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A former relic of Socialist central planning, China's defense economy has undergone a far-reaching makeover since the late 1990s to become one of the country's leading dynamos for innovation today. Measured by the output of weapons platforms, profits, and patents, the aviation, aerospace, shipbuilding, electronics, nuclear, and ordnance sectors that make up the defense industrial base are flourishing. Strong and sustained leadership support, generous state funding, pent-up domestic demand, the emergence of new generations of well-trained scientists and engineers, and access to foreign technology transfers are some of the principal factors contributing to this rejuvenation.

However, the structural foundations upon which this technological progress is built have not kept pace with the changes. Entrenched monopolies, bureaucratic fragmentation, continued dependence on foreign technology, and the absence of a rules-based acquisition system are some of the problems that confront the defense economy. This begs the question of whether the Chinese defense economy will be able to continue to move up the innovation ladder and reach its goal of entering the top tier of global defense champions within another decade or find itself bogged down in a transition between state planning and marketization that leads to growing inefficiencies and stifles innovation.

Change and Innovation in Today's Chinese Defense Economy

China's extensive efforts and investment in building its defense science, technology, and industrial capabilities have borne fruit since the second half of the last decade with the emergence of an impressive array of high-technology weapons systems. There are now so many projects under way that the Chinese defense industry appears to be on steroids. The aviation sector is simultaneously engaged in the development or production of more than half a dozen combat and transport aircraft, which is more than any other country in the world. They include fifth-generation low-observable Chengdu J-20 and Shenyang J-31 fighter aircraft and the Shenyang J-15 carrier-borne fighter, which is derived from Russian/Ukrainian technologies.

The shipbuilding industry is carrying out at least four active nuclear and conventional submarine programs along with research and development (R&D) and construction of aircraft carriers, destroyers, and numerous other surface warships. The space industry is also pursuing highly ambitious across-the-board development, including manned,

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lunar, anti-satellite, and satellite projects. The enormous scale and intensity of this technological and industrial undertaking has not been seen since the Cold War days of intense U.S.-Soviet technological and military rivalry. The pace, breadth, and nontransparent nature of China's activities is causing growing anxiety among its neighbors and the United States.

It is important, however, to distinguish between the expansive nature of China's defense technological and innovative activities and their quality and effectiveness. While China has made considerable efforts since the late 1990s to revamp its defense innovation capabilities, the results so far are mixed. Although the space and missile industries have made impressive progress and are able to engage in mid-level forms of innovation, many other sectors, including aviation, shipbuilding, and ordnance, continue to engage in a mixture of high-end imitation and lower-end innovation activities.

A good example is the development of China's aircraft carrier program and the J-15 fighter aircraft that will operate from the decks of these vessels. The PLA Navy's first aircraft carrier, the *Liaoning*, is a rebuilt vessel purchased from the Ukraine in the mid-1990s. Chinese officials argue that the *Liaoning* should be viewed as a wholly indigenously developed product because all of the ship's key systems, equipment, and armaments, such as engines, radar, command and control facilities, and aircraft landing equipment, were sourced domestically. While the technological capabilities of the *Liaoning* and J-15 are likely to have been enhanced with Chinese subsystems and components, the Chinese shipbuilding and aircraft industries required the initial architectural platforms from Russia and Ukraine as starting points for developing their own variants.

The uneven state of development of the defense industry is likely to continue for the foreseeable future, with pockets of excellence existing in a broader landscape of technological mediocrity. However, more of these innovation clusters are likely to appear and to expand in size and capability, especially over the medium to long term.

Innovation and Economic Performance by the Country's Defense Conglomerates

The country's ten state-owned defense corporations is a principal engine powering the Chinese defense economy's transformation and a key source for innovation. Average annual revenues from these defense firms since the mid-2000s have expanded by around 20 percent. Total reported revenues from these firms, excluding China State Shipbuilding Corporation, came to an estimated RMB 1.412 trillion (US$233 billion) in 2012.

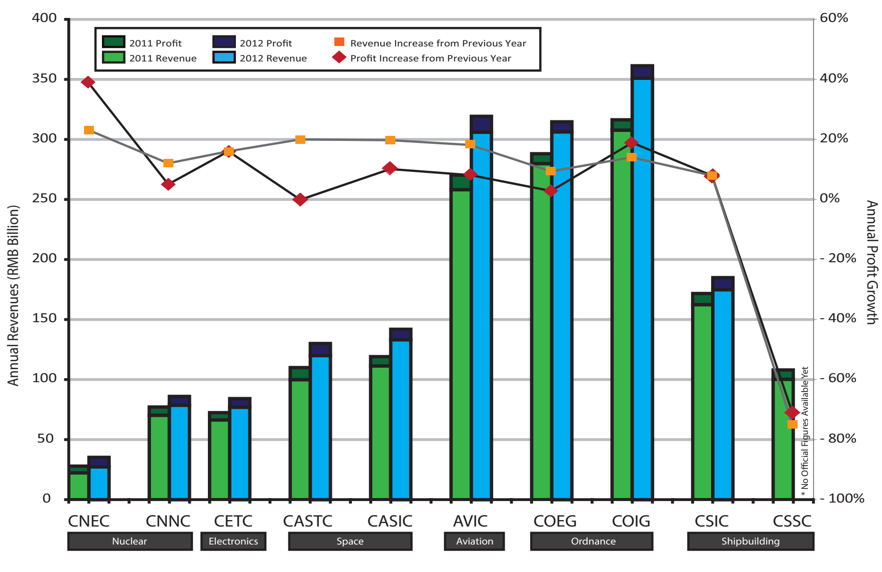

Figure 1. Financial performance of China's ten leading defense industry groups, 2011–2012

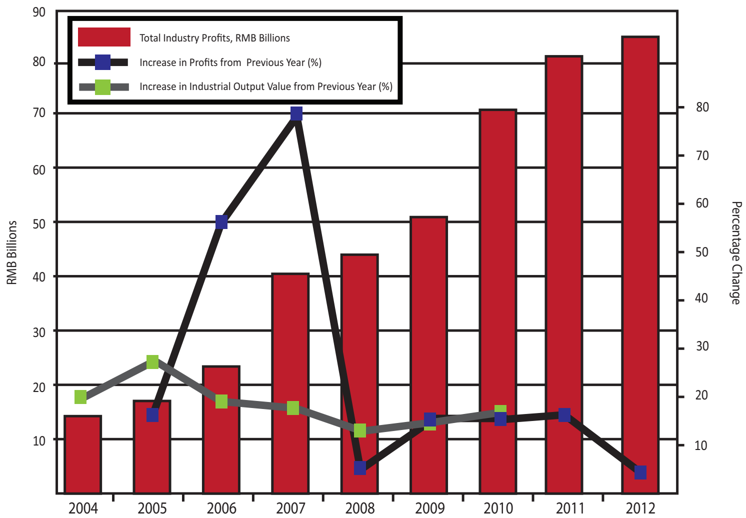

Figure 2. Financial performance of the Chinese defense industry, 2004–2012

An important indicator of improving efficiency is the profitability of the defense corporations. Total industry earnings reached an estimated RMB 85 billion in 2012. This is a remarkable turnaround for an industry that was a chronic money loser before the early 2000s.

There is no breakdown to show how much of the profits flow from civilian versus military sales, but contractors have long complained that they struggle to make any profits on their defense operations because regulations dating from the central planning era limit profit margins on military contracts to a fixed 5 percent on top of actual costs.

Approximately one-third of defense budget expenditures go to covering equipment expenses, according to Chinese official explanations. This includes research and development, experimentation, procurement, and maintenance activities. This would mean that the 2012 equipment budget would be in the region of RMB 220 billion.

Financial data from defense corporations, however, suggest that the scale of the PLA's acquisitions maybe significantly larger than these disclosed official figures. It is likely that around one-quarter of the income of the ten defense corporations would be defense-related business and the rest would be civilian output. Even accounting for modest levels of foreign arms exports, which is estimated to be US$1–1.4 billion annually, these figures suggest that Chinese military research, development, and acquisition (RDA) spending is at least 50 percent higher than the official figures would imply. Total estimated R&D corporate spending by the defense industry in 2010 would likely be around RMB 66–68 billion ($US10.4–10.7 billion).

This intensification in R&D shows the high priority that the defense authorities have placed on building up indigenous defense innovation capabilities over the last decade. A high-level review conference on the state of defense R&D in late 2011 noted that there had been a major enhancement of R&D capabilities during the 11th Five-Year Plan (1996–2000) with major breakthroughs in critical bottlenecks, higher rates of converting R&D into actual production, and an improvement in the level of research talent entering the defense science and technology (S&T) base.

Leadership Commitment to Defense Innovation

China's national leadership—civilian, military, scientific, and corporate—has provided strong support for the Chinese defense economy and its efforts to become more innovative since the late 1990s. This backing has been instrumental for much of the progress that has taken place, especially because it enabled access to large amounts of state resources and helped to overcome bureaucratic and other structural obstacles. If senior policymakers remain committed to the goal of building a world-class defense S&T system, funding remains plentiful, and military end-user demand continues to be strong, the development of the defense economy's innovation capabilities will continue on an upward trajectory and could even accelerate.

The fifth generation of civilian and military leaders that have taken charge of the country since the 18th Party Congress in 2012 appear to firmly subscribe to the vision defined by their immediate predecessors and enshrined in the various medium- and long-term S&T planning guidance issued since 2000 stating that having a world-class indigenous innovation capacity is critical to China's long-term national security and economic competitiveness. An ideological theme that Party general secretary and Central Military Commission (CMC) chairman Xi Jinping highlighted shortly after he took office at the 18th Party Congress was the importance of "rejuvenation" and "revival of the Chinese nation." These nationalistic sentiments suggest that Xi will embrace the techno-nationalistic philosophy that has been a cornerstone of China's approach to defense S&T innovation since the 1950s.

External Security Threats and Innovation

If China's leaders were to view the country's national security as under serious threat once again, as happened between the 1950s and 1970s, there could be another concerted drive to attain breakthroughs in critical defense technological capabilities. Several events since the 1990s have boosted the strategic priority of the development of the defense S&T system in the eyes of the Chinese authorities. Cross-strait tensions between Beijing and Taiwan beginning in the early 1990s led the PLA and the defense industry to ramp up their modernization efforts, amid fears that Taiwan was moving towards independence. This led to a concerted effort to develop ballistic missile and precision strike capabilities along with conventional forces such as armored fighting vehicles, combat aircraft, and warships.

The next key event was the U.S. bombing of the Chinese embassy in Belgrade in May 1999. The Chinese leadership's reaction was to sharply intensify efforts to develop strategic weapons systems. According to a biography by General 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 advanced armaments. Zhang pointed out that Jiang Zemin was especially insistent on the need to step up the pace of development of asymmetric weapons projects, saying that "what the enemy is most fearful of, this is what we should be developing." 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 capabilities targeting U.S. vulnerabilities.

A new major threat dynamic appears to have emerged since the beginning of the 2010s, with a sharp rise in maritime, especially territorial, tensions between China and several of its neighbors and with the United States announcing a strategic rebalancing back to the Asia-Pacific region, and in particular East Asia. A key plank of the U.S. pivot is the development of a new Air-Sea Battle doctrine that is designed to thwart China's efforts to curtail the U.S. military—especially naval—presence through an anti-access/area denial strategy. With China and Japan at loggerheads over the Diaoyu/Senkaku Islands in the East China Sea and rattling increasingly sharp sabers at each other, alongside standoffs between China and Southeast Asian countries over the Spratly Islands in the South China Sea, the Chinese leadership is calling for the PLA and the defense industry to step up their "preparations for military struggle, comprehensively improve deterrent and combat capabilities under informationized conditions, and safeguard the sovereignty, security, and development interests" of China. Under this new, more dangerous threat environment, the defense technological and innovation base may enjoy even greater access to resources and be encouraged to become more aggressive in pursuing technological breakthroughs and surprises, especially in areas such as asymmetric (cyber, space, missiles) warfare and long-range naval and air power.

Critical Obstacles to Future Progress

While the Chinese defense economy has taken important strides in transforming itself from a lower-tier military technological and industrial laggard, it still faces tough challenges that could impede continued progress. The fundamental problem is that large portions of the defense economy continue to operate according to the norms, operating principles, routines, and habits of the socialist central planning economy. This is not surprising, as the defense economy did not seriously begin to undertake market-oriented reforms until the late 1990s.

One major problem is the lack of competitive mechanisms for awarding contracts for major weapons systems and defense equipment because of the monopolistic structure of the defense industry. Contracts continue to be awarded through single sourcing mechanisms to the big ten state-owned defense corporations. Some PLA acquisition experts view this monopoly structure as the biggest obstacle in its long-term reform.

Bureaucratic fragmentation is another serious problem and affects a number of critical coordination and command mechanisms within the PLA and RDA systems. One serious gap at the top of the military RDA management pyramid is the truncated role of the PLA General Armament Department (GAD), which is only responsible for managing the armament needs of the ground forces, People's Armed Police, and militia. The navy, air force, and Second Artillery have 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 RDA process is also plagued by compartmentalization. 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 are ad hoc in nature with major gaps in oversight, reporting, and information sharing.

Two Models of Defense Innovation: "Good Enough" Versus High-End

The improvement of defense science, technology, and innovation capabilities is time-consuming and painstakingly slow, even for urgent, high-priority programs. Development periods for weapons projects are significantly longer than counterpart projects in the United States. Chinese combat aircraft projects, for example, take between 15 and 20 years from research to production. Much of this time is spent grappling with organizational and project management issues. This suggests that the stated overall goal of becoming a top-tier defense S&T power by the beginning of the 2020s may take considerably longer than China hopes, although a growing number of areas may close the gap to the top more quickly than anticipated.

China also appears to be pursuing two distinct innovation development strategies that stress different comparative advantages. The first model is what can be called the "good enough" approach, in which the central goal is affordability and the ability to field substantial quantities of arms that would overwhelm a more advanced but qualitatively smaller adversary. This is a widely adopted business model, known as Shanzhai, used by Chinese companies, especially smaller firms, to produce low-cost, high-volume versions of foreign products that lack their quality and capabilities but are much cheaper and meet the needs of the average Chinese consumer. This "good enough" strategy also appears to be the principal approach that the PLA and Chinese defense industry are currently pursuing, which fits very well with its asymmetric anti-access/area denial strategy.

The second innovation pathway is the high-end, high-cost, "gold-plated" approach, in which the goal is to develop sophisticated but hugely expensive weapons that are able to match those of the United States and other advanced rivals. This is more of a long-term aspirational strategy, as the Chinese defense industry presently lacks the necessary scientific and technological capabilities to effectively carry out higher-end innovation. However, Chinese defense S&T institutes are conducting R&D into increasingly advanced emerging technologies and weapons that may eventually find their way into production, although in small quantities because of their high cost. This includes directed energy laser weapons, robotic systems, and miniature and nano-based systems.