chang-Jung Yang*

I. Introduction

China's military industry has emerged as a rising power in recent years. The Military-Civil Fusion[1]national strategy and other measures in conjunction with the technology development and requirements of the country started to take off at the end of 2020. These actions have many implications for some countries, particularly the U.S., as the global leader in the defense industry. For instance, the then U.S. President, Donald Trump, signed an executive order in November 2020 to prohibit U.S. companies and individuals from investing in Chinese military firms.[2] Trump indicated that China adopted the national strategy of Military-Civil Fusion to enable private enterprises to support military and intelligence activities and expand the scale of its defense industry. While these companies appear to be privately

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1 "Military-Civil Fusion and the People's Republic of China," *U.S. Department of State*, May 28, 2020, https://www.state.gov/wp-content/uploads/2020/05/What-is-MCF-One-Pager.pdf; "China's Military-Civil Fusion Strategy: a View from Chinese Strategists," *China Aerospace Studies Institute*, June 10, 2020, https://static1.squarespace.com/static/5e356cfae72e4563b10cd310/t/5ee37fc2fcb96f5 8706a52e1/1591967685829/CASI+China%27s+Military+Civil+Fusion+Strategy-+Full+final.pdf; Military-Civil Fusion is not a unique concept to China. However, "MCF" is currently the term specifically for China's national strategy of Military-Civil Fusion. It was called Civil-Military Integration (CMI) under the Hu Jintao administration and replaced by the term "Military-Civil Fusion" under the leadership of Xi Jinping. The two terms share many similarities.

2 "Executive Order 13959 of November 12, 2020," November 17, 2020, https://home.treasury.gov/system/files/126/13959.pdf; "Trump Issues an Executive Order to Prohibit U.S. Nationals from Investing 31 PLA Firms," *Commercial Times*, November 13, 2020, https://ctee.com.tw/news/global/369281.html.

owned or operated, they directly support China's military, intelligence and security institutions. Investing in such firms is essentially funding them with American capital for its development and modernization. On June 3, 2021, the U.S. President Joe Biden signed the Executive Order 14032 to expand the prohibition of U.S. individuals from investing in Chinese defense companies even further. A total of 59 entities, including Huawei, China Aerospace Science and Technology Corporation (CASC) are listed as China military-related companies. Biden said in a statement that the extended ban is a response to the threat posing by Chinese defense firms.[3] This paper provides an analysis regarding the development and the strategy of China's defense industry in the context of legal and policy aspects in recent years.

II. National Strategy of Military-Civil Fusion

The most important national strategy China has recently put in place is the Military-Civil Fusion Strategy, which aims at developing state-of-the-art military technology. In particular, its purpose is to develop a "world-class military" by 2049—the 100th year of the Chinese Communist Party's ruling,[4] under the direct supervision of its leader, Xi Jinping.

In March 2015, China included the Military-Civil Fusion Strategy in its "Outline of the 13th Five-Year Plan for National Economic and Social Development" (the 13th Five-Year Plan). Xi Jinping emphasized that the Military-Civil Fusion

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[3] "Executive Order on Addressing the Threat from Securities Investments that Finance Certain Companies of the People's Republic of China," *The White House*, June 3, 2021, https://www.whitehouse.gov/briefing-room/presidential-actions/2021/06/03/executive-order-on-addressing-the-threat-from-securities-investments-that-finance-certain-companies-of-the-peoples-republic-of-china/; "FACT SHEET: Executive Order Addressing the Threat from Securities Investments that Finance Certain Companies of the People's Republic of China," *The White House*, June 3, 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/06/03/fact-sheet-executive-order-addressing-the-threat- from-securities-investments-that-finance-certain-companies-of-the-peoples-republic-of-china/; "Biden Signs an Executive Order to Expand the Ban on Investing in Chinese Military Companies," *Central News Agency*, June 4, 2021, https://www.cna.com.tw/news/firstnews/202106040008.aspx.

[4] M. Taylor Fravel, "China's 'World-Class Military' Ambitions: Origins and Implications," *The Washington Quarterly*, Vol. 43: 1, 2020, pp. 85-99. https://taylorfravel.com/documents/research/fravel.2020.TWQ.china.world.class.military.pdf.

Strategy is promoted to the national level.[5] In March 2016, the Politburo of the Chinese Communist Party published "Opinions on the Integrated Development of Economic and National Defense Construction", this document provides guidance on national defense and economic development, expounding on national security, development strategy, Military-Civil Fusion, and the details in priority tasks and policy measures. In January 2017, the Politburo of the Chinese Communist Party formally established the Central Commission for Integrated Military and Civilian Development, with Xi Jinping as the director. The major issues and the decision-making of the development of the Military-Civil Fusion are managed and coordinated at the central government level.

Military-Civil Fusion primarily consists of economic development and national defense development, aiming of achieving a balance between the two. In reference to the experience of the western countries (notably, the U.S.) with defense companies, China seeks to create its own version of the development paradigm, "military transferred to civil, civil participating in the military," for its national defense technology and industry.[6] The Chinese government plays a pivotal role in Military-Civil Fusion. In addition to government-led reforms in defense companies and intervention in M&A activities, relevant legislations and economic policies have been put in place to influence those companies. There is a robust legal and regulatory framework to orchestrate the activities of different actors under the banner of Military-Civil Fusion and to further the institutionalization. The cutting-edge technology for military and civil dual-use is either developed or obtained in a not necessarily legitimate manner, however.[7] As a consequence, many countries, including the U.S., is feeling unease with such practice.

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[5] Hui-ming Tung, "Current Status and Issues of China's Military-Civil Fusion strategy," *Prospect & Exploration*, 14(3), March 2016, pp. 31-38.

[6] "Military Transferred to Civil" Refers to the Use of Military Technologies by Private Sectors; "civil participating in military" indicates private entities taking part in the military market.

[7] *Supra note* 3.

III. The 14th Five-Year Plan

Under the Military-Civil Fusion Strategy, the development of the Chinese defense industry will continue to be at the top of the agenda over the next few years. The development of an industry is usually positively correlated with national policies, and with strong support from the government, China's defense industry has been thriving. Furthermore, there are a series of policies and plans, as well as legislative amendments and reform measures that drive the R&D capabilities and the long-term development of China's defense industry.

The most important national strategy for China's military industry is the "Outline of the 14th Five-Year Plan (2021-2025) for National Economic and Social Development and Vision 2035 of the People's Republic of China" (The 14th Five-Year Plan)[8] passed by the 4th Session of the Thirteenth National People's Congress in March 2021. The 14th Five-Year Plan is perhaps the most significant policy document for China's social and economic development over the next 5 or even 15 years. It is highly relevant to the defense industry, primarily by including the enhancement and integration of mechanization, informatization, and smartness; the strengthening of the preparation for wars; the emphasis on the strategic capabilities in defense of sovereignty, security and development interests; and the acceleration of weaponry and equipment modernization. There is also a focus on self-sufficiency in technology and speedy development as a tech power, encompassing home-grown innovations and the original innovation of the national defense technology, speeding up of the development of strategic, cutting-edge, and revolutionary technologies. It also implies a quicker upgrade and renewal of weaponry and equipment and the development of smart weaponry and equipment.

In addition to the 14th Five-Year Plan, the whitepaper, "China's National Defense in the New Era," published by the State Council of China in July 2019, articulated that China would push at a full drive for modernizing its national defense and military force. By doing so, China will deepen reforms in national defense and

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[8] "Outline of the 14th Five-Year Plan (2021-2025) for National Economic and Social Development and Vision 2035 of the People's Republic of China," *Central People's Government of the People's Republic of China*, March 13, 2021, http://big5.www.gov.cn/gate/big5/www. gov.cn/xinwen/2021-03/13/content_5592681.htm.

the army across the board, resolve systematic and policy problems, and push the comprehensive development of national defense and military establishment. Furthermore, it also seeks to drive the innovation and development of its national defense technology and military theories to construct modernized weaponry, equipment, and systems.[9] Following the start of the 14th Five-Year Plan, the defense industry will have an important influence on China's army strengths and economic growth, which will likely substantially affect regional security and global development.

IV. China's Legal System for Its Military Industry

To understand the development of China's legal system for its military industry, it is necessary to establish an understanding of its basic laws, in particular, the Constitution of the People's Republic of China, Legislation Law of the People's Republic of China, and Law of the People's Republic of China on National Defense.

1. Constitution of the People's Republic of China

In most countries with the written law system, the constitution is the highest form of domestic law. This is no exception for China's legal system, with its constitution claiming the highest level of legal validity. Under its constitution are laws, which are above regulations, and then rules (e.g., administrative regulations, local regulations, and rules).[10] Noteworthily, according to Article 87 of the

[9] "The Chinese Government Released the White Paper Titled 'China's National Defense in the New Era'," *Xinhua News Agency*, July 24, 2019, http://www.mod.gov.cn/big5/shouye/2019-07/24/content_4846366.htm.

[10] Article 79 of the Legislation Law of the People's Republic of China stipulates that "The effect of administrative regulations is higher than that of local regulations, and rules"; Article 80 states that "The effect of local regulations is higher than that of the rules of the local governments at or below the corresponding level. The effect of the rules formulated by the people's governments of the provinces or autonomous regions is higher than that of the rules formulated by the people's governments of the comparatively larger cities within the administrative areas of the provinces and autonomous regions"; Article 82 states that "The effect of the rules of different departments is equal between the departments, and the effect of the rules of departments and of the rules of local governments is equal between the departments and local governments; their application shall be confined to their respective limits of authority".

Legislation Law of the People's Republic of China, no laws may be in conflict with the Constitution.[11]

The Constitution of the People's Republic of China stresses the importance of armed forces, which emphasizes the importance of the national defense and military at the constitutional level and demonstrates its nation-founding spirit and policy development. Article 29 says, "The armed forces of the People's Republic of China belong to the people. Their tasks are to strengthen national defense, resist aggression, defend the motherland, safeguard the people's peaceful labor, participate in national reconstruction, and do their best to serve the people. The state strengthens the revolutionization, modernization, and regularization of the armed forces in order to increase national defense capability." Chapter 3 of the Constitution of the People's Republic of China specifies that the Central Military Commission (CMC) is the entity in charge of the country's military institutions. Article 93 stipulates that "the Central Military Commission of the People's Republic of China directs the armed forces of the country," adopting the chairperson responsibility system. According to Article 94, "The Chairman is responsible to the National People's Congress and its Standing Committee"—a stark contrast with the Constitution of the Republic of China where the military is abstractly mentioned. Furthermore, the establishment of military institutions in China is determined on the basis of law, which speaks of its fundamental emphasis on armed forces.

2. Basic Law: Legislation Law of the People's Republic of China

The Legislation Law of the People's Republic of China was promulgated by the National People's Congress in 2000 and amended in March 2015. The contents include the authority, procedures, and legal ranks of legislation. The regulation on the authority of the Central Military Commission (CMC) in the context of military laws is coded in the final section, "Supplementary Provisions." This seems

[11] Article 87 of the Legislation Law of the People's Republic of China stipulates that "All laws, administrative regulations, local regulations, autonomous regulations, separate regulations or rules shall contradict the *Constitution of the People's Republic of China*."

to be a deliberate act of showing that military laws are different from the laws applicable to civilians, an expression of the separation between military authorities and civil governance. Military laws retain a significant degree of flexibility. According to the first and second paragraphs of Article 103 of the Legislation Law of the People's Republic of China, "The Central Military Commission shall, in accordance with the Constitution and laws, formulate military regulations. The General Departments, the various services and arms, and the military commands of the Central Military Commission may, in accordance with laws and the military regulations, decisions, and orders of the Commission, formulate military rules within the limits of their power. Military regulations and military rules shall be implemented within the armed forces. Measures for formulating, revising and nullifying military regulations and military rules shall be formulated by the Central Military Commission following the principles laid down in this Law."[12]

3. Basic Law: Law of the People's Republic of China on National Defense

China made a significant amendment to the Law of the People's Republic of China on National Defense in December last year. There are extensive management rules on the organization of national defense development and enterprises, as well as tangible measures.

(1) *Authority and responsibility in national defense*

According to "Chapter II: National Defense Authority of State Institutions" of the Law of the People's Republic of China on National Defense, "The National People's Congress, pursuant to the Constitution, decides on issues of war and peace and exercises other functions and powers in respect of national defense as stipulated by the Constitution" (Article 12); "The State Council is to lead and manage the establishment of national defense and to draw up relevant development programs and plans for the construction of national defense; to

[12] However, it seems that the Central Military Commission (CMC) is not the only entity in charge of formulation of military laws. National defense related legislations are also established by the National People's Congress Standing Committee (NPCSC). For example, *the Law of the People's Republic of China on National Defense Education* was passed on April 28, 2001 and amended on April 27, 2018.

formulate policies and administrative regulations and regulations related to the construction of national defense; to direct and administer defense research and production; to manage defense expenditures and assets; to exercise leadership jointly with the Central Military Commission over the building of the Militia, the work of enlistment and reserve service, and the administration of defense of the frontiers, seas, and air space, and other major security field defense" (Article 14); "The Central Military Commission directs all the armed forces of the country and to decide on military strategies and form concepts of operations for the armed forces; to approve the system, development programs and plans for weapons and equipment of the armed forces, and to work together with the State Council in directing and administering defense research and production; to administer defense expenditures and assets jointly with the State Council" (Article 15); "The State Council and the Central Military Commission may, when necessary, convene a coordination meeting to solve problems relating to national defense" (Article 17).

(2) *Research and production of national defense technologies, talent development, military procurements, and national defense budgets*

The "Chapter V Defense Research and Production and Orders for Military Supplies" of the Law of the People's Republic of China on National Defense stipulates that "The State establishes and improves the scientific, technological, and industrial system, and develops national defense scientific research and production for national defense (Article 33); the principle to be applied to national defense science and technology industry is to combine military and civilians, combine peacetime-oriented work with wartime-oriented work, give priority to military product manufacturing, be driven by innovation, and be independent and take control" (Article 37); "the State promotes progress in defense science and technology, cultivates talents in defense science and technology, encourages and attracts outstanding talents into the field of defense science and technology to inspire the innovative ability of the talents" (Article 36). The military procurement system is run by the country according to laws to guarantee the purchase and the supply of weaponry, equipment, materials, engineering, and services required

to ensure the armed forces. Chapter 6, "National Defense Budgets and National Assets", explains the budgetary management of national defense budgets according to laws (Article 39) and the national ownership of national defense assets (Article 40). In sum, China intends to further simplify the flows of private companies entering the military industry and the military market in order to enhance the quality and quantity of national defense technologies, equipment, and development with a market mechanism.

4. Relevant Supporting Regulations

In addition to the stipulations of the basic laws regarding national defense and the military industry, China's defense industry has introduced numerous market competition mechanisms of capitalism and many relevant technical and supporting regulations and measures in recent years. Further, the enactment of the newly amended Regulations on Military Equipment on January 1, 2021 is worth mentioning. These regulations come in 14 chapters and 100 articles. The contents include the overriding principle regarding the CMC's overarching leadership role, the TCs' responsibility for military operations, and the services' focus on developing capabilities. In other words, "the CMC's Equipment Development Department shall centrally manage the deployment of military branches and the collective utilization of warzones". The functions and positions of different levels within equipment departments are defined under the new system and the new structure.[13] The Regulations on Military Equipment have improved the flows of equipment procurements and enhanced the requirements of equipment performances. This sheds light on the development direction of the weaponry and equipment system under the 14th Five-Year Plan.

Meanwhile, the decision on constructing the New Military Training System[14] published by the Central Military Commission (CMC) in February 2021 is also

[13] "Release of the Newly Amended Regulations on Military Equipment," *people.cn*, January 3, 2021, http://politics.people.com.cn/n1/2021/0103/c1024-31987074.htm.

[14] "Central Military Commission (CMC) Released the Decision on Constructing the New Military Training System," *people.cn*, February 22, 2021, http://military.people.com.cn/BIG5/n1/2021/0222/c1011-32033752.html.

noteworthy. The main contents include the "use of realistic combat scenarios in training, use of joint operations scenarios in training, improve the technology in training and guide the training under the law", "giving play to the fine traditions of the People's Liberation Army and stepping up reforms and innovations", "faster establishment of a new-type military training system", and "improvement of military training in all respects". The purpose is to establish the people's army an outstanding army by providing strong support. The actual effects of these regulations are yet to be observed.

V. Conclusion

With the Military-Civil Fusion integrating its military institutions, China has been riding the international trends and adjusting its national defense strategy to further the development of its national defense and military. Meanwhile, it is developing and acquiring technologies from both domestic and overseas with accompanying laws and economic measures, Thus, its international influence should not be overlooked. Moreover, China's constitutional system makes it easier for national policies and legal measures to effectively push forward military development. This is particularly the case with the newly amended and enacted Law of the People's Republic of China on National Defense and Regulations on Military Equipment. Further, being the manifestation of China's tangible and national policy, these two laws can be more effective in creating substantial effects. Moreover, the U.S.'s investment ban as an attempt to stop or slow down the threats of China's military development is likely to achieve very little.

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