Asia Policy, volume 16, number 1 (january 2021), 5–24
~ http://asiapolicy.org ~

ROUNDTABLE ESSAY

China's Shift from Civil-Military Integration to Military-Civil Fusion

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NOTE ~ *This essay draws on several previously published works by the author: "Introduction" in* Emerging Critical Technologies and Security in the Asia-Pacific, *ed. Richard A. Bitzinger (London: Palgrave Macmillan, 2016); "Reforming China's Defense Industry,"* Journal of Strategic Studies *39, no. 5–6 (2016): 762–89; "Reforming China's Defense Industry: Progress in Spite of Itself?"* Korean Journal of Defense Analysis *19, no. 3 (2007): 99–118; "Dual-Use Technologies, Civil-Military Integration, and China's Defense Industry," in* Chinese Civil-Military Relations: The Transformation of the People's Liberation Army, *ed. Nan Li (Abingdon: Routledge, 2006), 178–88; and "Civil-Military Integration and Chinese Military Modernization," Jamestown Foundation, China Brief, November 24, 2004.*

KEYWORDS: china; people's liberation army; military modernization

EXECUTIVE SUMMARY

This essay examines how China has come to value Military-Civil Fusion (MCF) as a critical strategy for next-generation military-technological innovation and how the country is attempting to apply MCF to its weapons development process.

MAIN ARGUMENT

MCF is part of a long-term and broad-based strategic effort by Beijing to develop China into a technological superpower by pursuing both guns and butter and using them to mutually support each other. Chinese leaders, particularly Xi Jinping, are using MCF to position the country to compete militarily and economically in an emerging technological and strategic competition with the U.S. In this respect, current efforts are far more ambitious and far-reaching than previous initiatives, particularly in their determination to fuse China's defense and commercial economies. At the same time, China is only at the beginning of an arduous, multiyear process to leverage advanced commercial technologies for military modernization, and there is no certainty that MCF will work any better than earlier efforts. Nevertheless, it is unlikely that Xi, the Chinese Communist Party, or the People's Liberation Army will abandon MCF anytime soon.

POLICY IMPLICATIONS

- Despite the availability of advanced technologies in the commercial sector, MCF is a gamble, and it will require considerable effort and resources to adapt and apply these technologies to military innovation. Legal, regulatory, and cultural hurdles could impede the pace and intensity of MCF.
- Nevertheless, should China successfully implement MCF and achieve significant results, the resulting "world-class" military could pose a worrying challenge to the U.S. and its allies in the Indo-Pacific.

Military-Civil Fusion (MCF) is rapidly becoming a critical strategy for next-generation military-technological innovation and development. If fourth industrial revolution (4IR) technologies are the basis for future military capabilities and advantage, then MCF is a crucial course for militaries seeking to exploit these technologies. At the same time, however, MCF is not only an important military-technological innovation strategy but also increasingly part of many countries' strategic efforts to remain militarily competitive with likely adversaries and rivals. The essence of such competitive strategies, according to Thomas Mahnken, is all about "imposing costs upon a competitor in order to influence his decision-making calculus," and thus affect his strategic behavior.[1] This type of strategy has become increasingly prevalent in the Sino-U.S. strategic competition. China's growing military-technological capabilities in the areas of precision-strike weaponry and C4ISR (command, control, communications, computers, intelligence, surveillance, and reconnaissance) have been sapping the United States' margin of superiority for years.[2] Such capabilities "increasingly favor a strategy of denial," undermining U.S. military power where it must travel long distances before it can project force.[3] These efforts have been dubbed anti-access/area denial (A2/AD). Capabilities for A2/AD include, but are not limited to, ballistic and cruise missile strikes (both land-attack and anti-ship), artillery and rocket barrages, submarine operations (anti-ship and antisubmarine), long-range air strikes, cyberattacks, and anti-satellite warfare.

In the case of China, therefore, MCF has become a core military-technological innovation strategy, particularly as the People's Liberation Army (PLA) shifts to "intelligentized warfare." Intelligentized warfare is defined as the "operationalization" of artificial intelligence (AI) and its enabling technologies, such as cloud computing, big data analytics, quantum computing, and autonomous systems, for military applications. As such, this approach differs markedly from earlier PLA concepts of "informationized warfare," which mainly emphasized the use of information systems (e.g., improved systems for intelligence, reconnaissance, and surveillance; advanced command, control, and communications infrastructures) as

1 Thomas G. Mahnken, "Frameworks for Examining Long-Term Strategic Competition between Major Powers," in *The Gathering Pacific Storm: Emerging U.S.-China Strategic Competition in Defense Technological and Industrial Development*, ed. Tai Ming Cheung and Thomas G. Mahnken (Amherst: Cambria Press, 2018), 3.

2 Ibid., 2.

3 Ibid., 7–8.

a force multiplier.[4] Chinese military modernization is now entwined with civilian technological innovation in a number of critical dual-use technology sectors, including aerospace, additive manufacturing, AI, and computing. As such, MCF has become an essential ingredient in Beijing's long-term effort to make China a technological superpower in both military and civilian respects.

The remainder of this essay is divided into the following sections:

- pp. 8–11 cover the impact of technology and the continued interest in harvesting emerging commercial technologies for their military potential.
- pp. 12–20 survey China's experiences with MCF as well as previous attempts at civil-military integration from the early 1980s to 2017.
- pp. 20–23 analyze recent MCF initiatives under Xi Jinping.
- pp. 23–24 offer a brief conclusion.

THE IMPACT OF TECHNOLOGY ON MILITARY EFFECTIVENESS AND ADVANTAGE[5]

Technology is widely regarded as a crucial element of military effectiveness and advantage. As Keith Krause once put, "the possession of modern weapons is a key element in determining the international hierarchy of power."[6] In theory (and often in practice), the possession of cutting-edge militarily relevant technologies equates to more effective weapons systems, which in turn results in greater military power and eventually greater geopolitical power. At the same time, the transnational diffusion of military-related technologies is an important factor affecting the distribution of power in international politics. Consequently, the global dissemination of advanced, militarily relevant technologies should be as great a security concern as the spread of weapons systems themselves.

Complicating this predicament of advanced conventional weapons proliferation, "militarily relevant technologies" are becoming harder to identify and classify. Technological advances, especially in military systems,

4 U.S. Department of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China* (Washington, D.C., September 2020), 161 ~ https://media.defense.gov/2020/Sep/01/2002488689/-1/-1/1/2020-dod-china-military-power-report-final.pdf.

5 This section draws on Richard A. Bitzinger, "Introduction," in *Emerging Critical Technologies and Security in the Asia-Pacific*, ed. Richard A. Bitzinger (London: Palgrave Macmillan, 2016); and Richard A. Bitzinger, "Civil-Military Integration and Chinese Military Modernization," Jamestown Foundation, China Brief, November 24, 2004 ~ https://jamestown.org/program/civil-military-integration-and-chinese-military-modernization.

6 Keith Krause, *Arms and the State: Patterns of Military Production and Trade* (Cambridge: Cambridge University Press, 1992), 19.

are a continuous, dynamic process; breakthroughs are always occurring, and their impact on military effectiveness and comparative advantage can be both significant and hard to predict in nascent stages. In particular, many advanced technologies—particularly those embedded in commercial rather than military industrial sectors—offer new and potentially significant opportunities for defense application and, in turn, for increasing one's military edge over potential rivals.

Emerging 4IR technologies such as AI and machine-learning, block-chains, new man-machine interfaces, automation and robotics, and quantum computing promise to create challenges in identifying new and significant military technologies and understanding how these capabilities could provide a military advantage, and therefore political leverage, in the decades to come. As Sarah Kirchberger observes:

> The 4IR is generating technologies that not only further strengthen the interconnections between [the surface, subsurface, and air domains], but will interlink them more strongly with the outer space and cyber domains. Space and cyber are key enablers of naval capabilities such as navigation, ISR, communication, and targeting, but immense computing power is necessary to interpret large amounts of sensor and other input data, with secure data links…needed to provide connectivity between disparate units to allow a shared situational awareness—ideally, in real-time or near-real-time.[7]

A succinct example of the potential impact of 4IR on the military sphere is made by Nah Liang Tuang:

> [T]he use of armed, autonomous…drones equipped with advanced sensors, and linked to wireless command and control networks where artificial intelligence–enabled decision-making only requires human intervention when lethal force needs to be used. Several of such drones could be remotely overseen by a single soldier using improved man-machine interfaces.[8]

Due to their complexity, advanced learning systems, autonomous weaponry, and quantum technology are all unlikely to be widely diffused across East Asia before 2030. The ability to develop and integrate these technologies could be limited to larger, more technologically advanced countries. Nevertheless, there are many discrete 4IR

7 Sarah Kirchberger, "Maritime Power and Future of Conflict in the 21st Century: The Case of the Subsurface Domain" (paper presented to the conference "Defense Innovation and the 4th Industrial Revolution: Security Challenges, Technologies, and National Responses," Singapore, February 19–20, 2019), 1.

8 Nah Liang Tuang, "The Fourth Industrial Revolution's Impact on Smaller Militaries: Boon or Bane?" S. Rajaratnam School of International Studies (RSIS), Working Paper, no. 318, November 22, 2018, 2.

technologies—such as autonomous systems and AI—that could be successfully plugged into the existing force structures in some small states. For example, systems such as unmanned aerial vehicles (UAVs) are increasingly being used to complement or replace manned reconnaissance platforms. Although more innovative use of unmanned systems remains limited in the region, the situation is dynamic and likely to change. In particular, even many smaller or less advanced militaries are developing indigenous UAVs, including swarming concepts.[9]

In addition, the world is undergoing a revolution in networking and connectivity via the internet and social media. Building on the huge, 4IR-related technological leaps in the commercial sector, many countries around the globe are actively exploring the militarization of cyber and information operations. In fact, the global military environment today is more suited than ever for cyber operations, and such technology has significant potential to be disruptive.[10]

For all these reasons, there is ongoing interest in harvesting emerging, critical commercial technologies for their military potential. This process, commonly known as civil-military integration (CMI), has considerable potential to revolutionize the way militaries develop and produce defense-critical systems and holds particular promise in adapting commercial 4IR technologies, especially information technology (IT), to military purposes. Consequently, the proliferation of militarily relevant technologies is no longer simply a matter of immediate end-use but also of potential future use.

The classic definition of CMI is the process of combining the defense and civilian industrial bases so that common technologies, manufacturing processes and equipment, personnel, and facilities can be used to meet both defense and commercial needs. According to the former U.S. Congressional Office of Technology Assessment, CMI includes "cooperation between government and commercial facilities in research and development (R&D), manufacturing, and/or maintenance operations; combined production of similar military and commercial items, including components and subsystems, side by side on a single production line or within a single firm or facility, and use of commercial off-the-shelf items directly within

9 Henrik Paulsson, "Military-Technological Innovation in East Asia: Operational Perspectives," report prepared for the Singapore Ministry of Defence by the Military Transformations Programme, RSIS, 2017, 4–5.

10 Ibid., 6.

military systems."[11] CMI can occur on three levels: facility, firm, and sector. Facilities can share personnel, equipment, and materials, and even simultaneously manufacture defense and civilian goods. Firm-level integration involves separate production lines but the joint military-civilian use of corporate resources, such as management, labor, and equipment. Finally, integrated industrial sectors, such as aerospace or shipbuilding, can draw from a common pool of research and development activities, technologies, and production processes. This last strategy is increasingly seen as the most rewarding line of attack when it comes to CMI.

CMI provides many potential benefits to military modernization efforts. Adapting available commercial technologies to military needs can save money, shorten development and production cycles, and reduce risks in weapons development. Many militaries' approaches to CMI have been particularly influenced by the power of modern IT sectors, seeing considerable potential for force multipliers in areas such as information warfare, digitization of the battlefield, and networked systems. CMI can also improve the quality of military equipment and contribute to more efficient production and acquisition of military systems. Above all, CMI permits arms industries and militaries to leverage critical technological advances in sectors where the civilian side has clearly taken the lead in innovation, such as communications, computing, and microelectronics. To this can also be added 4IR technologies like AI and machine-learning, man-machine interfaces, automation and robotics, quantum computing, and the Internet of Things.

China, like many countries, has long been keenly aware of the benefits of CMI for reducing the costs and risks of weapons development and production and accelerating military modernization. Additionally, China views CMI and MCF as advancing its long-term objective of achieving greater self-sufficiency in arms procurement by enabling the PLA "to source more of its critical and sensitive technologies domestically"[12] and subsequently reducing its dependency on foreign suppliers for its most advanced weapons. Therefore, CMI and MCF add a new wrinkle to China's classic techno-nationalist development strategy through the launching of a joint government-industry-military effort to acquire, nurture, indigenize, and diffuse critical dual-use technologies deemed essential to national security.

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11 U.S. Congress, Office of Technology Assessment, *Other Approaches to Civil-Military Integration: The Chinese and Japanese Arms Industries* (Washington, D.C., March 1995), 3 ~ https://ota.fas.org/reports/9532.pdf.

12 Tai Ming Cheung, *Fortifying China: The Struggle to Build a Modern Defense Economy* (New York: Cornell University Press, 2013), 201.

CHINA AND MCF: A NEW APPRECIATION

Few countries are more appreciative of the potential military impact of commercial 4IR technologies than China. China is keen to expand its CMI efforts as a means of driving military breakthroughs in these areas. MCF, particularly in areas such as AI, robotics, advanced microelectronics and computing, and quantum technologies, is especially critical to the PLA's "informationization" efforts. In 2007 at the 17th Party Congress, then general secretary Hu Jintao was reportedly the first to use the term "military-civil fusion." In 2015, President Xi Jinping made the "aligning of civil and defense technology development" a national priority, a strategy that was subsequently reaffirmed in China's 2015 white paper on military strategy and again at the 19th Party Congress in October 2017.[13] In 2017, Beijing established the Central Commission for Integrated Military and Civilian Development as the body responsible for overseeing MCF.[14] It is likely, therefore, that the Chinese leadership will maintain significantly high levels of defense spending in order to underwrite the PLA's overall modernization activities, including MCF.

Beijing's efforts to utilize dual-use technologies for military modernization have considerable implications for Sino-U.S. strategic competition. China is in the midst of an unprecedented military buildup and has long searched for ways to promote MCF, develop dual-use technology, and exploit commercial-to-military spin-on in support of the PLA's modernization efforts. The United States has an obvious interest in retarding this effort—hence, its continued opposition to lifting the Western ban on arms sales to China. Dual-use technology exports are much harder to control, however. Such transfers are overwhelmingly commercial and therefore are seen as benign and beneficial to both seller and buyer alike. In addition, many of these technologies are already widely diffused throughout the world, and it would be difficult and impractical to restrict their sales. Consequently, the United States may not be able to halt China's MCF and dual-use technology exploitation.[15]

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13 Lucie Béraud-Sudreau and Meia Nouwens, "Weighing Giants: Taking Stock of the Expansion of China's Defence Industry," *Defense and Peace Economics* (2019): 12.

14 U.S. Department of Defense, *Annual Report to Congress 2020*, 21, 96, 102.

15 Bitzinger, "Civil-Military Integration and Chinese Military Modernization."

China's Defense Industry and CMI, Early 1980s to the Mid-1990s: Defense Conversion[16]

The Chinese defense industry's first attempts at CMI ran from roughly the early 1980s to the mid-1990s and focused on rectifying acute economic, structural, and organizational problems through a concerted attempt to convert military factories over to manufacturing civilian products. In particular, commercial production was seen as a means of absorbing excess capacity in the arms-producing sector, providing defense enterprises with additional revenue to compensate for their underperforming military product lines, and encouraging directors and managers to bring their ventures more in line with market forces. This strategy was officially embodied in Deng Xiaoping's "sixteen character" slogan, which called for "combining the military and civil, combining peace and war, giving priority to military products, and making the civil support the military."[17]

With Beijing's enthusiastic blessing, the defense industry branched out in a broad array of civilian manufacturing during the 1980s and 1990s. China's aviation industry, for example, established a number of joint ventures with Western aircraft companies. McDonnell Douglas set up a production line in Shanghai to build MD-82 and MD-90 passenger jets. Boeing, the Airbus consortium, Sikorsky Aircraft, Pratt & Whitney, and Bombardier of Canada all established facilities at various Chinese factories to produce sub-assemblies and parts for Western civilian aircraft. Beginning in the 1980s, Chinese shipyards also successfully converted much of their production to more profitable civilian products, such as bulk carriers and general cargo ships. Meanwhile, China's missile industry entered the lucrative satellite-launching business with its series of Long March space-launch vehicles.

During the period, many defense enterprises became engaged in commercial ventures far outside their traditional economic activities. Ordnance factories assembled motorcycles, aircraft companies built mini-cars and buses, and missile facilities put together refrigerators, television sets, and even corrugated boxes. By the mid-1990s, 70% of all taxicabs, 20% of all cameras, and around 65% of all motorcycles produced in China came out of

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16 This section is adapted from Richard A Bitzinger, "Dual-Use Technologies, Civil-Military Integration, and China's Defense Industry," in *Chinese Civil-Military Relations: The Transformation of the People's Liberation Army*, ed. Nan Li (Abingdon: Routledge, 2006), 178–88; and Bitzinger, "Civil-Military Integration and Chinese Military Modernization."

17 Toby Warden, "A Revolutionary Evolution: Civil-Military Integration in China," Australian Institute of International Affairs, October 1, 2019 ~ http://www.internationalaffairs.org.au/australianoutlook/a-revolutionary-evolution-civil-military-integration-in-china.

former weapons factories. By the late 1990s, an estimated 80%–90% of the value of China's defense industry output was nonmilitary.

However, little of this early conversion effort actually aided the Chinese military-industrial complex. For one, defense conversion in China has been no guarantee of financial success, and many former weapons factories lost money in the transition to civilian production. In particular, many failed to create reliable, mainstay product lines or develop a more consumer-savvy attitude toward price, quality, or adding new features. More important, defense conversion did little to benefit China's defense industry in terms of acquiring and diffusing potentially useful commercial technologies to the military sector. The concern that conversion meant a process of "swords into plowshares and better swords" was largely unfounded. If anything, "spin-off"—the transfer of military technologies to civilian applications—was more important during this period than civilian-to-military "spin-on."

At the same time, opportunities for the direct spin-on of civilian technologies to military production remained limited. In the aviation industry, for example, while China acquired a number of advanced numerically controlled machine tools for use in commercial aircraft production, end-user restrictions kept these from being converted to military use. With regard to the shipbuilding industry, even as late as the mid-1990s, commercial programs had little impact on improving China's ability to produce modern warships or develop advanced naval technologies. The shipbuilding industry's low-technology base, while sufficient for building cargo ships, added little value to the design and construction of warships.

This is not to say that no dual-use technology development occurred. In fact, a critical science and technology development effort, the 863 Program, was launched in the mid-1980s. The program was a long-term initiative to expand and advance China's high-technology base in a number of areas, many of which had potential military applications, including aerospace, lasers, opto-electronics, semiconductors, and new materials. The 863 Program, however, was essentially a research activity and not set up (or funded) to promote and diffuse these technologies for practical or military use.

At best, CMI efforts during this period only indirectly aided Chinese weapons development and production, to the extent that the military-industrial complex benefited from overall economic growth. In some cases, defense conversion did help reduce overhead costs and generate sources of income to underwrite new arms production. In general, however, there were few linkages between military and civilian production and, in particular, very few efforts to develop dual-use technologies or apply innovative civilian technologies to military use.

China's Defense Industry and CMI, Mid-1990s to 2017: Exploitation of Dual-Use Technologies[18]

China's approach to CMI began to change around the mid-1990s with a crucial shift in policy from conversion (i.e., switching military factories over to civilian use) to the promotion of integrated dual-use industrial systems capable of developing and manufacturing both defense and military goods. This new strategy was embodied and prioritized in the defense industry's five-year plan for 2001–5. It emphasized the dual importance of both the transfer of military technologies to commercial use and the transfer of commercial technologies to military use, calling on the Chinese arms industry to not only develop dual-use technologies but actively promote joint civil-military technology cooperation. Consequently, the spin-on of advanced commercial technologies both to the Chinese military-industrial complex and in support of the PLA's overall modernization was made an explicit policy.[19]

China began to seriously pursue the idea of leveraging advanced technologies and manufacturing processes found in the commercial sector in order to benefit defense R&D and production. According to many analysts, CMI was a central feature of defense industry reform from 1997 to 2017.[20] It was viewed as a fast (or at least faster) and ready means to shortcut the R&D process of advanced weapons systems, cherry-pick civilian manufacturing practices in high-tech sectors (e.g., computer-aided design and manufacturing and program management tools), exploit dual-use technologies (e.g., space systems for surveillance, communication, and navigation), and, in particular, take advantage of the latent capabilities found in commercially based IT. Such civil technologies could be either

18 This section draws on Richard A. Bitzinger, "Reforming China's Defense Industry: Progress in Spite of Itself?" *Korean Journal of Defense Analysis* 19, no. 3 (2007): 99–118; and Richard A. Bitzinger, "Reforming China's Defense Industry," *Journal of Strategic Studies* 39, no. 5–6 (2016): 762–89.

19 Warden, "A Revolutionary Evolution."

20 Eric Hagt, "Emerging Grand Strategy for China's Defense Industry Reform," in *The PLA at Home and Abroad: Assessing the Operational Capabilities of China's Military*, ed. Roy Kamphausen, David Lai, and Andrew Scobell (Carlisle: Strategic Studies Institute, 2010), 481–84; Brian Lafferty, Aaron Shraberg, and Morgan Clemens, "China's Civil-Military Integration," Study of Innovation and Technology in China, January 2013, 58; and James Mulvenon and Rebecca Samm Tyroler-Cooper, "China's Defense Industry on the Path of Reform," prepared for the U.S.-China Economic and Security Review Commission, October 2009, 57–58.

domestically developed or obtained from foreign sources via joint ventures, technology transfer, or even espionage.[21]

This new strategy was embodied in the principle of *yujun yumin* (locate military potential in civilian capabilities), enunciated at the 16th Party Congress in 2002.[22] Yujun yumin has subsequently been made a priority in the last several five-year defense plans, as well as in the 2006–20 Medium- and Long-Term Science and Technology Development Plan (MLP) and the parallel 2006–20 Medium- and Long-Term Defense Science and Technology Development Plan (MLDP). The MLP defined indigenous innovation as the promotion of original innovation by reassembling existing technologies in different ways to produce new breakthroughs and absorbing and upgrading imported technologies. Meanwhile, the MLDP prioritized implementing policies and measures that supported the importation, absorption, and re-innovation of foreign technology. Taken together, these plans and strategies emphasized the importance of the transfer of commercial technologies to military use and called on the Chinese arms industry to not only develop dual-use technologies but also actively promote joint civil-military technology cooperation.

During this period, China focused on dual-use technology development and subsequent spin-on of microelectronics, space systems, new materials (such as composites and alloys), propulsion, missiles, computer-aided manufacturing, and IT. During 1997–2017, Beijing worked both to encourage further domestic development and growth in these key sectors and to expand linkages and collaboration between China's military-industrial complex and civilian high-tech sectors. Factories were also encouraged to invest in new manufacturing technologies, such as computer-aided design, computer numerically controlled multi-axis machine tools, computer-integrated manufacturing systems, and modular construction in shipbuilding. They were also urged to embrace Western management techniques. In 2002, for example, the Chinese government created a new industry enterprise group, the China Electronics Technology Group Corporation, to promote national technological and industrial developments in defense-related electronics. In addition, under the 10th Five-Year Plan (2001–5), many technology breakthroughs generated under the 863 Program were finally

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21 Hagt, "Emerging Grand Strategy for China's Defense Industry Reform," 514–18; Mulvenon and Tyroler-Cooper, "China's Defense Industry on the Path of Reform," 35–37, 38–43; and Tai Ming Cheung, "Dragon on the Horizon: China's Defense Industrial Renaissance," *Journal of Strategic Studies* 32, no. 1 (2009): 47.

22 Mulvenon and Tyroler-Cooper, "China's Defense Industry on the Path of Reform," 5.

slated for development and industrialization. Defense enterprises formed partnerships with Chinese universities and civilian research institutes to establish technology incubators and undertake cooperative R&D on dual-use technologies, while foreign high-tech firms wanting to invest in China were pressured to set up joint R&D centers and transfer their technology. In this regard, it is worth noting that during the 10th Five-Year Plan, four times as much funding (22 billion yuan) was allocated to the 863 Program than during the entire period from 1985 to 2000.[23]

Chinese CMI efforts during 1997–2017 appear to have paid some dividends. China's aggressive development of advanced commercial technologies and their subsequent spin-on into the defense sector have been successful in a number of areas, such as electronics and information technologies, shipbuilding, aviation, space-launch vehicles, satellites, and advanced manufacturing. In particular, China's military shipbuilding sector appears to have benefited.[24] Following an initial period of low-end commercial shipbuilding—such as the production of bulk carriers and container ships—since the mid-1990s China's shipyards have increasingly progressed toward more sophisticated ship design and modular construction. To this end, they modernized and expanded operations, built huge new dry-docks, acquired heavy-lift cranes and computerized cutting and welding tools, and more than doubled shipbuilding capacity. At the same time, Chinese shipbuilders entered into a number of technical cooperation agreements and joint ventures with shipbuilding firms in Japan, South Korea, Germany, and other countries, which gave them access to advanced ship designs and manufacturing technologies. As a result, Chinese military shipbuilding programs, which are usually collocated at shipyards engaged in mostly commercial activities, were able to leverage these considerable infrastructure and software improvements for design, development, and construction. One outcome of these efforts was the comparatively higher quality and capacity of warships being delivered to the PLA Navy.[25]

China's rapidly expanding aircraft and space industry also spurred the development and application of dual-use technologies that are basically commercial in nature but also serve military purposes. For example, to enter the large commercial aircraft market, in 2008, Beijing created the state-owned Commercial Aircraft Corporation of China (COMAC), which

23 Warden, "A Revolutionary Evolution."

24 Bitzinger, "Civil-Military Integration and Chinese Military Modernization."

25 Evan S. Medeiros et al., *A New Direction for China's Defense Industry* (Santa Monica: RAND Corporation, 2005), 140–52.

openly views its mission as equally important as the nation's development of nuclear weapons or the launch of its first satellite. China currently has two passenger jets in and near commercial production, respectively: the ARJ21 regional jet and the C919 narrow-body jet. Other passenger jets are also envisioned, and COMAC has begun to plan for the production of two wide-body airliners: the 300-seat CR929 and the 400-seat C939.[26] These projects are expected to have spin-on effects for China's defense sector, particularly for the design and production of large military aircraft such as bombers and transport aircraft. Likewise, CMI has advanced China's space-launch business and its emerging capacities for the development and manufacture of various spacecraft, including telecommunications satellites, the BeiDou navigation satellite system, and the Yaogan and Ziyuan earth observation satellites. In addition, many of the technologies being developed for commercial reconnaissance satellites, such as charge-coupled device cameras, multispectral scanners, and synthetic aperture radar imagers, have obvious spin-on potential for military systems.

During this same period, the PLA benefited from the development and growth of China's commercial information and communications technology (ICT) industry. As James Mulvenon and Rebecca Samm Tyroler-Cooper have pointed out, the Chinese military electronics, communications, and information systems have always been a special case when it comes to R&D and production, benefiting from a "digital triangle" comprising the PLA (as a sponsor of commercial-to-military spin-on), China's increasingly sophisticated commercial ICT industry, and state laboratories, research institutes, and R&D funding institutions. In particular, the PLA has been aided by the "growing use of COTS [commercial off-the-shelf technologies]," which permit it to "directly benefit from the globally competitive output of China's commercial IT companies."[27]

Problems with Earlier CMI Efforts[28]

Despite these achievements, China's CMI efforts—particularly in commercial-to-military spin-on—remained limited. There has been so far little evidence of any significant CMI in other sectors of the Chinese defense industry, even in the aviation industry, where one might expect it to be a naturally occurring phenomenon. Commercial and military aircraft

26 The CR929 is a collaborative project with Russia's United Aircraft Corporation.

27 Mulvenon and Tyroler-Cooper, "China's Defense Industry on the Path of Reform," 35–37.

28 This section draws on Bitzinger, "Civil-Military Integration and Chinese Military Modernization."

manufacturing is still carried out not only on separate production lines but also in separate facilities and enterprises, with little apparent communication or crossover between these compartmentalized operations. Moreover, with the exception of helicopters (and possibly transport aircraft), the technological overlap between civil aviation and military aircraft is small and not conducive to CMI. As such, there are few opportunities to share personnel, production processes, and materials, and perhaps even fewer prospects for joint R&D or collocated production.

Likewise, China's overall record of indigenous high-tech development and innovation has been mixed, further limiting opportunities for CMI. Gaps and weaknesses still exist in China's science and technology base, and little indigenous design and manufacturing actually take place in many of China's high-technology sectors. Rather, high-tech production is still oriented toward the fabrication of relatively mature consumer or commodity goods, such as DVD players or semiconductors, built according to original equipment manufacturer specifications. For the most part, from the early 1980s to the 2000s, China still lacked sufficient numbers of skilled designers, engineers, scientists, and technicians in crucial high-tech sectors, and so most high-end items, such as microprocessor chips, had to be imported. Finally, many of the country's high-tech incubators are still in their nascent stage, and China continues to spend relatively little on high technology compared to the United States and the rest of the West.

At the same time, much of China's high-tech R&D and industrial base was still heavily foreign-controlled, particularly during the early part of this period. Foreigners owned virtually all of China's high-tech intellectual property and most of its manufacturing capacity (e.g., semiconductor plants). As such 85% of China's high-tech exports came from foreign-owned companies or joint-venture operations. In addition, many foreign-established R&D centers were actually geared more toward training and education than joint science and technology development.[29] In general, therefore, China's CMI remained limited in scope and operation, and both civilian and military authorities were unable to formulate or implement a specific strategy for effectively exploiting CMI. As one consequence, the development, as well as importation, of defense-specific technologies continued to be crucial in the modernization of the country's military-industrial complex and the development of next-generation weapons systems.

[29] Kathleen A. Walsh, written testimony for the Hearing before the U.S.-China Security Review Commission, January 17, 2002.

Overall, in both of these earlier periods, China's CMI efforts turned out to be much less successful than expected. Central authorities struggled to entice commercial enterprises to transition to defense work or partner with defense firms on joint projects that would entail diffusing technologies and innovations to the military. Consequently, according to Tai Ming Cheung, less than 1% of China's commercial high-tech firms were ever engaged in defense work, and as a result, CMI "barely scratched the surface of the Chinese economy."[30] There still existed many impediments to deepening and broadening engagement, including weak institutions, mechanisms, and guidelines to promote and support CMI; high barriers between civilian enterprises and the defense market; corporate parochialism on both sides (commercial firms were too often overly protective of their intellectual property, while military secrecy made technology-sharing problematic); insufficient resource-sharing; and underdeveloped industries dedicated to CMI.[31] Overall, until well into the second decade of the 21st century, civilian firms were still only tangentially engaged in armaments production.

MILITARY-CIVIL FUSION UNDER XI JINPING: TURNING A NEW PAGE?

Although the term "military-civil fusion" was used by then general secretary Hu Jintao as far back as the 17th Party Congress in 2007, MCF is mostly associated with Xi Jinping.[32] As previously mentioned, in 2015 he announced the "aligning of civil and defense technology development" as a national priority.[33] In addition, China's 2015 white paper on military strategy called for an "all-element, multi-domain, and cost-efficient pattern of CMI." Nevertheless, it was not until the 19th Party Congress in October 2017 that Xi fully realized his MCF vision. As Lucie Béraud-Sudreau and Meia Nouwens state:

> The deepening of the CMI policy can be interpreted both as a way to tackle the lack of competitiveness and the lack of innovation. This has become an integral part of Xi's strategy to complete the modernization of China's armed forces by 2035 and turn them into a world-class army by midcentury. Xi reiterated

30 Tai Ming Cheung, "The Chinese Defense Economy's Long March from Imitation to Innovation," *Journal of Strategic Studies* 34, no. 3 (2011): 343–44.

31 Lafferty, Shraberg, and Clemens, "China's Civil-Military Integration," 58–60.

32 Warden, "A Revolutionary Evolution."

33 U.S. Department of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China* (Washington, D.C., 2019), 21.

> the importance of CMI for China and for the PLA by declaring at the 19th Party Congress that "we will...deepen reform of defense-related science, technology, and industry, achieve greater military-civilian integration, and build integrated national strategies and strategic capabilities."[34]

In 2017, Beijing created the Central Commission for Integrated Military and Civilian Development, a new and powerful body for overseeing MCF strategy and implementation. The same year, China issued the 13th Five-Year Special Plan for Science and Technology MCF Development, which "detailed the establishment of an integrated system to conduct basic cutting-edge R&D in AI, bio-tech, advanced electronics, quantum, advanced energy, advanced manufacturing, future networks, [and] new materials," in order "to capture commanding heights of international competition."[35]

After 2017, MCF appears to differ from earlier efforts at CMI in several critical ways. First, it seeks to fully integrate the civilian industrial base into the PLA's supply chain. For the first time, nondefense companies are being encouraged to sell directly to the military.[36] Second, MCF is being explicitly used to help China's military access critical 4IR technologies, particularly AI. MCF entails the militarization of AI, which the PLA sees as critical for such tasks as command and control, intelligence processing, targeting, and navigation.[37]

Third, given the demand for cutting-edge commercial technologies, MCF inevitably necessitates the redirection of foreign technologies to support the modernization of the PLA. This is because much of China's high-tech industrial base is still highly dependent on imported technologies, designs, and manufacturing equipment and processes. In many instances, the Chinese government is encouraging private firms to acquire foreign technology for the PLA.[38] This, in turn, risks making foreign companies

34 Béraud-Sudreau and Nouwens, "Weighing Giants," 12.

35 Tai Ming Cheung, "From Big to Powerful: China's Quest for Security and Power in the Age of Innovation," East Asia Institute, Working Paper, April 4, 2019, 12.

36 Chriss Street, "Chinese Army Employs Military-Civil Fusion to Weaponize Industrial Base," *Epoch Times*, September 30, 2019 ~ https://www.theepochtimes.com/chinese-army-employs-military-civil-fusion-to-weaponize-industrial-base_3101117.html.

37 Kathrin Hille and Richard Waters, "Washington Unnerved by China's 'Military-Civil Fusion,'" *Financial Times*, November 7, 2018 ~ https://www.ft.com/content/8dcb534c-dbaf-11e8-9f04-38d397e6661c.

38 Kate O'Keefe and Jeremy Page, "China Taps Private Sector to Boost Its Military, Raising Alarms," *Wall Street Journal*, September 25, 2019 ~ https://www.wsj.com/articles/china-taps-its-private-sector-to-boost-its-military-raising-alarms-11569403806.

de facto suppliers to the PLA.[39] Consequently, the U.S. government is increasingly concerned that normally benign technology transfers and commercial joint ventures between U.S. and Chinese private companies could inadvertently help the PLA become a more technologically advanced adversarial force. There is particular concern that algorithms used for AI and machine-learning—some of the most complex software and therefore the hardest to copy—would be particularly vulnerable to theft. Nevertheless, as Christopher Ford, then U.S. assistant secretary for international security and nonproliferation in the U.S. Department of State, noted, MCF means that "it is very difficult and in many cases impossible to engage with China's high-tech sector in a way that does not entangle a foreign entity in supporting ongoing Chinese efforts to develop or otherwise acquire cutting-edge technological capacities for China's armed forces."[40]

Finally, and perhaps most importantly, MCF is part of a long-term and broad-based strategic effort by Beijing to position China as a technological superpower by pursuing both guns and butter and having them mutually support each other. According to Greg Levesque, Chinese leaders are using MCF to position the country "to compete militarily and economically in an emerging technological revolution."[41] In this respect, Chinese MCF is much more ambitious and far-reaching than any present U.S. efforts at CMI, particularly in terms of China's determination "to fuse defense and commercial economies."[42] According to Lorand Laskai, "since Xi Jinping ascended to power in 2012, civil-military fusion has been part of nearly every major strategic initiative, including Made in China 2025 and Next Generation Artificial Intelligence Plan."[43]

It should therefore come as no surprise to see that MCF has intertwined military modernization with civilian innovation in a number of critical dual-use technology sectors, including aerospace, advanced equipment manufacturing, AI, and alternative sources of energy. At the

39 Derek Scissors and Daniel Blumenthal, "China Is a Dangerous Rival, and America Should Treat It Like One," *New York Times*, January 14, 2019 ~ https://www.nytimes.com/2019/01/14/opinion/us-china-trade.html.

40 Christopher Ashley Ford, "Huawei and Its Siblings, the Chinese Tech Giants: National Security and Foreign Policy Implications," U.S. Department of State, September 11, 2019 ~ https://www.state.gov/huawei-and-its-siblings-the-chinese-tech-giants-national-security-and-foreign-policy-implications.

41 Greg Levesque, "Military-Civil Fusion: Beijing's 'Guns AND Butter' Strategy to Become a Technological Superpower," Jamestown Foundation, China Brief, October 8, 2019.

42 Lorand Laskai, "Civil-Military Fusion: The Missing Link between China's Technological and Military Rise," Council on Foreign Relations, January 29, 2018 ~ https://www.cfr.org/blog/civil-military-fusion-missing-link-between-chinas-technological-and-military-rise.

43 Ibid.

same time, MCF also "involves greater integration of military and civilian administration at all levels of government: in national defense mobilization, airspace management and civil air defense, reserve and militia forces, and border and coastal defense."[44] As Laskai notes, the PLA Strategic Support Force, which was established in 2015 and is responsible for space, cyber, and electronic warfare, has "energetically built ties outside the military, signing cooperation agreements with research universities and even stationing officers within an unnamed software development company."[45] Moreover, it is important to recognize that Xi's "personal legitimacy" is increasingly tied to the success or failure of MCF. According to Toby Warden, MCF is categorically entwined with "long-term party planning" and "party consensus," and any move to scale back this strategy would come at a great cost to Xi's authority.[46]

CONCLUSION

China is only at the beginning of an arduous, multiyear (or even multidecade) effort to leverage advanced commercial technologies for the advancement and modernization of the PLA. There is no certainty that Xi Jinping's MCF initiatives will work better than earlier efforts at CMI. According to Béraud-Sudreau and Nouwens, many obstacles remain, including "the private sector's lack of access to large-scale and high-tech facilities and experimental instruments" and the question of whether private-sector companies will get permission and clearances to work on larger and more sensitive projects or "simply be used to supply less sensitive components."[47] Nevertheless, it is unlikely that Xi, the Chinese Communist Party, or the PLA will walk away from MCF anytime soon, even if the program does experience setbacks. As Warden states, "the Party-state's long-term ambitions [for MCF] should not be underestimated," and China's "doctrine" of MCF will continue to serve as a "guiding principle" for its long-term strategy of parallel economic development and military modernization.[48]

Moreover, should China successfully implement MCF and achieve significant results in terms of military-technological advances, the results

44 Levesque, "Military-Civil Fusion."

45 Laskai, "Civil-Military Fusion."

46 Warden, "A Revolutionary Evolution."

47 Béraud-Sudreau and Nouwens, "Weighing Giants," 12.

48 Warden, "A Revolutionary Evolution."

could pose a worrying challenge to the United States and its allies in the Indo-Pacific. Altogether, the PLA is proceeding apace to develop robust A2/AD capacity within the first island chain, eventually expanding farther into the Pacific Ocean. As China shifts toward intelligentized warfare,[49] MCF will be a key component of the PLA's overall strategy to achieve "complete military modernization" by 2035 and become a "world-class" military by 2049. ◈

49 U.S. Department of Defense, *Annual Report to Congress 2020*, 161–62.