

The Competitive Challenge of Military-Civil Fusion

Testimony to the U.S.-China Economic Security Commission for Hearing on “China’s Pursuit of Defense Technologies”

Elsa B. Kania*

13 April 2023

As the United States and its allies continue to reckon with China’s rise, military-civil fusion must be recognized as a consequential component of Beijing’s strategy to catch up with and ultimately surpass the United States. This agenda has particularly concentrated on new frontiers and emerging technologies, where American advantage is neither assured nor unassailable. The pursuit of military-civil fusion may be especially impactful in new domains, such as space, cyberspace, and the deep seas, and in strategic technologies, including robotics, artificial intelligence, and quantum computing. Looking forward, while military-civil fusion is unlikely to provide the truly seamless integration that the CCP aspires to achieve, this initiative is nonetheless a critical enabler of China’s rise as a global military power.

The PLA today, while untested, has continued consistently exceeding expectations and outpacing previous predictions on the trajectory of its military modernization. Once, a not uncommon assumption in U.S. defense circles was that the PLA was unlikely to be creative or truly innovative, whether in its development of new generations of weapons systems or introduction of new concepts of operations. However, China’s efforts in military-civil fusion raises the risks of technological surprise, even as this agenda remains incomplete and aspirational, likely falling short of achieving the true fusion that the CCP seeks to create. While China’s military-civil fusion initiatives are sometimes surprisingly transparent, including because of the need to release publicly available information to implement a strategy of such complexity with multiple stakeholders, there are nonetheless a number of gaps in information, as well as a trend toward increased controls on information by the CCP, that can impede analysis. This agenda will continue to raise complex issues and competitive challenges for U.S. policy.

The scope and scale of military-civil fusion is probably on track to exceed comparable American initiatives, based on the available indicators. There is no definitive answer at this point regarding the current magnitude of this agenda, nor obvious assessments of the prospects for success on various fronts, and direct comparisons between the U.S. and Chinese defense economies and innovation ecosystems are challenging at best. However, the CCP’s capacity to mobilize resources to pursue a systemic approach may be unique and has been enabled by centralized guidance that creates incentives and direction for a range of local initiatives. Ultimately, military-civil fusion is likely to remain at the core of the PLA’s drive to become a “world-class” military that aspires to achieve military-technological advantage on the future battlefield.¹ This testimony seeks to highlight several salient trends and issues in the current trajectory of military-civil fusion for the Commission’s consideration.

Imperatives for Military-Civil Fusion

* Elsa Kania is an Adjunct Senior Fellow with the Center for a New American Security and a PhD candidate in Harvard University’s Department of Government. Her views are her own. This testimony builds upon previous research and ongoing analysis, based entirely on open sources.

For China, military-civil fusion is framed as a grand strategy that seeks to create and leverage synergies between economic development and military modernization.² The objective has been to create an “integrated national strategic system and capabilities,” as articulated by Xi Jinping on multiple occasions.³ That is, military-civil fusion is intended to promote a deeper integration of China’s civilian and defense economies, along with their respective technological ecosystems, such that resources will be combined and advances will be mutually reinforcing. While aspects of military-civil fusion have been inspired by or even explicitly emulate U.S. initiatives, this strategy is more ambitious by far and more far-reaching in taking a systemic approach. The enablers of military-civil fusion include not only equipment and technology but also data, capital, and personnel. Beyond defense technology, this approach is also applied in such contexts as emergency response and national defense mobilization, such as for a conflict scenario, which highlights the strategic relevance.⁴

China’s pursuit of military-civil fusion is intended to bolster national security and development and to enable competitive advantage in strategic competition.⁵ At the same time, this strategy is aimed at overcoming previously persistent challenges within its military research, development, and acquisition ecosystem. Beyond the usual players in the Chinese defense industry, including the state-owned enterprises that have been dominant traditionally, a new ecosystem of technology companies has emerged, ranging from national champions with global reach to newer start-ups, of which a number have prioritized participating in military-civil fusion as core elements of their business models. In this regard, PRC policies that have aimed to lower barriers to entry for emerging enterprises, along with a range of initiatives and incentives for companies to contribute to defense, have the potential to be impactful. Beyond the efforts of military research institutions, military-civil fusion initiatives sought to expand academic partnerships, aiming at cutting-edge research and development in new frontiers of technological development.

Beijing’s decision to pursue military-civil fusion is inherently a reaction to changing technological circumstances. With the progression of the latest industrial revolution, which is also believed to be catalyzing a Revolution in Military Affairs (RMA), operationalizing emerging technologies with dual-use potential is regarded as a strategic imperative for the PLA to contest future military advantage. Increasingly, the center of gravity for innovation has shifted from states towards commercial enterprises that have become leaders in technological development, increasingly pioneering advances that states are seeking to capitalize upon. China’s dynamic, competitive, and expanding ecosystem of technology companies has become globally unique and has the potential to prove distinctively advantageous. However, the proportion of Chinese technology companies that are actively engaged with the PLA is likely to remain limited in the near term. The potential for Chinese companies to be coerced to transfer technologies to the PLA, a possibility often raised in U.S. policy debates, is relevant and certainly feasible considering the Party-state’s coercive capacity.⁶ However, such a practice is unlikely to be a systemic or scalable solution, and PRC policies have primarily concentrated on incentives and systemic reforms.

For China, the underlying objectives of military-civil fusion are to challenge and ultimately undermine American military-technological advantage. To date, the achievements of military-civil fusion have been uneven across various lines of efforts with more headway achieved in

emerging industries and less traction in more traditional defense sectors. The urgency of this agenda will likely continue to be heightened, as strategic competition intensifies and as U.S. policies come into play that Beijing regards as attempts at technological containment. The PRC's emphasis on "self-reliance and self-strengthening" (自立自强) has been elevated under the 14th Five-Year Plan and reiterated in Xi's remarks on multiple occasions. Chinese leaders have been especially concerned with U.S. efforts to restrict access to sensitive "chokepoint" technologies, especially semiconductors.⁷ For instance, at the "Two Sessions" in March 2023, Xi also emphasized the need to "strengthen the direction on defense science and technology industry in the service of strengthening the military and winning wars."⁸

Beyond military-civil fusion, the CCP has also invoked the concept of "military-civil unity" (军民团结), which Xi Jinping has characterized as an "important magic weapon" to overcome grave national security challenges.⁹ As the CCP has started to regard the international environment as more hostile and contentious, the aphorism has been invoked: "If the military and the people are united as one, who under heaven can try to resist" (军民团结如一人，试看天下谁能敌), a sentiment that can be traced back to the time of Mao Zedong. The idea of military-civil unity also implies the solidarity such as was required previously in times of crisis or conflict and could be necessary mobilization and national preparations for a future conflict scenario.

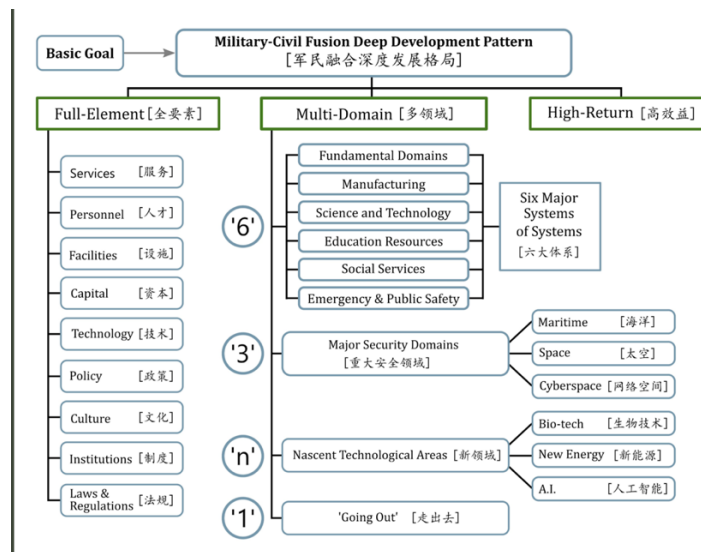
While the potential that military-civil fusion could be successful as a strategy cannot be discounted, the prospects remain uncertain, and future progress will likely remain uneven across various domains. To some extent, Xi Jinping's emphasis on and elevation of military-civil fusion reflected the urgency and severity of issues that had plagued China's defense innovation ecosystem previously, which have yet to be fully resolved. There can be a gap between ambition and reality; to be sure, CCP discussion of military-civil fusion or propaganda narratives about the importance of military-civil fusion and unity can outpace or precede demonstrable progression. However, to the extent that results may fall short of the ambition articulated, that is unlikely to be due to a lack of resourcing, given the tens of billions reportedly dedicated to this agenda based on ample evidence of extensive funding and investments.¹⁰

Progression of Military-Civil Fusion

The CCP's decision under Xi Jinping's leadership to elevate military-civil fusion to the level of national strategy was likely intended to accelerate the advancement of this initiative. Xi's repeated exhortations to advance military-civil fusion are also indicative of the perceived imperative to catalyze progress and overcome prior inertia. The PRC's previous attempts to improve levels of military-civil integration (军民结合) had seemingly stalled without achieving the full effects desired.¹¹ Among the recurrent problems for military-civil fusion had been insufficient top-level coordination, limited opening of military industry to new entrants, and inadequate sharing of resources, among other factors.¹² However, since 2013, Xi has overseen what might be considered a new era of military-civil fusion, through introducing of an array of plans and policies. Through newer and traditional stakeholders participating in this national program, military-civil fusion has been increasingly institutionalized with its reach and national importance reinforced over time.

The emphasis on military-civil fusion has played out through a series of central policies that have catalyzed local initiatives.[†] In 2016, SASTIND (国防科工局, the State Administration of Science, Technology and Industry for National Defense) issued the “Opinion on Accelerating and Advancing S&T Collaborative Innovation in National Defense S&T Industry” (关于加快推进国防科技工业科技协同创新的意见).¹³ This directive called for China to establish national defense laboratories and industry innovation centers, seeking to improve the overall defense science and technology enterprise with military-civil fusion as a core feature. The CCP Central Committee, State Council, and Central Military Commission also jointly released the “Opinion on the Integrated Development of Economic Construction and National Defense Construction (关于经济建设和国防建设融合发展的意见) in 2016.¹⁴ The opinion highlighted the importance of creating a “full-factor, multi-domain, highly effective” plan for the development of military-civil fusion” with primary objective to ensure “economic construction provides a more solid material foundation for national defense construction, and national defense construction provides more powerful security assurance for economic construction.”¹⁵

In practice, this model of development seeks to leverage all relevant resources to enable progress across a series of priorities. These range from core functions, such as national emergency response, to key domains and emerging technologies.



Source: Alex Stone and Peter Wood, “China’s Military-Civil Fusion Strategy: A View from Chinese Strategists”

The CCP has since consistently reinforced and enhanced the implementation of military-civil fusion. The Central Commission for the Development of Military-Civil Fusion (中央军民融合发展委员会) was established and initially convened in 2017, with Xi Jinping serving personally as the director.¹⁶ This new committee was intended to provide an organizational framework to coordinate economic and defense developments at the highest levels, in an endeavor that has often been characterized as possessing the complexity of systems engineering.¹⁷ When the 19th

[†] This is not intended to provide a comprehensive discussion of military-civil fusion, recognizing a more detailed description of the range of policies and initiatives relating to military-civil fusion is beyond the scope of this testimony.

CCP National Congress approved an update to the Party constitution in October 2017, this revision clearly enshrined Xi's priorities, to include military-civil fusion as a major strategy for development, among other state strategies.¹⁸ In 2018, the Military-Civil Fusion Development Strategy Outline (军民融合发展战略纲要) reportedly introduced a formal framework for the development of military-civil fusion as a national strategy, yet only limited information is available, since the strategy in full has not been released publicly.¹⁹

Across the 13th and 14th Five-Year Plans, military-civil fusion has been an evident emphasis for the CCP. As of August 2017, the 13th Five-Year S&T Military-Civil Fusion Special Projects Plan (科技军民融合发展专项规划) highlighted the extent to which military-civil fusion is emphasizing the pursuit of emerging technologies, including intelligent unmanned systems, quantum computing and communications, and brain-inspired intelligence.²⁰ The 14th Five-Year Plan reaffirmed these priorities, declaring, "We will deepen military-civil S&T collaboration and innovation, strengthen military-civil overall development planning for maritime, aerospace, cyberspace, biotechnology, new energy, artificial intelligence, quantum technology, and other fields."²¹ The focus on these critical technologies has been reflected in partnerships and local or regional programming that has concentrated on these technologies through leveraging local strengths and clusters of expertise.²²

Stakeholders for Military Civil Fusion

The implementation of military-civil fusion extends from central guidance to local initiatives with multiple organizations involved in guidance, oversight, and implementation. The Central Military-Civil Fusion Development Committee oversees and provides the high-level coordination for this agenda.²³ This role and structure are replicated across provinces; even municipalities have established their own mechanisms. At the central level, SASTIND has also introduced guidance and overseen specific programming, such as a series of "special action plans."²⁴ The Ministry of Industry and Information Technology has established a Military-Civil Fusion Promotion Department (军民融合推进司).²⁵ The degree to which there is effective coordination among these varied organizations and stakeholders is difficult to ascertain.

Within the PLA, the Central Military Commission (CMC) provides guidance and leadership for Chinese military, to include defense science and weapons development and acquisitions. The CMC Strategic Planning Department has established a Military-Civil Fusion Bureau (军民融合局) that is likely responsible for long-term planning and strategic design.²⁶ The CMC Equipment Development Department has created a new website to facilitate procurement that opens up the process to new companies and also oversees the EDD Military-Civil Fusion Joint Fund, about which limited information is available.²⁷ The CMC Science and Technology Commission has established a Military-Civil Fusion and Achievement Transformations Office (军民融合与成果转化办公室).²⁸ There are also multiple examples of initiatives and outreach occurring at the level of services and theater commands, such as the PLA Rocket Force engagement with civilian technical experts.²⁹

PLA scientific institutions have also facilitated research and program focused on military-civil fusion in emerging technologies. In 2018, the Chinese Academy of Sciences and Academy of

Military Sciences signed a strategic cooperation agreement for joint research projects, including in energy and new materials, and collaboration on talent training.³⁰ Notably, the PLA's AMS established a new National Defense S&T Innovation Research Institute (国防科技创新研究院),³¹ which encompasses an Artificial Intelligence Research Center, Unmanned Systems Research Center, and Frontier Cross-Domain Technology Research Center, which has actively recruited new personnel, including a growing number of civilians.³² In Tianjin, the new AI Military-Civil Fusion Innovation Center (人工智能军民融合创新中心), associated with the National Supercomputing Center, was established by the local government and maintains a partnership with the Academy of Military Science.³³ There are many instances of such initiatives and emerging partnerships that have been announced, but the results so far are more difficult to evaluate.

Mechanisms for Military-Civil Fusion

Across China within the past decade, there has been a surge in efforts to promote military-civil fusion through multiple modalities. These include: new platforms and funding mechanisms to open up military contracts to commercial enterprises; research institutes and joint laboratories focused on military partnerships with academic or commercial enterprises for dual-use research; a range of funds dedicated to military-civil fusion that can combine or coordinate governmental and commercial investments; local initiatives across multiple cities and provinces military-civil fusion bases for innovation and demonstration that bring in private companies and facilitate their relationships with military stakeholders; and PLA convening/sponsorship of challenges and competitions, among other elements.

While a comprehensive discussion of these efforts is beyond the scope of this testimony, a review of several examples of potential interest can highlight the range of these activities.

Opening Options for Procurement:

The PLA Equipment Development Department created a new website focused on military armaments requirements in 2015, which publishes notices for procurement and relevant information.³⁴ The release of requirements and advertisement of opportunities on the website was intended to open up the process and break down barriers on information in order to open up competition, and the advertisements have often highlighted the PLA's interest in acquiring new and emerging capabilities.³⁵

'Agile' Exploitation of Commercial Technologies:

CMC S&TC notably launched the Agile Innovation Defense Unit (AIDU), the "defense S&T innovation rapid response small group" (国防科技创新快速响应小组), which concentrates on leveraging commercial technologies, in 2017.³⁶ Not unlike the U.S. Defense Innovation (DIU) that was likely its inspiration and *de facto* namesake, the Agile Innovation Defense Unit (AIDU), which was first stood up in Shenzhen and has since established units in Dalian, Chongqing, and Shaanxi, has released calls for technology solutions, organized competitions, and facilitated partnerships with commercial enterprises.³⁷

This new model for rapidly developing and accessing commercial technologies does demonstrate the PLA's capability and willingness to experiment and progress in scaling and implementing with new models. For instance, AIDU has supported efforts ranging from COVID response capabilities to drone swarming and autonomy.³⁸ Typically, projects focus on a short timeline for delivery of a new technology or capability.

MCF Funds and Guidance Funds

The PRC's implementation of military-civil fusion initiatives has drawn upon new sources of funding for scaling and sustainment. In December 2017, State Council opinion released called for policies that were supportive of 'social investment' into military-civil fusion and "expand investment and financing channels" to promote military-civil fusion.³⁹ In practice, this has involved efforts to establish funds for investments in priority military-civil fusion industries with local governments encouraged to launch their own funds to promote high-tech military industries.

Even as sizable figures are associated with military-civil fusion, the actual allocation of resources is difficult to ascertain. There were ostensibly tens of billions of RMB (or several billion dollars in counting) of funding dedicated to military-civil fusion between ~2016 and ~2020, with funds launched across Sichuan, Shanghai, Hebei, Henan, Guangdong, Zhejiang, Shaanxi, Guizhou, Hunan, Heilongjiang, Liaoning, among other cities and provinces. For instance, one fund for military-civil fusion launched in 2016 reportedly involved ~30.2 billion RMB or ~\$4.4 billion in its initial round of funding.⁴⁰ The Ministry of Finance established the National Military-Civil Fusion Industry Investment Fund (国家军民融合产业投资基金), which was intended to direct investments to align with central requirements.⁴¹ However, the amounts of funding announced do not necessarily correspond to the amount actually invested, nor are the likely returns on investment clearly identifiable.

Industry Alliances

A number of military-civil fusion industry associations have promoted active and ongoing engagement between defense and commercial stakeholders. For instance, the high-tech zone of Zhongguancun has focused on advancing military-civil fusion in emerging technologies. The Zhongguancun Joint Innovation Military-Civil Fusion Industry Alliance has grown to include ~600 members and has reportedly facilitated research sharing and collaborative innovation in critical industries.⁴²

Local Zones and Initiatives

The central emphasis and strategic guidance for military-civil fusion have provided impetus and created ample incentives for local initiatives. China's numerous industrial parks and "innovation demonstration" zones dedicated to military-civil fusion also help create conditions for 'clustered development' with critical synergies between scientists and enterprises.⁴³ For instance, Hainan has established a military-civil fusion innovation demonstration zone focused on maritime technologies, especially deep sea technology.⁴⁴

Competitions

The PLA has organized a range of challenges and competitions intended to promote creative solutions to operational problems. These competitions integrate involvement of research institutes, private enterprises, and other stakeholders in addition to traditional state-owned enterprises. For example, the PLA Army has organized a series of events known as “Striding Across Obstacles” (跨越险阻), which started in 2016, an annual challenge series intended to promote the development of UGVs organized by the PLAA Equipment Development Department.⁴⁵ Similarly, the PLA Navy organized a competition concentrating on the development of unmanned surface vessels.⁴⁶ The PLA Strategic Support Force has engaged with space and cyber security companies on talent and training.⁴⁷ The PLA Rocket Force has sponsored the “Smart Arrow·Fire Eye” (智箭·火眼) competition focused on AI-enabled image detection and recognition, advances that could facilitate automated targeting.⁴⁸ In 2020, the PLA CMC Equipment Development Department organized challenge based on an AI wargaming platform applied to a joint operations. This contest, titled “Stratagem at Heart, Jointness to Win” (谋略方寸·联合制胜), focused on leveraging wargaming as environment in which to develop algorithms capable of enabling future joint operations.⁴⁹

New-Type Militias and Mobilization

China’s militias have been starting to engage in more active and regular training with the PLA’s services and theater commands.⁵⁰ As the PLA shifts its focus to new-type forces, militias have looked to leverage local high-tech industries to contribute to force construction. For instance, Shanghai initially established a UAV militia unit as early as 2015, primarily for purposes of reconnaissance.⁵¹

Future militia and reserve forces construction intend to emphasize new efforts to incorporate “talents from new professions related to wartime requirements,” including e-sports players and AI technicians to provide “technical support and talent guarantee” for winning future warfare.⁵² Increasingly, “new-type” militia units that have been established that specialize in emerging capabilities, including network protection and “online public opinion struggle.”⁵³ Within several municipalities or provinces, the creation of national defense mobilization alliances looked to prepare high-tech enterprises to contribute to this endeavor.⁵⁴

Challenges for Military-Civil Fusion

As has been the case for other Chinese initiatives, when military-civil fusion is declared as central priority, actors across the systems are inclined to brand their efforts accordingly, even those that are less relevant or impactful with that moniker. For every success, there will be some failures or, possibly, future corruption investigations. Indeed, the graft that has historically been a problem in the Chinese military and defense industry is unlikely to be truly overcome in this context. Across these varied programs, there is probably a level of waste, inefficiency, and redundancy beyond what would likely be tolerated in a U.S. context. While these issues may reduce the return on military-civil fusion initiatives and investments, the potential for long-term progress is likely to be prioritized over near-term yields.

China's efforts to enable and encourage technology companies to become involved in defense research and development have required reducing the practical obstacles to their participation. In some cases, the results have been ostensibly impactful; reportedly, for China's first domestically developed aircraft carrier, the 'rate' of military-civil fusion was reportedly nearly 80%.⁵⁵ However, Chinese scholars of military-civil fusion has raised concerns about the persistence of 'policy issues, institutional obstacles, and structural contradictions,' including because of inadequate top-level coordination and limited institutionalization of rule of law, along with insufficient market opening in the defense economy and inadequate resource sharing.⁵⁶ Moreover, Chinese companies initially didn't understand military requirements or the process of procurement. As such, efforts to mitigate such barriers were important to realize the full potential of military-civil fusion.

The question of how many Chinese companies have been engaged in the defense economy and how impactful their contributions have been remains difficult to evaluate. Only an estimated 1,000 private enterprises held the Weapons and Equipment Research and Production Certificate (武器装备科研生产许可证) as of 2016 data, a certificate that was required to participate in many projects related to advanced weapons systems.⁵⁷ As of 2018, an estimated 2,300 private companies had the Equipment Manufacturing Unit Qualification Permit (装备承制单位资格认证), a similar certification.⁵⁸ Chinese experts had estimated only 2% of China's private high technology enterprises were involved in defense projects as of 2019, primarily in support roles.⁵⁹

Anecdotally and based on incomplete data/estimates, the proportions of companies that are qualified and actively participating in military initiatives appears to have increased in the years since. Moreover, quantity is not necessarily the primary indicator, as a small number of impactful contributors can have disproportionate influence in some situations. However, it is likely that only a relatively limited proportion of private companies have participated in defense projects, and often enterprises developing technologies relevant to the military have found cutting through the red tape involved in procurement to be cumbersome, not unlike the frustrations of their American counterparts.⁶⁰ There have since been efforts to simplify certification requirements and mitigate the impact of previously expensive and burdensome processes.

Process for Certification

Previously, the timeline required for approval was too lengthy and time- and resource-intensive relative to the need for progress to keep pace with technological advancements.⁶¹ As one Beijing-based law firm described the previous situation, "the main obstacles to private sector participation in the military sector are found in the relatively high barriers to entry into the market, the intersecting management that exists, lengthy application cycles, and relatively high maintenance costs."⁶² This system was later simplified from four to three certificates in order to simplify and streamline the process.⁶³

Efforts in Standardization

Fundamental to the progression of military-civil fusion has been efforts to synchronize standards to enable seamless transfer of resources across domains. In 2018, the "Overall Plan for

Promoting Standardization of Military-Civil Integration Work”(统筹推进标准化军民融合工作总体方案) was created in order to “eliminate the problem of overlapping and repetitive conflicts between military and civilian standards” and create a compatible system for standards to enhance the implementation of military-civil fusion.⁶⁴ The later opinion on strengthening “Opinion on Further Strengthening the Standardization of Military-Civil Fusion” (关于进一步加强标准化军民融合工作的意见), released in 2019, also aimed to synchronize initiatives and avoid conflicting or redundant requirements.⁶⁵ Underlying these efforts is likely a recognition that the scope and complexity of military-civil fusion had resulted in efforts that weren’t clearly coordinated.

Issues of ‘Integrity’

The drive for military-civil fusion has likely generated corruption and inefficiencies that official oversight and initiatives have since sought to address. In July 2022, CMC Equipment Development Department and SASTIND the released of “Regulations on the Responsibility of Governance Integrity Supervision in Military Industry Departments” (军队行业部门廉政主管责任规定), the issuance of which corresponded with the launch of a ‘joint inspection’ of military industry.⁶⁶ While reporting on instances of corruption in military-civil fusion initiatives have been limited, these efforts to ‘clean up’ efforts and promote improved ‘integrity’ appear to reflect such concerns.

Lack of Legal Framework

For military-civil fusion to be effective and sustainable in the long term could eventually necessitate a more formal legalized framework. However, several previous proposals to create a law on military-civil fusion in order to legally institutionalize this initiative appear to have stalled since early drafts and proposals were first raised,⁶⁷ initially in 2012 and later in 2018.⁶⁸ Whether a law will be introduced to expand authorities, ensure protection of intellectual property to facilitate collaborations, and introduce legal requirements for military-civil fusion beyond the provisions of laws existing that mandate support for the military, remains to be seen.

Priority Domains for Military-Civil Fusion

The review of several priority domains for military-civil fusion can highlight the range and diversity of efforts that have been underway. Although comprehensive assessments of each technology or application are beyond the scope of this testimony, these examples are intended to illustrate trends and priorities, as well as several representative enterprises.

Unmanned Systems

The PLA’s leveraging of unmanned systems is uniquely expansive and uniquely exemplifies military-civil fusion. PRC-made drones, including many sold for primarily commercial applications, that have been found on the battlefield on both sides in Ukraine provides ample illustration of that phenomenon. DJI’s ‘RoboMaster S1’ (机甲大师 S1), a small UGV, has been reportedly employed for by the Eastern Theater Command urban warfare training.⁶⁹ Beyond the

UAVs that abound, Zhuhai Yunzhou-Tech (珠海云洲智能科技), which is recognized for its significant contributions to military-civil fusion, have developed a wide array of models and designs of unmanned surface vessels.⁷⁰ SUBLUE/DEEPINFAR (深之蓝) makes undersea robotic systems for defense and commercial applications and aspires to become the DJI of the undersea domain. The company has also established a partnership with Tianjin's AI MCF Innovation Center.⁷¹

Space

The expansion of national networks of satellite constellations has taken a typically dual-use approach. China's concern about the capability that StarLink presented had prompted the development of its own national counterpart and competitor. China SatNet (中国卫星网络集团), the newest state-owned enterprise, is involved in the creation of a "national network" (*Guowang*, 国网) satellite internet project, which would be composed of "low Earth orbit (LEO) constellations totaling 12,992 satellites."⁷² There are also several companies bringing enhanced analytic capabilities, such as ADASpace (国星宇航科技有限公司), which produces and operates AI-enabled satellites that seek to employ data processing capabilities as a central feature.⁷³

Cyberspace

Space and cyberspace are domains in which military-civil fusion has been active and successful. Qihoo360 is prominent in cyber security, not only as a leading company but also because of its apparent contributions to Chinese military cyber security and talent cultivation.⁷⁴ For instance, Tianmu Data (Fujian) Technology Co. (天目数据科技有限公司) has focused on big data, cyber security, and artificial intelligence, including in collaboration with the PLA.⁷⁵

Data Analytics and Artificial Intelligence

Several companies have positioned themselves as leaders in military applications of data analytics and artificial intelligence. For instance, Tianhe Defense (天和防务) has focused on big data services, as well as advanced electronics equipment, including in 5G.⁷⁶ StarSee (摄星智能) has focused on decision support systems that could support battle management applications.⁷⁷ DataExa (渊亭科技 or Yuanting S&T) has focused on cognitive decision-making intelligence for defense applications.⁷⁸

Deep Sea Technology

Several Chinese companies in the deep sea equipment industry have focused on military-civil fusion. For instance, Baoli (China Poly Group) Tiantong Deep Sea Equipment Technology (保利天同深海技术) Co., Ltd. has specialized in equipment, including underwater acoustic communications, acoustic navigation and positioning, and hydrophones.⁷⁹ Poly Tiantong has also participated in the Military-Civil Fusion Deep Sea Science and Technology International Innovation Park supported with Yunnan and Anning city⁸⁰

Chinese companies have expanded partnerships with the PLA with concentration on undersea communications. In 2016, the PLA Naval Engineering University jointly established the Undersea Optical Network Joint Laboratory (水下光网络联合实验室) in conjunction with Hengtong Optoelectronics, Zhongtian S&T Submarine Cable Co., Ltd. and the Beijing University of Posts and Telecommunications.⁸¹ The joint laboratory was intended to concentrate on research and development in optical communications, as well as integrated optical network design.⁸²

Wargaming

In the world of wargaming, the PLA is actively leveraging commercial partnerships to bring computerized wargaming into training and for national defense education. Increasingly, Chinese companies have become involved in the commercialization and popularization of wargaming, from tactical to more complex campaign scenarios that are variously historical and more contemporary. Huaru Technology (华如科技) specializes in the development of big data platforms and military simulations,⁸³ and the company has also marketed wargames focused on space and cyber operations.⁸⁴ Huashu Defense Technology (华戎防务), located in Beijing, has also designed several wargames for PLA purposes, including those used in recent tournaments and competitions.⁸⁵

Several Chinese companies also supply the PLA with battlefield simulation systems to facilitate training. Realis (瑞立视) is developing VR training rooms equipped with AI that allow for multi-person training, including for scenarios of counter-terrorism operations.⁸⁶ Beijing QingCloud S&T (青云科技) reportedly developed an “urban combat digital training environment system platform” integrating three-dimensional situation display, synchronous video display, and synchronous acquisition and storage of combat data.⁸⁷ Such systems could facilitate the PLA’s capacity to enhance the realism of its training and preparation for future conflict.

Policy Recommendations and Considerations

In closing, this testimony recognizes that military-civil fusion presents competitive challenges and raises a series of directions for policy recommendations.

1. Sustain and redouble investment in American science and innovation.

The increases in investment in academic research and critical technologies that have occurred under the Biden administration are welcome. Going forward, the consistency and sustainment of these efforts over time will be critical to enable long-term progress. So too, America’s trajectory and potential to remain a leader in science and technology will also depend, fundamentally, on the cultivation and retention of talent, which hinges upon policies in education and immigration.

2. Leverage the depth and capacity of U.S. capital markets to facilitate targeted investments in critical technologies.

Whereas China has implemented specific government programming to direct venture capital toward dual-use technology development, most such efforts in a U.S. context so far have occurred through private or independent initiatives. The U.S. government can expand efforts to partner more effectively with commercial stakeholders in order to identify available capital and resources to direct to advance the development and commercialization of critical technologies.

3. Scale up initiatives for flexible acquisitions to facilitate leveraging of commercial technologies.

The question of how the U.S. Department of Defense can best facilitate flexible partnerships with commercial enterprises and enable more adaptive acquisitions has long been the focus of much debate and concern. These issues take on greater urgency given current competitive challenges. The efforts of the Defense Innovation Unit, which have been impactful in enabling rapid prototyping of commercial technologies, could be further expanded and institutionalized.

4. Promote technology demonstration and operational experimentation across the joint force.

American leadership in innovation can only be operationally advantageous when applied and scaled. For instance, within under the auspices of U.S. Naval Forces Central Command (NAVCENT) the unique approach that Task Force 59 has taken to commercial partnerships, including the use of COCO (contractor owned, contractor operated) capabilities, and active operational experimentation, has been effective and provided a model that can be explored and possibly expanded across other fleets. The introduction of similar initiatives in the Indo-Pacific as well—and in conjunction with our allies and partners—could be effective to enhance U.S. agility in innovation adoption.

5. Enhance capacity for a targeted approach to technology protection.

When it comes to export controls on sensitive technologies or research integrity measures aimed to increase oversight of academic research, a core concern and debate remains how to strike a balance and to imply measures in a manner that mitigates damage to U.S. academic research and commercial collaborations.

6. Expand upon and bolster multilateral coordination with allies and partners.

To be effective, U.S. policy measures must be multilateral and coordinated with allies and partners. For these initiatives to be effective requires information- and intelligence- sharing, as well as the exchange of lessons learned in policy and process.

7. Enhance efforts to leverage open-source resources to inform research and policymaking.

Today, there are reasons for urgent concerns about a closing of open-source resources. The increasing restrictions on access to the China National Knowledge Infrastructure (CNKI), the Chinese academic database previously available to universities, are concerning.⁸⁸ The availability of information for research is critical to enable understanding and mitigate the risks of misperceptions worsening due to an information vacuum.

Despite several critical and impactful initiatives within and beyond government that concentrate on leveraging or increasing accessibility through the translation of open-source resources, U.S. policymakers are not yet fully leveraging publicly available information. The expansion of successor to the Open Source Enterprise to allow additional resourcing for research and analysis could be impactful.

Implications for Strategic Competition

China's strategy of military-civil fusion is likely to remain a central concern in a moment when technological competition is a particularly prominent dimension of U.S.-China relations. To the extent that the PLA is able to increase its capacity to leverage commercial technologies, especially in new domains and to enhance emerging capabilities, these initiatives could be impactful in this ongoing rivalry. In crisis, the leveraging of military-civil fusion to facilitate defense mobilization also could erode warning—and also provide an advantage to China in scenario of a protracted conflict given the potential capacity to sustain resources. Looking forward, the policy and analytic challenges of military-civil fusion will merit continued analytic attention.

Endnotes:

¹ “Xi Jinping: Firmly promote in-depth development of military-civil fusion to provide strong impetus and strategic support for realization of the China Dream and strong military dream” [习近平：扎扎实实推进军民融合深度发展为实现中国梦强军梦提供强大动力和战略支撑], Xinhua, March 12, 2018.

² Alex Stone and Peter Wood, “China's Military-Civil Fusion Strategy,” China Aerospace Studies Institute, June 15, 2020, <https://www.airuniversity.af.edu/CASI/Display/Article/2217101/chinas-military-civil-fusion-strategy/>.

³ “When attending the plenary meeting of PLA and PAP delegations, Xi Jinping emphasized unifying thinking and understanding, strengthening mission responsibility, paying close attention to work implementation, and striving to create a new situation of integrated national strategic system and capacity building” [习近平在出席解放军和武警部队代表团全体会议时强调 统一思想认识 强化使命担当 狠抓工作落实 努力开创一体化国家战略体系和能力建设新局面], Xinhua, March 8, 2023.

⁴ “National defense mobilization: keeping pace with the times and taking the express train of military-civil fusion” [国防动员：与时俱进，搭乘军民融合的快车], Xinhua, October 6, 2017.

⁵ “Xi Jinping discusses military-civil fusion: related to the overall outlook for national security and development” [习近平谈军民融合：关乎国家安全和发展全局], *Seeking Truth* [求是], October 16, 2018, http://www.qstheory.cn/zhuangqu/rdjj/2018-10/16/c_1123565364.htm.

⁶ For more discussion of this concern and dynamic, see “Myths and Realities of Military-Civil Fusion,” co-authored with Lorand Laskai.

⁷ For previous analysis of PRC concerns about chokepoint technologies, see: Ben Murphy, “China’s Self-Identified Strategic Technology Import Dependencies,” CSET, May 2022, <https://cset.georgetown.edu/publication/chokepoints/>

⁸ “When attending the plenary meeting of PLA and PAP delegations, Xi Jinping emphasized unifying thinking and understanding, strengthening mission responsibility, paying close attention to work implementation, and striving to create a new situation of integrated national strategic system and capacity building” [习近平在出席解放军和武警部队代表团全体会议时强调 统一思想认识 强化使命担当 狠抓工作落实 努力开创一体化国家战略体系和能力建设新局面], Xinhua, March 8, 2023.

⁹ “Consolidate and develop military-government (and) military-civil unity in the new era” [巩固发展新时代军政军民团结], CNR, March 13, 2023.

¹⁰ Our initial estimate of military funds comes from this 2021 report: “Myths and Realities of Military-Civil Fusion,” co-authored with Lorand Laskai; additional data/analysis is available on request.

¹¹ “From “Military-Civil Integration” to “Military-Civil Fusion” —— Adjustment and Improvement of China's National Defense S&T Industry Leadership Management System Since Reform and Opening Up” [从“军民结合”到“军民融合”——改革开放以来中国国防科技工业领导管理体制的调整与完善], CCP History Network [中共党史网], August 29, 2019.

¹² “SASTIND interprets opinions on promoting military-civil fusion in national defense S&T industry – reform solves problems, innovation enhances vitality” [国防科工局解读推动国防科技工业军民融合的意见——改革破难题 创新增强活力], Economics Daily [经济日报], December 7, 2017.

¹³ “SASTIND Issued the Opinion on Accelerating and Advancing S&T Collaborative Innovation of National Defense S&T Industry” [国防科工局出台意见 加快推进国防科技工业协同创新], Xinhua, June 29, 2016.

¹⁴ ““Opinion on the Integrated Development of Economic Construction and National Defense Construction” Proposed” [《关于经济建设和国防建设融合发展的意见》提出], Xinhua, July 28, 2016.

¹⁵ “The Central Military Commission of the Central Committee of the Communist Party of China issued the “Opinions on the Integrated Development of Economic Construction and National Defense Construction” [中共中央 国务院 中央军委印发《关于经济建设和国防建设融合发展的意见》], Xinhua, July 21, 2016.

¹⁶ See: “Xi Jinping chaired the Central Military-Civil Fusion Development Committee first plenary meeting” [习近平主持召开中央军民融合发展委员会第一次全体会议], July 20, 2017, Xinhua.

¹⁷ Jin Zhuanglong [金壮龙], “Create a new situation for in-depth development of military-civil fusion in the new era” [开创新时代军民融合深度发展新局面], *Seeking Truth* [求是], July 16, 2018. Jin Zhuanglong (金壮龙) has served as Executive Deputy Director of the Central Military-Civil Fusion Development Committee Office. “Xue

Huifeng: Use Qian Xuesen's system engineering concepts to promote in-depth development of military-civil fusion of cybersecurity and informatization” [薛惠锋：用钱学森系统工程思想，助推网信军民融合深度发展], *People's Daily*, July 5, 2018.

¹⁸ Brenda Goh and John Ruwitch, “Pressure on as Xi's ‘Belt and Road’ enshrined in Chinese party charter,” *Reuters*, October 24, 2017.

¹⁹ “Xi Jinping: Opening up a new era of in-depth development of military-civil integration” [习近平：开创新时代军民融合深度发展新局面], *Xinhua*, March 2, 2018.

²⁰ “‘13th Five-Year’ S&T Military-Civil Fusion Development Special Plan Issued” [“十三五”科技军民融合发展专项规划发布], *Xinhua*, August 25, 2017.

²¹ “Outline of the People's Republic of China 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives for 2035” [中华人民共和国国民经济和社会发展第十四个五年规划和2035年远景目标纲要], *Xinhua*, March 12, 2021.

²² “Military-civil fusion deep sea S&T international innovation park project investment agreement signed in Anning City” [军民融合深海科技国际创新园项目投资协议在安宁市签署], *China National Defense Science and Technology Information Center* [中国国防科技信息中心], August 22, 2018.

²³ See: “Xi Jinping chaired the Central Military-Civil Fusion Development Committee first plenary meeting” [习近平主持召开中央军民融合发展委员会第一次全体会议], July 20, 2017, *Xinhua*.

²⁴ SASTIND has released several plans and initiatives. “SASTIND released the 2017 Military-Civil Fusion Special Action Plan” [国防科工局发布2017年军民融合专项行动计划], June 22, 2017, SASTIND.

²⁵ “SASTIND interprets opinions on promoting military-civil fusion of national defense S&T industry; reform solves problems, innovates and enhances vitality” [国防科工局解读推动国防科技工业军民融合的意见——改革破解难题 创新增强活力], *Economics Daily* [经济日报], December 7, 2017.

²⁶ “Military and civilians gather together to accelerate the construction of a comprehensive public service platform for national military-civil fusion” [军民聚力加快推进国家军民融合综合公共服务平台建设], *Xinhua*, July 14, 2017.

²⁷ The references available are incomplete and don't indicate the amount of funding associated.

²⁸ For an early reference to it, see: “The 9th China Military-Civil Fusion Annual Conference and Achievements Exhibition was successfully convened in Beijing” [第九届中国军民融合年会暨成果展在京成功举办], December 12, 2016, <http://military.cctv.com/2016/12/12/ARTIAvVZd4PH6M7sEoCjM6PV161212.shtml>

²⁹ “13 experts from private enterprises entered the Rocket Force ‘think tank’ and gave the national team treatment” [13名民企专家进火箭军“智库”给予国家队待遇], *PLA Daily*, October 5, 2018.

³⁰ “Academy of Military Sciences and Chinese Academy of Sciences signed a strategic cooperation framework agreement” [军事科学院与中国科学院签署战略合作框架协议], *PLA Daily*, March 25, 2018.

³¹ “Academy of Military Science National Defense Science and Technology Innovation Research Institute – Exploring the ‘Matrix’ Research Model to Enhance Innovation Capability” [军事科学院国防科技创新研究院——探索“矩阵式”科研模式提升创新能力], April 2, 2018. “Academy of Military Science National Defense Science and Technology Innovation Research Institute has taken measures to gather top talents” [军科院国防科技创新研究院多措并举集聚顶尖人才], *China Military Network*, February 4, 2018.

³² “The Academy of Military Sciences selects more than 120 urgently needed scientific research personnel from the whole military” [军事科学院面向全军集中选调120余名急需科研人才], *Xinhua*, January 1, 2018.

³³ “Tianjin (Binhai) AI Military-Civil Fusion Innovation Center” [天津（滨海）人工智能军民融合创新中心], October 23, 2018, <http://www.yingjiesheng.com/job-003-781-914.html>

³⁴ “PLA launches website for military equipment procurement,” *China Daily*, January 4, 2015, https://www.chinadaily.com.cn/china/2015-01/04/content_19232029.htm

³⁵ Liu Zhen, “Chinese military hints at plans for airborne laser attack weapon,” *The South China Morning Post*, January 7, 2020, <https://www.scmp.com/news/china/military/article/3045066/chinese-military-hints-plans-airborne-laser-attack-weapon>

³⁶ See: “Notice on the Forwarding of Applications for the CMC S&T Commission Rapid Response Small Group Projects” [关于转发中央军委科技委快响小组项目申报的通知]

³⁷ “China's first national defense S&T innovation rapid response team was launched in Shenzhen” [全国首个国防科技创新快速响应小组在深圳启动], *Sina*, March 18, 2018.

- ³⁸ “Emergency Operations Drones in Epidemic Areas! National Defense S&T Innovation Rapid Response Small Group (Chongqing) issued an emergency notice on requirements” [疫情区应急作业无人机! 国防科技创新快速响应小组(重庆)发布紧急需求通知], February 9, 2020.
- ³⁹ “Opinion on Promoting Deeper Development of Military-Civil Fusion in National Defense S&T Industry” [国务院办公厅关于推动国防科技工业军民融合深度发展的意见], December 4, 2017.
- ⁴⁰ “Guohua Military-Civil Fusion Industrial Development Fund established” [国华军民融合产业发展基金创立], National Defense Science and Industry Bureau, September 7, 2016.
- ⁴¹ “Cheng Jibin, chairman of the National Military-Civil Fusion Fund, and his party went to the Changjiang Industry Group for discussions and exchanges” [国家军民融合基金监事长程继斌一行到长江产业集团座谈交流], July 25, 2022.
- ⁴² See: “Introduction to Zhongguancun Joint Innovation Military-civil Fusion Equipment Industry Alliance” [中关村联创军民融合装备产业联盟简介]
- ⁴³ See, for instance: “Military-Civil Fusion Innovation Industry Park Will Be Unveiled at Shunde” [军民融合创新产业园将在顺德揭牌], CNR, December 22, 2017.
- ⁴⁴ “Hainan vigorously promotes marine technology innovation to create a new highland for deep-sea technology” [海南大力推动海洋科技创新 打造深海科技新高地], CCTV, February 15, 2023.
- ⁴⁵ Hu Yu [胡宇] and Huo Yihui [火艺卉], “‘Crossing Obstacles 2016’ Ground Unmanned Systems Challenge Ends Wonderfully” [“跨越险阻 2016”地面无人系统挑战赛精彩落幕], China Military Online, October 19, 2016.
- ⁴⁶ “2019 Navy Unmanned Surface Vessel Challenge Series” [2019年度海军水面无人艇挑战赛系列活动公告], June 13, 2019.
- ⁴⁷ “Notice on Calling for S&T Achievements Exhibition Project of “Frontier S&T into the Military Camp – Entering the Strategic Support Force Information and Communication Base” [关于征集“前沿科技进军营—走进战略支援部队信息通信基地”科技成果展项目的通知], Chinese Institute for Command and Control, March 11, 2019.
- ⁴⁸ “Rocket Force’s “Smart Arrow·Fire Eye” Artificial Intelligence Challenge Finals Held in Beijing” [火箭军“智箭·火眼”人工智能挑战赛决赛在京举办], *China Daily*, June 5, 2021.
- ⁴⁹ See, for reference: “The warm up match of the Joint Operations Smart Game Challenge is about to start” [联合作战智能博弈挑战赛热身赛即将打响].
- ⁵⁰ “New-quality militia forces all debut their skills” [新质民兵力量悉数登场显身手], China Military Network, October 10, 2018.
- ⁵¹ “Shanghai established militia drone reconnaissance sub-unit” [上海成立民兵无人机侦察分队], *Observer*, May 14, 2015.
- ⁵² “Exploring new mobilization power among talents from new professionals” [在新职业人才中挖掘新质动员力量], Sohu, March 29, 2019.
- ⁵³ “Winning the online information public opinion war! Shunde established the first militia cyber unit” [打赢网络信息舆论战! 顺德组建首支民兵网络分队], Sohu, September 28, 2018.
- ⁵⁴ “Expanding the science and technology innovation “circle of friends” for national defense mobilization” [扩大国防动员的科技创新“朋友圈”], *PLA Daily*, November 19, 2018.
- ⁵⁵ How precisely that was calculated or evaluated was not specified. “How private enterprises “join the army” and shine” [民企“参军”如何大放异彩], *S&T Daily* [科技日报], March 16, 2018.
- ⁵⁶ “Xu Dazhe: Promoting in-depth development of military-civil fusion of defense S&T industry” [许达哲: 推进国防科技工业军民融合深度发展], *People’s Daily*, November 2, 2015.
- ⁵⁷ “Over one thousand private companies receive Weapons and Equipment Research and Production Certificate” [千余民营企业获武器装备科研生产许可证], Guancha, March 15, 2016. However, other indicators support the inference that companies involved in military-civil fusion are not particularly numerous. There is almost certainly overlap between companies holding the two types of licenses.
- ⁵⁸ “MCF S&T equipment industry investment promotion report” [军民融合科技装备产业投资促进报告], Ministry of Commerce, November 2018, https://web.archive.org/web/20200608231930/http://pdf.dfcfw.com/pdf/H3_AP202002211375367494_1.pdf.

- ⁵⁹ “A private enterprise breaks through the “glass door” of military-civil integration [一家民营企业突破军民融合“玻璃门”], *China Youth Daily*, January 9, 2019. For a more detailed discussion of the general challenges, see: Alex Stone and Peter Woods, “China’s Military-Civil Fusion Strategy: A View From Chinese Strategists,” China Aerospace Studies Institute, June 2020.
- ⁶⁰ “A private enterprise breaks through the “glass door” of military-civil integration [一家民营企业突破军民融合“玻璃门”], *China Youth Daily*, January 9, 2019.
- ⁶¹ See: “Thoughts on Optimizing Access Mechanism of “Three Military Certificates”” [优化“军工三证”准入机制的思考], October 14, 2020.
- ⁶² See Yang Ming [杨明], “Analysis of China’s Legal System for Military-Civil Fusion Development (Part One)” [浅析我国军民融合发展法律制度(一)], *China Law Insight*, April 17, 2018.
- ⁶³ This system is determined by the “Measures for the Implementation of Licensing for Scientific Research and Production of Weaponry and Equipment” (武器装备科研生产许可实施办法).
- ⁶⁴ “The Office of the Central Military-civil Fusion Development Committee held a deployment meeting to coordinate promotion of standardized military-civil fusion” [中央军民融合发展委员会办公室召开统筹推进标准化军民融合工作部署会], *Xinhua*, August 1, 2018.
- ⁶⁵ “National Standardization Management Committee Central Military Commission Equipment Development Department Notice on Regulating the National Standard Formulation Procedure Common to Military and Civilian” [国家标准化管理委员会 中央军委装备发展部关于规范军民通用的国家标准制定程序的通知],
- ⁶⁶ “The CMC Equipment Development Department and SASTIND launched a joint inspection of the entire military’s equipment industry to jointly clean up and manage the military and localities” [中央军委装备发展部、国家国防科技工业局启动全军装备行业领域整肃治理军地联合检查], *Sohu*, July 12, 2022.
- ⁶⁷ For context on debates at the time, see: ““Military-Civil Fusion Law” legislation added to the agenda” [《军民融合促进法》立法提上日程], *PLA Daily*, March 4, 2012.
- ⁶⁸ See: “Improve the level of legalization in deep development of MCF” [提高军民融合深度发展的法治化水].
- ⁶⁹ “A Brigade of the Eastern Theater Command an Urban Offensive and Defensive Drill” [东部战区某旅展开城镇攻防演练], *CCTV*, May 5, 2021.
- ⁷⁰ Kelvin Wong, “IMDEX 2017: China’s Yunzhou-Tech showcases latest USVs,” *IHS Jane’s International Defence Review*, May 18, 2017.
- ⁷¹ “Deep Blue signed a strategic cooperation agreement with the Tianjin (Binhai) Artificial Intelligence MCF Innovation Center” [深之蓝与天津（滨海）人工智能军民融合创新中心签订战略合作协议], *TEDA*, February 22, 2019.
- ⁷² Andrew Jones, “China is developing plans for a 13,000-satellite megaconstellation,” *Space News*, April 21, 2021.
- ⁷³ “This young startup will send AI satellites to the sky” [这家年轻的初创企业，将 AI 卫星送上天], *Xinhua*, November 13, 2018.
- ⁷⁴ “Zhou Hongyi: Military-civil fusion enhances national network security technology level” [周鸿祎：军民融合提升国家网络安全技术水平], *China Military Online*, August 19, 2016. “SASTIND Information Center and 360 Enterprise Security Sign Strategic Cooperation Agreement” [国防科工局信息中心与 360 企业安全签署战略合作协议], *Global Times*, April 19, 2018, <http://www.cnbeta.com/articles/tech/718377.htm>
- ⁷⁵ “Tianmu Data was invited to participate in the 2018 National Cyber Security Week” [天目数据受邀参加 2018 年国家网络安全周活动], *Tencent*, September 2018.
- ⁷⁶ “Tianhe Defense: Concentrate on strategic innovation and transformation of “combination of peacetime and wartime, military-civil fusion” and launch a new “engine” for growth” [天和防务：聚焦“平战结合、军民融合”战略 创新转型启动增长新“引擎”], *Sohu*, June 17, 2022.
- ⁷⁷ “Starsee opens the first internal domestic military algorithm “Star Intelligence” platform” [摄星智能开放首个内部国产军事算法“星智”平台].
- ⁷⁸ “About DataExa” [关于瀚亭科技].
- ⁷⁹ The company’s full name is 保利天同深海技术股份有限公司. “Military-civil fusion deep sea S&T international innovation park project investment agreement signed in Anning City” [军民融合深海科技国际创新园项目投资协

议在安宁市签署], China National Defense Science and Technology Information Center [中国国防科技信息中心], August 22, 2018.

⁸⁰ “Military-civil fusion deep sea S&T international innovation park project investment agreement signed in Anning City” [军民融合深海科技国际创新园项目投资协议在安宁市签署], China National Defense Science and Technology Information Center [中国国防科技信息中心], August 22, 2018.

⁸¹ “Hengtong Ocean and BUPT jointly established the “Underwater Optical Network Joint Laboratory”” [亨通海洋与北邮等联合成立“水下光网络联合实验室”], China Quality News [中国质量新闻]

⁸² Hengtong Ocean and Beiyou jointly established the “Underwater Optical Network Joint Laboratory”” [亨通海洋与北邮等联合成立“水下光网络联合实验室”], China Quality News [中国质量新闻网].

⁸³ “Huaru Technology: The advantages of military simulation are obvious” [华如科技：军事仿真优势明显], Security Times Network [证券时报网], June 6, 2022.

⁸⁴ “Huaru Technology was invited to participate in the inaugural meeting of the China Military-Civil Fusion Collaborative Innovation Alliance” [华如科技应邀参加中国军民融合协同创新联盟成立大会], Huaru S&T [华如科技], March 22, 2017.

⁸⁵ “The national defense popular science war game deduction system jointly created by CICC and Huashu Defense is here!” [由 CICC 与华成防务联合打造的国防科普兵棋推演系统来了], CICC, June 9, 2019.

⁸⁶ “Introduction to the Company” [公司介绍], <http://www.realis-e.com/aboutus.html>

⁸⁷ See, for instance, promotional materials for the company. “Urban special operations digitalization training environment system” [城市特种作战数字化训练环境系统], 81IT.com, June 9, 2020, <http://www.81it.com/2020/0609/11480.html>.

⁸⁸ Lin Yang, “China to Limit Access to Largest Academic Database,” March 30, 2023, <https://www.voanews.com/a/china-to-limit-access-to-largest-academic-database-/7029581.html>.