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Strengths and Weaknesses of China's Defense Industry and Acquisition System and Implications for the United States[1]

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Abstract

Major technological progress is taking place across virtually the entire spectrum of the Chinese defense industry, from traditional sectors such as aerospace and seapower to the newer domains of space, information technology, and cyber. This is steadily narrowing the defense technological gap with the United States. At the same time though, the Chinese defense industry and acquisition system is plagued by deep-seated problems that call into question whether the current progress is sustainable over the long term. Understanding the state, reforms, and prospects for China's defense industry and acquisition system is of critical importance to the United States. This paper examines the dueling realities of China's defense industry and acquisition system. A central reason that the Chinese defense industry has been able to be keep costs down and accelerate the pace of acquisition is because it has operated on an absorption-based, good-enough development model. But as it transitions to more of an original innovation-based, higher end development framework, risks grow significantly, and this will impact the costs and pace of the acquisition process

Introduction

The opening decades of the 21st century have been a gilded age for China's defense industry and acquisition system. Lavished with high-level leadership attention and ample funding, the country's armament community from scientists to testers have been busy on a scale not seen since the Soviet–U.S. Cold War in the second half of the 20th century. Major progress is taking place across virtually the entire spectrum of the Chinese defense industry, from traditional sectors such as aerospace and seapower to the newer domains of space, information technology, and cyber. This is steadily narrowing the defense technological gap with the United States.

At the same time though, the Chinese defense industry and acquisition system is plagued by deep-seated problems that call into question whether the current progress is sustainable over the long term. The chief defense acquisition tsar, General Zhang Youxia, director of the Central Military Commission Armament Development Department (CADD), highlighted this predicament in a speech in 2014 when he said that structural and process problems have become such an obstacle that the primary "bottleneck issue for armament development is no longer the shortage of funds or technology. Instead, institutional systems and mechanisms have become the greatest hurdle to armament building and development"

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(Zhang, 2014). Zhang added that if these impediments cannot be removed, future progress in weapons development "may just be empty talk." Since then, the Chinese authorities have launched major reform initiatives to tackle these problems.

Understanding the state, reforms, and prospects for China's defense industry and acquisition system is of critical importance to the United States, countries in the Asia-Pacific, and the international community because of China's rise as a global power. A key enabler of China's growing might and external influence is its military technological capabilities, as evidenced by the acquisition of long-range power projection and anti-access/area denial capabilities. For the U.S, China represents a "pacing threat" and is its chief long-term defense technological competitor. China's technological transformation is one of the principal drivers behind the U.S. Defense Department's Third Offset Strategy aimed at addressing the long-term erosion of U.S. defense technological superiority.

This paper examines the dueling realities of China's defense industry and acquisition system. The starting point is an overview of the nature and characteristics of the Chinese defense acquisition system. Attention will then turn to assessing the causes behind the rapid progress that has been made within the past two decades in the development of China's defense science and technology capabilities and the role that the acquisition system has played. The focus will then turn to analyzing the structural constraints and weaknesses, especially as they relate to the defense acquisition system, that could pose serious barriers to the China's continuing defense technological and industrial advancement. The paper concludes with a discussion of the implications for the United States.

The Nature of the Chinese Defense Acquisition System

Although the People's Liberation Army (PLA) in coordination with the Chinese defense industry has been engaged in the design, engineering, test and evaluation, production, and operation and support of defense systems since the 1950s, acquisition was considered of lower-order importance compared to warfighting, political discipline, and logistics until the end of the 1990s. It was not until 1998 that the PLA high command established a separate acquisition organization called the General Armament Department (GAD) to serve alongside the General Staff Department (GSD), General Political Department, and General Logistics Department.

Previously, the acquisition system had been divided between two competing systems. One portion was manned by serving military officers who worked within the GSD as well as in armament management entities at the service-level, while another component comprised civilians and uniformed personnel who were attached to the Commission for Science, Technology, and Industry for National Defense (COSTIND) that was a state entity and represented the interests of the civilian defense industry. This bifurcated arrangement was a product of the Socialist central planning system that managed the Chinese economy between the 1950s until the 1990s. It meant that the acquisition system was compartmentalized between civilian and military masters, which led to constant and often bitter bureaucratic infighting because these two groups had widely divergent interests. As the consumer, the military wanted weapons that could be produced on time, met its specifications, and were cost-effective. But the defense industry had little incentive to meet the PLA's requirements because it faced little competition.

The establishment of the GAD led to a far-reaching reorganization of the acquisition system. A crucial change was that the GAD assumed primary responsibility for acquisition matters, while the defense industry—through COSTIND—was relegated to a supporting role. This change did not happen overnight though and was met with considerable resistance because of the entrenched control that the defense industry had enjoyed over the acquisition process for several decades. But the GAD gradually consolidated its management of the acquisition system until it was replaced by the CADD at the beginning of 2016.

A defining characteristic of the current Chinese defense acquisition system is that it operates as a classic command and control regulatory system. The military authorities rely on administrative coercion and threats to achieve compliance, they are responsible for direct micro-management and rule-making, and the primary focus of rules and regulations is more on addressing what enterprises do rather than on their performance or outputs (Ogus, 2002, pp, 21–22). While this top-down regulatory approach may work in a centrally planned system, it is poorly suited to market-based environments. One major reason is that activity-based intervention requires regulatory agencies to have adequate information to monitor what is going on, but their access to data is limited in more open markets because they are required to play a less direct regulatory role and allow enterprises greater autonomy and privacy.

The model used in the United States and other advanced economies is the independent regulatory system that emphasizes the importance of political independence, impartiality, and transparency. The Chinese defense industry began to take concrete steps towards the establishment of a more independent regulatory structure in the late 1990s, especially taking advantage of reforms to separate the military-civilian regulatory system by rolling back the authority and intervention of COSTIND and allowing defense corporations to have greater autonomy. COSTIND's status and influence was further reduced in 2008 when it was demoted from a super-ministry to a sub-ministerial agency under the Ministry of Industry and Information Technology (MIIT) and retitled as the State Administration for Science, Technology, and Industry for National Defense (SASTIND; Mao, 2012, pp. 58–60).

Another distinguishing feature of the Chinese defense acquisition system is that it operates a predominately absorptive model of technology development. This is typical of catch-up countries whose domestic research and development capabilities still lag behind the world's advanced defense technology powers. Absorption-oriented acquisition systems organize and operate in a fundamentally different way from innovation-based systems like the United States'. Two differences stand out. First, absorption is a low-risk, high-reward enterprise because the technological development path has already been mapped out. Second, absorptive systems place overwhelming priority in investing in engineering, capabilities, especially related to reverse engineering, and less on research and development.

The primary benefits from absorption are significant cost savings and time reductions. This has allowed the Chinese defense establishment to narrow, and in a few cases eliminate, the technological gap with regional and global competitors in an expanding number of areas. The biggest beneficiaries have been in the aviation, naval shipbuilding, and select precision strike missile sectors. Without these technological achievements that are being translated into operational capabilities, the PLA's shift to a more regionally assertive and maritime-oriented posture would have been little more than empty talk.

The military aviation sector has been especially reliant on the leveraging of foreign technology transfers to support its development.[2] A significant proportion of the country's combat aircraft development programs have depended on foreign, mostly Russian, technology inputs. These technology transfers come in several forms:

- **Reverse engineering:** The Chinese aviation industry has been able to reverse engineer complete platforms acquired through license assembly agreements (Su-27), off-the-shelf purchases (Su-30MK2), and opportunistic acquisition of prototypes (Su-33), which it then adapts and indigenizes with local sub-systems and components. A substantial proportion of the PLA Air Force's combat inventory consists of these re-innovated aircraft, such as the J-11B (Su-27), J-15 (Su-33), and J-16 (Su-30MK2).
- **Research and development assistance:** A number of Chinese "indigenous" programs have received extensive levels of foreign assistance in their design and development, including co-design and co-development. Much of the original design of the J-10A fighter, for example, was from Israel. China and Russia are also reportedly close to signing an agreement on the co-design and development of a heavy-lift helicopter, of which Russia is in charge of aerodynamics design and China providing avionics systems ("China, Russia to Co-Develop," 2015).
- **Critical components and sub-systems:** While the overall technological level of the Chinese aviation industry is steadily improving, there are pockets of backwardness in critical components and sub-systems. High-end turbofan jet engines stand out as the biggest weakness, which has made China dependent on Russian engines.
- **Enabling technologies:** As the Chinese aviation industry becomes more sophisticated across all the stages of the research, development, and acquisition process, it is sourcing foreign assistance for wind tunnels, computer-aided design and manufacturing software, and advanced production equipment such as multi-axis machine tools.

Foreign technology has also played an influential role in the improving technological performance of the naval shipbuilding industry. This was especially the case from the 1990s to the mid-2000s when there was extensive importation of Russian technology and knowhow. As Chinese shipbuilders absorbed these transfers, they have been able to substantially reduce their foreign reliance in the past decade. A 2015 U.S. Office of Naval Intelligence (ONI) assessment of the equipment modernization of the PLA Navy's surface fleet noted that, "By the second decade of the 2000s, the PLA(N)'s surface production shifted to platforms using wholly Chinese designs and that were primarily equipped with Chinese weapons and sensors (though some engineering components and subsystems remain imported or license produced in country)" (ONI, 2015, p. 14).

The ONI report noted that the last purchase of a foreign naval platform was the Sovremennyy-II guided missile destroyer in 2006 and since then, the Chinese naval shipbuilding industry has been engaged in

[2] For useful background analysis, see Saunders and Wiseman (2011).

much longer production runs of its domestically produced surface combatants and conventional submarines, suggesting greater satisfaction with recent designs. The Jiangkai-class (Type 054A) frigate series, Luyang-class (Type 052B/C/D) guided missile destroyer (DDG) series, and the upcoming new cruiser (Type 055) class are considered to be modern and capable designs that are comparable in many respects to the most modern Western warships. (ONI, 2015)

Faster and Cheaper: China's Accelerated Defense Acquisition Process and Comparisons With U.S. Accelerated Programs

Taking advantage of the absorptive low-risk, high-reward development model, the Chinese defense acquisition community has been able to successfully undertake the rapid development, production, and deployment of select high priority weapons projects over the past couple of decades. The speed of China's achievements initially surprised outside observers, especially in the late 2000s and early 2010s when a number of Chinese programs were unveiled.[3] This is because of the checkered historical track record of the Chinese defense industry, especially before the late 1990s, in which many projects failed or were seriously delayed because of bureaucratic red tape, lack of support, or inadequate resources.

The Chinese accelerated acquisition process has some of the following features:

- **Concurrent development, testing, and low rate initial production:** This sees the compression, overlapping, or even skipping of various phases in the acquisition process with the goal of getting programs into production and deployment as quickly as possible. Some of this compression occurs with concurrent technology maturation, risk reduction, and development as well as concurrent production and deployment.
- **Accelerated research & engineering development, but often lengthy delays in early production phases:** A number of Chinese weapon development programs have been rushed through the initial research and development phases, but then spend extended periods of time undergoing prototyping or demonstration testing. If compared to the U.S. acquisition process, this would be the equivalent of manufacturing readiness levels (MRL) 5 (capability to produce prototype components in a production relevant environment) and 8 (pilot line capability demonstrated; ready to begin low rate initial production).
- **High-level leadership attention and active intervention:** The Chinese authorities have designated the development of a small hand-picked number of strategic weapons and technology capabilities to be critical national priority and have established oversight mechanisms to allow senior top-level national leaders such as the Communist Party General Secretary, who is concurrently

[3] For example, Vice Admiral David Dorsett, deputy chief of Naval Operations for Information Dominance, said in 2011 that the U.S. intelligence community has "been pretty consistent in underestimating the delivery and IOC [initial operational capability] of Chinese technology, weapon systems. They've entered operational capability quicker [than expected]."

the commander-in-chief, and prime minister to be involved in program review and decision-making. The benefits from this top-level engagement includes access to resources and fewer bureaucratic obstacles, but drawbacks include political interference and more reporting requirements that impact project management.

- **Trial batch production runs followed by upgrading to improved variants:** A distinguishing pattern of Chinese weapons development programs in recent years has been the manufacturing of very small batches of platforms, often numbering no more than one or two items, which are put into operational service. This is followed with upgraded variants that are also produced in small numbers until the end-users are satisfied and allows for larger production runs.

These features of the accelerated acquisition model can be found in a number of current Chinese weapons development programs. They include the Chengdu J-20 and Shenyang J-15 carrier-borne fighter aircraft, Type 052 DDG, and the Xian Y-20 heavy-lift transport aircraft (see Table 1). The 052 DDG and J-15 fighter programs are prime examples of this fast track model as they have compressed research cycles to Milestone A (4–5 years for the 052 DDG and 2–3 years for the J-15), but lengthy periods for technology, engineering, and demonstration to low rate initial production.

Table 1. Acquisition Cycles for Four Chinese Fighter Aircraft, Transport Aircraft, and Warship Programs

	J20 Fighter	Luyang-Class 052C/D DDG	J-15 Fighter	Y-20 Transport
Preliminary Research to Milestone A	9 Years (1998–2007)	052C: 4–5 Years (1997/8–2001)	2–3 Years (2005–2007/8)	8 Years (2000–2007)
Technology & Engineering Development to Milestone B	9–10 Years (2007–2016/7) Maiden Flight 2011	052C: 7 Years: Initial 2 Years (2001–2003) Followed by Another 5 Years (2005–2010)	9–10 Years (2007/8–2016) Maiden Flight 2009	9 Years (2007–2016) Maiden Flight 2012
Manufacturing Status	MRL 7 LRIP Forecast 2017	052D: MRL 9–10 FRP Begun 2015	MRL 7–8 LRIP Forecast 2020	MRL 7–8 LRIP Begun 2016
Field Deployment	Forecast 2018	052C: 2005 052D: 2014	Pilot Training & Testing since 2015; Operational Deployment 2020	First Aircraft Accepted by PLA Air Force in 2016
Foreign Inputs	Indigenous Platform, Foreign Engines	Indigenous Platform and Armaments, but Heavily Influenced by Russian Designs and Armaments (SAMs)	Reverse Engineered Version of Russian Su-33	Design & Technology Inputs from Ukraine & Russia, especially from IL-76
Upgrading	None Yet	5 Year Gap Between 052C #2 & #3; 052D #1 Followed Immediately After 052C #6	Reports of Electronic Warfare Variant	None Yet
Total Acquisition Period	18–19 Years	052C: 11–12 Years	11–13 Years	17 Years

This accelerated Chinese acquisition process has similarities with the more advanced U.S. defense acquisition system. The United States has also been engaged in efforts to speed up its defense acquisition processes, especially in the past couple of decades in response to its long-term wars and military campaigns in Afghanistan, Iraq, and other parts of the Middle East (DoD, 2015, p. 13). A 2016 study of accelerated U.S. defense acquisition programs by the Institute for Defense Analyses (IDA) identified several types of fast track mechanisms (Van Atta, Kneece, & Lippitz, 2016):

1. **Time-constrained acquisition:** Cost and performance are the primary drivers of acquisition programs, but more attention is now being paid to schedule needs, including to make it a key performance parameter and management priority;
2. **Crash programs:** These are extremely urgent and high priority programs managed by specially created high-level entities that involve the development of early stage technologies with potentially far-reaching disruptive impact. A U.S. example is the F-117A stealth fighter and a Chinese example is the development of its nuclear and ballistic missile programs in the 1950s–1970s;

3. **Rapid acquisition programs:** These projects are aimed to meet urgent operational requirements but involve the development of mature "off-the-shelf" capabilities and are managed by entities located within the regular defense acquisition system. The MRAP is a U.S. example and the DF-21C anti-ship ballistic missile is a Chinese example;
4. **Early fielding experiments:** This refers to promising technologies that are emerging or ready for operational use but lack interest from end-users for acquisition, so the defense acquisition system or defense companies build operational prototypes to experiment. The Global Hawk, Predator, and Reaper unmanned aerial vehicles are U.S. examples, while the Shenyang FC-31 stealth fighter is a Chinese early fielding experiment.
5. **Spiral/evolutionary acquisition:** This is a cyclical or iterative approach that allows for the incremental development of new capabilities, especially for information technology and software projects.

The IDA study identifies top-level leadership support, management, and intervention as the most important factor for the success of U.S. accelerated programs, which is also the case for Chinese programs.

Opportunities and Progress in China's Defense Technological Development and the Role of the Defense Acquisition System

China's defense industry has been enjoying a remarkable renaissance in its fortunes since the turn of the 21st century. Driven by leadership concerns of mounting challenges to the country's external security environment and rapid advances in the global technological order, investment into research, development, and acquisition has soared, greater efforts are being made to acquire and absorb foreign technologies, and the existing defense innovation system is being remade.

This has resulted in significant improvements in technological, economic, and industrial performance. Defense corporations are posting ever-bigger record annual profits, and the armaments research and development pipeline is bulging. The aviation sector, for example, is simultaneously engaged in the development or production of more than half a dozen combat and transport aircraft, while the shipbuilding industry has at least four active nuclear and conventional submarine programs along with research, development, and construction of aircraft carriers, destroyers, and numerous other surface warships. The PLA Navy is estimated to have laid down, launched, or commissioned more than 60 vessels in 2014 and 2015 (ONI, 2015), and commissioned 18 ships in 2016, including 1 Type 052D DDG, 3 Type 054A guided missile frigates and 6 Type 056 corvettes ("Navy Upgrades," 2017; "New 'Carrier Killer,'" 2017). The space industry is also pursuing a highly ambitious across-the-board development, including manned, lunar, anti-satellite, and satellite projects.

A number of key factors have played instrumental roles behind the improving performance of the defense industry. They include high-level leadership support, a clear well-defined long-term vision backed up with detailed development plans and a more capable acquisition system, the growing role of defense corporations, the nurturing of a defense innovation system and overhaul of the research and development apparatus, and efforts to promote the integration of the civilian and defense economies.

Top Leadership Support

High-level and sustained support and guidance from the political and military leadership elites is essential in the Chinese defense industry's ability to carry out innovation activities. Leadership backing and intervention has been vital in addressing entrenched bureaucratic fragmentation, institutional compartmentalization, and chronic project management problems that cause prolonged delays, decision-making paralysis, and cost overruns. Without outside leadership involvement, there would have been a high chance that many achievements of the defense industry would not have happened, especially the turnaround in the defense industry since the end of the 1990s.

The central leadership's direct and continuing involvement and oversight in the operations of the defense industry and of critical projects is essential. This is often done through the establishment of leadership small groups and special committees. The committed involvement of the country's top leaders is also critical, and the defense industry has been fortunate that Xi Jinping has taken a keen and active interest in defense issues. Xi has paid particular attention to the development of China's defense and overall innovation capabilities as demonstrated by his intensive engagement in defense and science and technology matters. Between November 2012 when Xi assumed power and the end of 2016, he took part in 36 publicly reported events related to military and defense science, technology, and industrial issues (see Figure 1). By comparison, Xi's predecessors such as Hu Jintao and Jiang Zemin made far fewer defense-related site visits during the same periods of their rule.

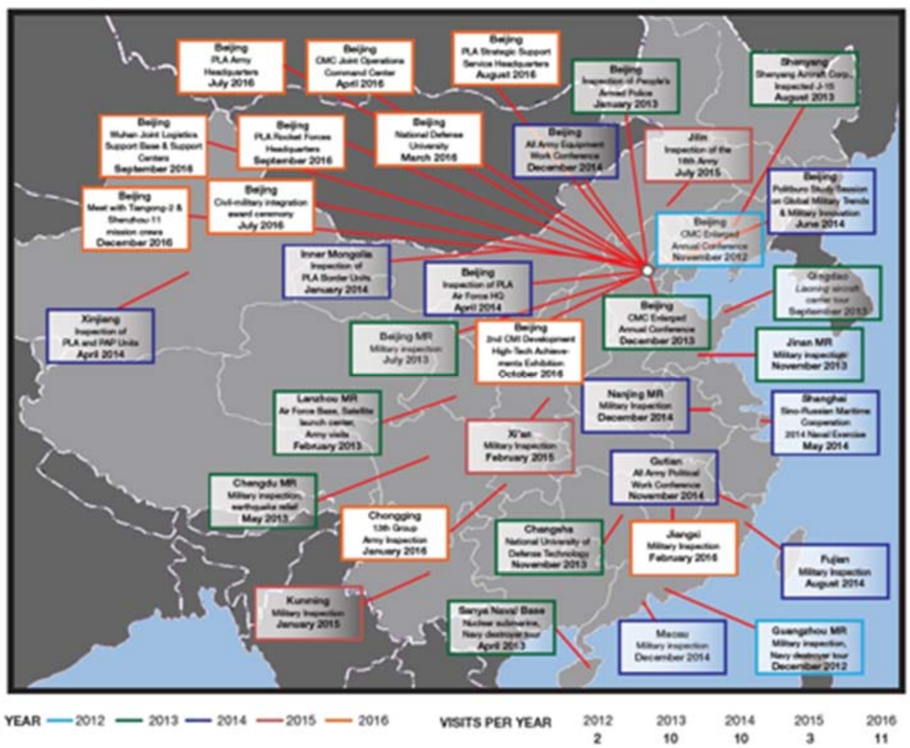

Figure 1. Reported Visits to Military and Defense Science and Technology-Related Facilities Made by Xi Jinping, November 2012–December 2016

Adhering to Medium and Long-Term Strategic Planning

Research and development of China's defense technological capabilities have benefited considerably from the formulation and implementation of medium-term (5 years) and long-term (10–20 years) armament development plans. These strategic and planning guidances provide long-term planning stability, help to mitigate against parochial bureaucratic interests and political intervention, and more rigorously link the weapons acquisition process with threat assessments.

One of the most important of these plans is the 2006–2020 Medium and Long-Term Defense Science and Technology Development Plan (MLDP) that focuses on guiding defense-related basic and applied research and development over a 15-year time horizon (COSTIND, 2006). COSTIND drafted the MLDP in the mid-2000s in coordination with a national medium and long-term science and technology development plan (MLP) and targeted the development of China's defense research and development capabilities and innovation eco-system in a number of areas.

First was the focus on enhancing the capacity for original innovation through the building of defense laboratories, research institutes, and universities to promote basic science along with the development of service support capabilities such as technology transfer and commercialization mechanisms. A second priority was the building of a robust governance regime, especially in areas such as regulations, intellectual property protection, and establishing a comprehensive standards system. A third area targeted was civil-military integration. The overall goal of the MLDP was to significantly narrow the technological gap with the world's leading defense technological powers by 2020.

Another important medium-term defense science and technology development plan is the New High-Technology Program, which is also known as the 995 Program, in reference to the U.S. bombing of the Chinese embassy in Belgrade in May 1999 that was the spark for this project.[4] The Chinese leadership's reaction to the attack was to sharply intensify efforts to develop strategic weapons systems, or what the PLA terms "Assassin's Mace," or *Shashoujian* capabilities. According to Gen. Zhang Wannian, who was a CMC vice chairman during the Belgrade Embassy crisis, the CMC convened an emergency meeting immediately following the bombing, and one of the key decisions made at the meeting was to "accelerate the development of Shashoujian armaments" (Zhang Wannian Writing Team, 2011, p. 416).

Zhang pointed out that then CMC Chairman Jiang Zemin was especially insistent on the need to step up the pace of development of *Shashoujian* mega-projects, saying that "what the enemy is most fearful of, this is what we should be developing" (Zhang Wannian Writing Team, 2011, p. 419). As the "enemy" was the United States, the implication was that the defense and strategic science, technology, and innovation systems should be engaged in developing asymmetric capabilities targeting U.S. vulnerabilities.

The Central Role of Defense Conglomerates

The revival of China's 10 major state-owned defense corporations since the beginning of the 21st century has had a major impact in shifting the center of gravity for research, development, and innovation from research academies and universities towards enterprises. These conglomerates, each of which have between 100 to more than 200 subsidiaries, have sought to transform themselves from loss-making quasi-state

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[4] There is no official Chinese acknowledgement of the 995 Project, but there are occasional allusions to it in media reports, writings by Chinese military analysts, résumés of Chinese scientists, and project listings of university laboratories and companies engaged in defense-related work. See, for example, Zeng (2009).

bureaucracies to become more market-driven enterprises. They have been slimmed down, allowed to shed heavy debt burdens, and given access to new sources of investment, especially from the capital markets.

Combined with a strong pickup in defense and civilian orders, these companies have become highly profitable since the mid- to late 2000s. Around two-thirds of the defence industry's annual revenue comes from civilian operations, such as automobiles and white goods. The aviation, space/missile, defense electronics, and naval sectors have been the chief beneficiaries from this rising tide of defense procurement, while the ordnance industry has enjoyed considerable success from sales of civilian products such as motor vehicles. These corporations are now engaged in an ambitious expansion strategy to become global arms and strategic technology champions.

Building of a Defense Innovation System and Research and Development Base

The Chinese defense innovation system, and especially its research and development component, has been undergoing a significant overhaul and expansion to meet growing demand for its services from the PLA and also as part of a larger development of the national innovation system. The development of a robust defense R&D system is a top priority in defense science and technology development plans such as the MLDP, which emphasizes a number of key goals. A top priority is the shifting of ownership and funding of key portions of the state-controlled defense R&D apparatus to the country's defense conglomerates. The primary goals of this reform include (1) reducing the dependence of the R&D apparatus to state funding; (2) increasing the amount of investment that firms devote to R&D, especially in applied and commercial development; and (3) speeding up the exploitation and commercialization of proprietary R&D output.

Another high-level priority is the development of an extensive defense laboratory system that would pave the way for long-term technological breakthroughs. Around 90 laboratories belonging to both the defense industry and PLA have so far been established. It will take some time though before these research outfits are able to conduct high quality R&D because they lack experienced and top-rated scientific personnel.

Civil-Military Integration

Intensifying efforts have been made since the early 2000s to forge close linkages between the civilian and defense economies to allow the defense industry to gain access to more advanced and more globalized civilian sectors. This has led to the development of some modest functional and geographical pockets of civil-military activity since the early to mid-2000s. The electronics, information technology, high technology, and automotive sectors have been in the vanguard.

Another area of growing CMI activity is the competitive opening up of the defence research, development, and acquisition system to the private sector that until a few years ago was the exclusive preserve of the 10 state-owned conglomerates that monopolized the aviation, space and missile, ordnance, nuclear, electronics, and shipbuilding sectors that make up the defence industrial base. More than 1,000 private firms have so far received licenses that allow them to bid for contracts, although it is likely that the overwhelming flow of business still goes to the established state giants because they have deep-seated connections in a non-transparent and under-regulated system.

The use of capital markets to fund the development and production of weapons projects is the third area in which CMI initiatives are being pursued, and this has potentially the most significant near and longer term impact on innovation. While defence companies have been allowed to list subsidiaries on stock markets since the 1990s, this was limited to their non-defence operations. This changed in 2013 when SASTIND permitted firms to issue share placements using military assets as securitization.

The high level of state commitment to the defence industry shows few signs of weakening anytime soon, despite the noticeable slowing of growth in the national economy in the past couple of years. For defence research and development, the investment in national science and technology activities is a useful proxy indicator of political support and the trajectory in growth rates in science and technology. China's research and development expenditure in 2015 was Rmb 1.42 trillion ($208 billion), which was 2.07% of Gross Domestic Product (GDP) and a sizeable increase of 8.9% from the 2014 spending of Rmb 1.34 trillion ("China's R&D Spending," 2016). However, it is not known how much was spent on defence-related activities. The Chinese authorities have set a target for science and technology spending to reach 2.5% of GDP by 2020, which would mean even higher growth rates in budget growth for the next few years.

Constraints and Weaknesses in China's Defense Industry and Acquisition System

The principal constraints and weaknesses that the Chinese defense industry faces at present stem from its historical foundations and the uncertain efforts to overcome the corrosive legacy of its difficult history. The institutional and normative foundations and workings of the Chinese defense industry were copied from the former Soviet Union's command defense industry and continue to exert a powerful influence to the present day. The PLA and defense industrial regulatory authorities are seeking to replace this outdated top-down administrative management model with a more competitive and indirect regulatory regime, but there are strong vested interests that do not want to see any major changes.

Monopolies

One of the biggest hurdles that PLA and civilian defense acquisition specialists point out is the defense industry's monopoly structure. Little competition exists to win major weapons systems and defense equipment because each of China's six defense industrial sectors is closed to outside competition and is dominated by a select handful of state-owned defense corporations. Contracts are typically awarded through single sourcing mechanisms to these corporations. Competitive bidding and tendering only takes place for non-combat support equipment, such as logistics supplies.

An effort in 1999 to inject more competition by splitting corporations that monopolized their sectors into two separate entities did little to curb monopolistic practices because these firms focused on different areas of business in their domains and there was little direct rivalry. These powerful defense firms have subsequently sought to reverse this effort at de-monopolization by finding ways to re-merge or collaborate together. In 2008, the aviation industry made the first and so far only successful challenge by consolidating its two post-1999 entities back into a single monopoly structure. There have been occasional reports that the space and shipbuilding sectors might also seek to re-establish a single holding company arrangement.

Bureaucratic Fragmentation

A second serious weakness that has seriously handicapped the effectiveness of the Chinese defense industry is its bureaucratic fragmentation. This is a common characteristic of the Chinese organizational system, but is especially virulent within the large and unwieldy defense sector. A key feature of the Soviet approach to defense industrialization that China imported was a highly divided, segmented, and stratified structure and process. There was strict separation between the defense and civilian sectors as well as between defense contractors and military end-users, compartmentalization between the conventional defense and strategic weapons sectors as well as among the different conventional defense industrial sub-sectors, and division between research and development entities and production units. Key reasons for this excessive compartmentalization include an obsessive desire for secrecy and the powerful influence of the deeply ingrained Chinese model of vertical functional systems (tiao tiao) that encouraged large-scale industries like those in the defense and supporting heavy industrial sectors such as iron and steel and chemicals to become independent fiefdoms.

This severe structural compartmentalization is a major obstacle to the development of innovative and advanced weapons capabilities because it requires consensus-based decision making that is carried out through extensive negotiations, bargaining, and exchanges. This management by committee is cumbersome, risk-adverse, and results in a lack of strong ownership that is critical to ensure that projects are able to succeed the thicket of bureaucratic red tape and cut-throat competition for funding.

When the Chinese authorities in the late 1950s began to pursue the development of strategic weapons programs such as nuclear weapons and ballistic missiles, they recognized that the fragmented nature of the defense industrial economy represented a potentially fatal weakness, so they designed a special high-level leadership arrangement called the Central Special Committee (CSC) to provide the decisive leadership support needed for high-priority strategic projects (Cheung, 2012). The CSC played a central role in ensuring the successful development of China's strategic weapons capabilities, so much so that the Chinese authorities resurrected this leadership group in the late 1980s to oversee the initial development of key strategic programs. The CSC has played an important role in the early development of the Shenzhou manned space project, for example, and has been mentioned in other major strategic technology programs such as nuclear submarine development and other space projects.

This entrenched bureaucratic fragmentation is a prominent feature of the armament management system. Although the GAD was one of the PLA's four general headquarters departments with a seat on the CMC, it was only responsible for managing the armament needs of the ground forces, People's Armed Police, select space programs, and the militia (Mao, 2012, p. 46). The navy, air force, and Second Artillery had their own armament bureaucracies, and competition is fierce for budgetary resources to support projects favored by each of these services. This compartmentalized structure serves to intensify parochial interests and undermines efforts to promote joint undertakings.

The defense acquisition system also suffers from compartmentalization along many segments of the acquisition process. Responsibilities for research and development, testing, procurement, production, and maintenance are in the hands of different units and under-institutionalization has meant that linkages among these entities tend to be ad hoc in nature with major gaps in oversight, reporting, and information sharing (Liu & Wang, 2009). The fragmented nature of the acquisition process may help to explain why Hu Jintao was apparently caught by surprise by the first publicized test flight of the J-20 fighter aircraft that occurred during the visit of U.S. Defense Secretary Robert Gates in January 2011 (Bumiller & Wines, 2011; Pomfret, 2011).

Weak Acquisition Management Mechanisms

A third major weakness is that the PLA continues to rely on outdated administrative tools to manage acquisition projects with defense contractors in the absence of the establishment of an effective contract management system. The PLA did implement the use of contracts on a trial basis in the late 1980s with the introduction of a contract responsibility system (Cheung, 2008, pp. 83–85). These contracts are administrative in nature though and have little legal rights because of a lack of a developed legal framework within the defense industry. Consequently, contracts are vague and do not define contractual obligations or critical performance issues such as quality, pricing, or schedules. Contracts for complex weapons projects can be as short as 1–2 pages, according to analysts.[5]

Moreover, the military acquisition apparatus is woefully backward in many other management approaches and tools that it uses compared to its counterparts in the United States and other advanced military powers. It has yet to adopt total life-cycle management methods, for example, and many internal management information systems are on stand-alone networks that prevent effective communications and coordination. One analyst said that this often meant that the only way for project teams to exchange information was through paper transactions.[6]

Outdated Acquisition Pricing Regime

A fourth serious weakness is the lack of a transparent pricing system for weapons and other military equipment, representing a lack of trust between the PLA and defense industry. The existing armament pricing framework is based on a "cost-plus" model that dates to the planning economy, in which contractors are allowed 5% profit margins on top of actual costs (Mao, 2012, pp. 158–159). There are a number of drawbacks to this model that holds back efficiency and innovation. One is that contractors are incentivized to push up costs as this would also drive up profits. Another problem is that contractors are not rewarded with finding ways to lower costs such as through more streamlined management or more cost-effective designs or manufacturing techniques. Contracts rarely have performance incentives, which discourages risk-taking and adoption of new innovative approaches.

To address this long-standing problem, the PLA, Ministry of Finance, and National Development and Reform Commission held a high-level meeting on armament pricing reform in 2009 that concluded that the outdated pricing system had seriously restricted weapons development and innovation (Zong & Zhao, 2009). A number of reform proposals were put forward: (1) provide incentives to contain costs; (2) switch from accounting procedures that focus on ex post pricing to ex ante controls; and (3) expand from a single pricing methodology to multiple pricing methods.

At the beginning of 2014, the GAD announced that it would conduct and expand upon pilot projects on equipment pricing. These reforms include the strengthening of the pricing verification of purchased goods, improving cost controls, shifting from singular to plural pricing models, from "after-purchase pricing" to "whole process pricing," and from "individual cost pricing" to "social average cost pricing" ("Armament Work," 2014). These represent modest steps in the pricing reform process, but the PLA will continue to face fierce opposition from the defense industry on this issue.

Corruption

A fifth impediment is corruption, which appears to have thrived with the defense industry's uncertain transition from centralized state planning to a more competitive and

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[5] From an interview with a PLA acquisition specialist, Beijing, November 2011

[6] Ibid.

indirect management model.[7] PLA leaders have highlighted the RDA system as one of a number of high-risk areas in which corruption can flourish along with the selection and promotion of officials, the enrollment of students in PLA-affiliated schools, funds management, and construction work ("PLA Gets Tough," 2014).

At the PLA's annual conference on military discipline inspection work in January 2014, CMC Vice-Chairman General Xu Qiliang, who heads the PLA's anti-corruption efforts, pointed out that armament research, production, and procurement was one of two areas that required "better oversight" ("CMC Vice Chairman Stresses," 2014). The other area that Xu highlighted was construction projects, which has been plagued by a number of high-profile corruption scandals in recent years.

The almost complete absence of public reporting on corruption in the defense industry and acquisition system means that the extent of the problem is not known. Military authorities justify this lack of transparency as many of the cases are likely to involve classified programs. In the latest anti-corruption crackdown that began with Xi Jinping's ascent to power at the 18th Party Congress in November 2012, there have only been a handful of cases of defense industry executives being arrested on corruption charges (e.g., see "Wu Hao, Deputy General Manager," 2014).

The Next Stage in China's Defense Technological Transformation: Formulating New Long-Term Plans and the Reform of the Defense Acquisition System

The Xi Jinping administration signaled its intention to carry out a major overhaul of the defense industry as part of an ambitious national program of economic and military reforms at the Third Plenum of the 18th Party Congress in 2013. A flurry of activity since then by defense industrial decision-makers has produced new medium and long-term defense industrial development strategies, plans, and institutional arrangements that collectively represent a potentially key turning point in the defense industry's evolution from an innovation follower to becoming an original innovation leader. After almost two years of investigation, a reform plan was approved and released at the CMC Working Conference on Reform in November 2015, which marked the formal start of the implementation of the most far-reaching structural reform of the PLA in its history ("Documentary of the Design," 2015).

While these reforms were targeted at the PLA's central, regional, and service commands, it also had important implications for the armament management system, which plays a highly influential role in defense science, technology, and industrial matters. At the end of 2015, the PLA's armament system underwent a far-reaching reorganization ("Central Military Commission," 2016):

- The GAD was reorganized into the CADD and given responsibility for the centralized unified management of the military armament system ("Ministry of National Defense," 2016).

[7] *Corruption* is defined broadly in China as covering the improper behavior of state, party, or military officials, but the more common Western definition is the abuse of public office for personal gain in violation of rules.

- The GAD Science and Technology Committee was elevated to a commission-level rank reporting directly to the CMC and renamed as the CMC Science and Technology Committee (CSTC).

Although it will take some time before these reforms are fully implemented and can be adequately assessed, some initial speculative thoughts can be offered. First, the promotion of the CSTC from the GAD to the CMC demonstrates that the Chinese military authorities, and especially Xi, are increasingly serious about engaging in higher-end STI activities and establishing a high-level coordinating mechanism through the CSTC to provide operational leadership and guidance.

Second, the ability of the new CADD to carry out its mandate of providing centralized management of the armament system looks to have a greater chance of success than the GAD, which was hamstrung by its institutional bias towards the oversight of the ground forces. The nature of the relationship between the CADD and the armament departments belonging to the service arms will be critical in determining how much jointness versus compartmentalization there will in the PLA's armaments development. The authority and influence of the CADD will benefit with the appointment of GAD Director Gen. Zhang Youxia as its new head, who reportedly has close ties with Xi ("Former GAD Director," 2016).

In parallel, the state defense industrial bureaucracy has formulated new strategies and plans for a significant adjustment to the defense industry as well as to chart its medium and long-term transformation. One of these key plans is the 13th Defense Science, Technology, and Industry Five Year Plan (13th Defense S&T FYP). This plan was issued at the beginning of 2016 and sets out six key tasks to 2020: (1) facilitating so-called "leapfrog" development of weapons and military equipment; (2) enhancing innovation capabilities in turnkey areas; (3) improving overall quality and efficiency; (4) optimizing the structure of the defense industry and vigorously promoting civil-military integration; (5) accelerating the export of armaments and military equipment; and (6) supporting national economic and social construction ("2016 National Defense Science," 2016).

Compared to its predecessor, the 13th Defense S&T FYP has a stronger focus on the development of high-technology weaponry and civil-military integration. It also signals a significant shift in the direction of defense industry development from absorption and re-innovation to giving greater emphasis to original innovation. The 13th FYP also shows that China is seeking to build on the inroads it has been steadily making in the international arms market. Chinese arms sales have almost doubled over the past five years, according to the Stockholm International Peace Research Institute and it supplies arms to 37 countries, although three-quarters of the exports were within the Asia-Pacific region, led by Pakistan, Bangladesh, and Myanmar ("China Almost Doubles," 2016).

A long-standing Achilles' heel of the Chinese defense industry being addressed by defense planners is a lack of higher-end manufacturing capability. Currently, SASTIND is in the process of preparing a "2025 Defense Science and Technology Plan" that will align closely with the national-level "Made in China 2025 Advanced Manufacturing Plan" and "Internet Plus" Plan which are aimed at lifting the overall level of the country's industrial equipment manufacturing base and curtailing excessive dependence on foreign core technology and products. The defense industry features prominently in the Made in China 2025 plan, especially the space and aviation sectors ("Defense 2025 Is Coming Soon," 2015).

Implications for the United States

The emergence of the Chinese defense industry and acquisition system as an increasingly capable and peer competitor has enormous implications and challenges for the United States, which can be assessed at three levels: geo-strategic, industrial, and acquisition.

At the geo-strategic domain, the two countries are increasingly engaged in an escalating arms competition with each other. While the Third Offset Strategy is focused at rectifying the overall global erosion in U.S. defense technological pre-eminence, the top challenge over the next 25–30 years comes from the "great powers" of Russia and China. Although the Pentagon is deeply concerned with Russian aggression in the short to medium term, China "embodies a more enduring strategic challenge," according to U.S. Deputy Defense Secretary Work ("Work Outlines Key Steps," 2015).

The Third Offset Strategy has a number of characteristics, in which China looms large as the "pacing threat":

- **Conventional deterrence against great powers:** The central tenet of the U.S. strategy is to develop a dominant conventional deterrent against Russia and China that reduces the chances of major military conflict between them.
- **Asymmetric competition:** Avoid competing in quantitative arms races with potential adversaries and instead focus on developing technologically superior quality that would compensate for the numerical superiority enjoyed by these rivals.
- **Strategy based, technology-oriented:** While technology is important, operational strategies and organizational constructs are also key elements in gaining advantages against numerically stronger opponents.
- **Cost Imposition:** With constrained resources, the United States is looking at ways to shift the cost equation that is heavily in favor of China by seeking to impose higher costs, such as forcing the Chinese to invest in areas that are extremely expensive and in which the United States has a technological edge, like in autonomy.
- **Operational level of war:** The primary focus of the initiatives is in the operational planning and conduct of campaigns that consist of assigning missions, tasks, and resources to military organizations. The principal operational concerns that the Defense Department has are as follows (Martinage, 2014, pp. 23–32):
    1. Growing vulnerability of its global system of military bases, especially those that are close to major potential adversaries in the Asia-Pacific and Europe;
    2. Increasing ability of opponents to detect, track, and engage U.S. aircraft carriers and other major surface warships at extended ranges from their coasts;
    3. Build-up of modern integrated air defense systems that is making it increasingly difficult for U.S. and allied airpower to enter into contested opposition airspace;
    4. Militarization of space that no longer makes it a sanctuary from military conflict.

While the Third Offset Strategy is still at an early stage of development, it does signal that the United States has unambiguously taken its first consequential steps in engaging

China directly in defense technological competition. From a U.S. defense acquisition perspective, this strategy is being operationalized in the Long-Range Research and Development Planning Program, which is modeled on an effort started in the 1970s when the United States successfully offset Soviet military numerical superiority with disruptive technological capabilities such as stealth and precision strike ("DoD Seeks Future Technology," 2014).

While there is little open discussion by Chinese military or civilian officials about the technological threat posed by the United States, they have been responding vigorously at the defense acquisition level since the end of the 1990s, most notably with the 995 Plan, which can be viewed as the Chinese counterpart to the Third Offset Strategy.

At the industrial level, the advances that the Chinese defense industry has accomplished over the past two decades have been impressive, but can they continue at such a rapid pace and in which direction will they lead? If the critical enabling factors that have been instrumental to this progress are still in place, then the prospects look encouraging for China's continued defense technological transformation.

Two particularly key drivers are leadership support and the threat environment. Xi Jinping will almost certainly stay at the leadership helm until the 20th CCP Congress in 2022, so leadership support for the defense industry will remain strong. China's external security environment will remain complicated because of sovereignty disputes and structural competition with the United States and regional neighbors such as Japan. Moreover, the PLA's efforts to build up its long-range power projection capabilities to support its increasingly global ambitions look set to continue. These factors make it likely that the generous levels of funding that the defense industry has received will continue at least over the course of the 13th Five Year Plan to the end of this decade.

However, the continued progress in the development of China's defense technological capabilities rests on troubled foundations. The structural weaknesses of the defense industry makes it at serious risk of falling into a trapped transition, whereby key components are left unreformed or only partially reformed because of strong opposition from powerful interest groups. The negative consequences from this selective reform process has so far been masked by the abundance of resources flowing through the defense industry. But any tightening in budgets because of slowing economic growth could expose the fragilities of this deeply fragmented and flawed system.

At the defense acquisition level, the impact and implications of Chinese developments for the United States primarily revolve around competition in four critical areas: cost, schedule, performance, and innovation. Which country's acquisition system is producing outcomes that are faster, cheaper, better, and bolder than the other side? The Chinese defense acquisition system today is competitive or ahead in cost and schedule, and is behind but narrowing the gap in performance and innovation. As long as the United States is able to maintain a healthy lead of at least one generation or more in the technological capability and innovation of its weapons systems, this offsets China's advantages in schedule and cost.

But if China is able to succeed in narrowing the overall performance capability and innovation gap to within one and even half a generation and continues to maintain a decisive edge in schedule and cost, then it will have the upper hand in the acquisition competition with the United States. A key question is whether the Chinese system is able to be faster and cheaper even as it becomes better and bolder.

A central reason that the Chinese defense industry has been able to keep costs down and accelerate the pace of acquisition is because it has operated on an absorption-based, good-enough development model. But as the Chinese defense industry transitions to more of an original innovation-based, higher end development framework, risks grow significantly and this will impact the costs and pace of the acquisition process. The underdeveloped Chinese defense acquisition system could very likely find itself overwhelmed and lacking the expertise, experience, and organizational, business, and management tools to manage an advanced technology and innovation enterprise. One key exception is a select number of projects that come under special attention and oversight from the highest levels of the civilian and military leaderships. But they are the exception rather than the rule of the Chinese defense acquisition system.

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