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Rapid Innovation with Chinese Characteristics: National Defense Science and Technology Innovation Rapid Response Teams and the Military-Civil Fusion Innovation Ecosystem

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Abstract

To respond to China's military–civil fusion (MCF) strategy, the United States needs a prioritization framework. The United States must determine what technologies to protect and capabilities to develop. These determinations must be informed by U.S. goals, accounting for relative strengths and weaknesses. The determinations must also be informed by the adversary: how China operates, to what ends, and with what resources.

This paper leverages the technological demands of China's National Defense Science and Technology Innovation Rapid Response Teams in order to begin to address those questions—and to provide an example of the sort of data sets that might be used to answer them more comprehensively moving forward. Beijing's MCF innovation ecosystem clearly prioritizes information technology, broadly. More specifically, entities charged with fusing commercial and military innovation appear to prioritize autonomous systems (e.g., UAVs, UUVs), sensing and network technologies to dock into and connect them, and information aggregation and analysis platforms. Advanced algorithms and software do not feature prominently in the surveyed data set. These findings can inform U.S. Department of Defense (DoD) acquisition. Defensively, Beijing's priorities and commercial dependencies should shape the DoD's efforts to protect. Offensively, the insight this data provides into Chinese capabilities can assist U.S. efforts to identify and exploit weaknesses.

Introduction

We no longer require National Defense Strategies to signal that the United States and China are locked in a great power competition. And Beijing's military–civil fusion (军民融合; MCF) strategy—once a niche, technical concept reserved for fora like this one—has become a widely recognized component of today's great power contest (de La Bruyere & Picarsic, 2019). Discussion of MCF appears everywhere from U.S. policy documents to mainstream media coverage (e.g., Swanson, 2020). With this growing awareness of MCF comes growing awareness of the strategic asymmetries it portends, namely Beijing's ability to weaponize its integration into the international commercial ecosystem both to obtain resources and project power.

This diagnosis of the United States–China competition, and the role of MCF within it, is long overdue. Yet however accurate, broad diagnosis neither ensures an appropriate strategic response to China's challenge nor resolves the asymmetries of Beijing's competitive approach. MCF entails the integration of military and civilian resources, actors, and positioning for the sake of comprehensive, and international, power. The strategy is designed to take advantage of the twin trends of information technology and globalization. With innovation flowing relatively freely across national borders, Beijing siphons advanced research and development from abroad in order to bolster its own military and economic apparatus (de La Bruyere, 2020). In a world dependent on multinational supply chains, Beijing develops positions of relative control over key nodes within them—and then converts that control into coercive leverage (Bradsher, 2010). As international systems come to depend on information and its flow, Beijing works not only to collect superior information but also to build and to control emerging global information infrastructures (e.g., telecommunications, digital payment systems, surveillance networks). Beijing does so across military and commercial domains, for fused military and commercial advantage (de La Bruyere & Picarsic, 2020).

There is no easy response to China's approach. The U.S. commercial sector innovates, including in dual-use domains. That innovation circulates relatively freely at home and abroad. Washington can neither stop such circulation nor move domestic innovation into the isolated confines of government operations. Nor can Washington re-shore, or allied-shore, all supply chains over which China might exert coercive leverage—or match Beijing point for point in all emerging infrastructures everywhere.

Rather, the United States must prioritize. In military as well as in commercial and civilian competition, Washington will have to develop a prioritization framework—of what technologies to protect, what resources and manufacturing capabilities to develop, and through what infrastructures to compete. That framework should be derived from U.S. goals, factoring in U.S. strengths and weaknesses, including relative standing vis-à-vis China. The framework must also take into account the adversary's framework—how China operates, to what ends, and with what resources—including

- those technologies and applications that Beijing prioritizes for the emerging great power competition;
- those technologies for which Beijing relies on the civilian sector; and
- those actors within the Chinese system that play the most critical roles in the process.

These are large questions but not impossible ones. Reliable open-source indicators exist to benchmark comparative analysis and map out answers. This paper leverages one data set in particular: technological demands of China's National Defense Science and Technology Innovation Rapid Response Teams since 2018. This data set by no means reflects the entirety of the MCF innovation ecosystem. Neither it nor the analysis presented in this paper is exhaustive. Rather, they are offered as examples of the sort of open-source data, and analysis of it, that can fuel the requisite understanding of Beijing's systems and priorities.

The Rapid Response Team data set suggests that the MCF innovation ecosystem places particular emphasis on information-related technologies and applications. Among notable examples, those include autonomous vehicles—for air, ground, and maritime deployment—as well as the sensing and network capabilities to be docked into them. They also, and perhaps most significantly, include networks or platforms through which collected information can be integrated and analyzed. Those networks and platforms, and the power that they promise, apply to military as well as to civilian domains: MCF fuses both civilian and military inputs to develop outputs that are applied in traditional military domains. This much is already well documented in U.S. analysis. The MCF innovation effort, as reflected in this sample, also uses fused civilian and military inputs to develop outputs that are used to project power in civilian domains. These civilian domains those conventionally seen as cooperative rather than competitive. In other words, not only are military and civilian inputs to be fused, but military and civilian outputs are as well.

National Defense Science and Technology Innovation Rapid Response Teams

In 2018, the Science and Technology Committee of China's Central Military Commission established the first National Defense Science and Technology Innovation Rapid Response

Team, known as the Rapid Response Team. That team was based in Shenzhen (Office of the Military–Civil Fusion Development Committee of the Shenzhen Municipal Committee of the Communist Party of China, 2018).[1] Since, additional teams in Chongqing and Dalian have been established.

These Rapid Response Teams might be thought of as the Chinese equivalents of the Defense Innovation Unit (DIU). As the Office of the Military-Civil Fusion Development Committee of the Shenzhen Municipal Committee of the CCP puts it, the Rapid Response teams "link advanced commercial technologies and products to national defense capabilities." Their main task is to "pay close attention to advanced commercial technologies, concepts, and models; actively discover and quickly respond to commercial technologies and products with military application potential; and build a bridge between the frontiers of military and commercial innovation" (Office of the Military–Civil Fusion Development Committee of the Shenzhen Municipal Committee of the Communist Party of China, 2018). To that end, the Rapid Response Teams

- study advanced commercial technologies, monitoring new developments for applications to national security, including through monthly field research;
- solicit fast, innovative commercial solutions based on national defense needs, generally with a 6-to-12-month timeline for delivery; and
- use military-oriented demonstrations of technologies and their applications to build a communication platform for the military, innovative companies, innovative teams, and investment vehicles (Office of the Military–Civil Fusion Development Committee of the Shenzhen Municipal Committee of the Communist Party of China, 2018).

Since 2018, the Rapid Response Teams have issued requests for at least 57 technological solutions (see Appendix) and have organized at least six technology competitions or challenges (see Table 3). The technology solution requests tend to have timelines ranging from 6 to 12 months for delivery, with the exception of three directly related to COVID-19 response, which call for 5- to 30-day turnaround. In some but not all cases, the technology solution requests state explicitly that the projects should "give priority to domestic materials, equipment and systems."[2]

This paper uses the set of requests and challenges as a proxy for assessing those technologies and applications around which China's commercial-based MCF innovation efforts revolve and for identifying associated actors. Of course, the Rapid Response Teams and their projects do not reflect the entirety of China's national defense science and technology project or the MCF apparatus. By any metric—funding, employees, projects—these constitute a relatively small program. However, they do exist at a ripe intersection of MCF and innovation. The insight they provide might not be exhaustive, but it is unusually valuable.

Rapid Innovation with Chinese Characteristics

The National Defense Science and Technology Innovation Rapid Response Teams' technology requests and challenges reveal a decided focus on information-related technologies, namely autonomy and sensing. Nine of the Rapid Response Teams' 57 known technology requests relate directly to unmanned aerial vehicles (UAVs), and another three relate to

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[1] Shenzhen is considered China's high-tech hub (see, for example, Borak & Xue, 2021).

[2] See, for example, the shipborne 3D printing intelligent rapid repair manufacturing technology and the high voltage, high current pulse inductor coil assembly projects.

unmanned underwater vehicles (UUVs).[3] Those are matched by a similar number of requests for sensing and network capabilities that could be docked into them. Maritime examples include video-based maritime intelligent target recognition technology, shallow surface target detection technology, software-defined multifunctional sonar, environmental perception adaptive underwater acoustic mobile ad hoc network technology, and underwater distributed optical fiber sensing technology. Advanced algorithms and software do not feature prominently in this data set. That may be a function of information availability (e.g., stricter confidentiality protocols around their development) or time frame (i.e., they may require more lead time and therefore not fall under the purview of rapid innovation). The gap could also reflect a difference in prioritization (see Tables 1 and 2).

Table 1. Rapid Response Teams Requests and Challenges, by Technology Focus

Technology	Project Count
Autonomy/Guidance	17
Sensing/Networks	17
Manufacturing	14
Power	8
Medical	3
Explosives	2
Operations and Maintenance	1
Flight	1

Table 2. Rapid Response Teams Requests and Challenges, by Domain Focus

Domain	Project Count
Maritime	16
Air	14
Energy	7
Advanced Materials	6
Ground	6
Information Space	6
COVID-19	4
Electronics and Circuits	4

Across the board, regardless of the focus domain or technology, the data set reveals an emphasis on information collection, integration, and operationalization. This emphasis is evident in the host of technology requests focused on autonomy and sensing (e.g., video-based maritime intelligent target recognition technology). The emphasis is even more evident in the Rapid Response Teams' technology challenges.

[3] In what might reflect an asymmetry of technological approach, the technological requirements for one of these projects, the "hand-thrown micro aircraft," requested in January 2020, note that the communication module should "later provide the connection function with the 5G communication network."

Table 3. Rapid Response Team Challenges: 2018–2020

Date	Name	Additional Organizing Entities	Description
Dec 2018	Exoskeleton quick sprint project	-	Execution period of 3 years (2018.12 ~ 2021.12); carried out in three 12-month stages, including two application sprints (6 months) and one technical sprint.
Apr 2019	Massive Optical Remote Sensing Data Intelligent Processing Algorithm Competition	Harbin Institute of Technology (Shenzhen); Aerospace Dongfanghong Satellite Co.; Changchun Institute of Optics, Fine Mechanics and Physics (Chinese Academy of Sciences); Shenzhen Pusheng Intelligent Technology Co.; Zhuhai Orbit Aerospace Technology Co.; China Yuan Jinxin (Dalian) Information Technology Co.	Promote the development of massive optical remote sensing satellite data processing technology, aim at in-orbit applications, and support the realization of massive remote sensing data processing and application capabilities.
Dec 2019	Ground Target Detection and Recognition Technology in Complex Environments Challenge	National Defense Science and Technology Innovation Special Zone Expert Group, National Space Science Center of the Chinese Academy of Sciences, Institute of Automation of the Chinese Academy of Sciences.	Focus on detection and recognition needs of ground targets in complex urban scenes through algorithm performance comparison tests based on real-environment video data sets; the goal is to enhance the intelligent recognition and real-time warning capabilities of ground threat targets in the perimeter of key areas.
Jan 2020	“Ground Sentinel” Challenge	National Defense Technology Innovation Special Zone Expert Group	Focus on the needs of security prevention and control in the core area of the city and the detection and identification of ground threats, as well as to promote and lead the innovative development of the AI security field; the goal is to select new solutions for intelligent image/video analysis in natural surveillance scenarios and promote rapid development of smart security technology.
Jan 2020	“Unlimited Smart Communication-2020” Urban Environment Broadband Communication Technology Challenge	National Defense Technology Innovation Special Zone Expert Group, China Academy of Ordnance Science, PLA Army Research Institute, Chongqing High-Tech Zone Feima Innovation Research Institute, Chongqing University of Technology, China Ordnance Industry Testing Research Institute, Chongqing Science and Technology Bureau	Based on large-scale activities in the urban environment, explore the multi-scenario, multi-node dynamic communication group in the urban environment based on the complex geographic environment, electromagnetic environment, and dynamic movement of people in the city.
Jan 2020	Accurate Aerial Docking Technology of “Range Go” UAV Challenge	National Defense Technology Innovation Zone Expert Group, China Aerospace Science and Industry Corporation, The Third Institute of Aerospace Science and Technology of China, China Electronics Technology Group Corporation Electronic Science Research Institute, Shanghai Jiaotong University, University of Electronic Science and Technology, Xidian University, Yuanwang Think Tank, Shanxi Datong Aviation Sports School	This challenge focuses on the drone aerial docking process, including precise flight control of drones against aerodynamic interference, precise identification and tracking of docking points, the efficient approach strategy for air pre-docking, and collision avoidance and obstacle avoidance technology.

Of the six known challenges held since December 2018, four revolve around information collection, processing, and analysis, and a fifth on aerial docking of UAVs (see Table 3). A host of other entities cooperate with the Rapid Response Teams in organizing those challenges, suggesting a breadth of data types, collection methods, and applications—as well as of players—involved in the MCF information innovation process. For example, the organizing entities for the January 2020 Unlimited Smart Communication Challenge span military, industrial, academic, and government units. They include the China Academy of Ordnance Science and China Ordnance Industry Testing Research Institute, both of which exist under China North Industries Group Corporation (NORINCO), one of China's centrally state-owned defense industry conglomerates; the People's Liberation Army's (PLA's) Army Research Institute; the Chongqing High-Tech Zone Feima Innovation Research Institute (重庆高新区飞马创新研究院), a research institute dedicated to the development of dual-use technology and housed within a MCF-focused industry zone (Chongqing University Graduate Employment Information Network, n.d.); as well as the Chongqing University of Technology and the Chongqing Science and Technology Bureau (National Defense Science and Technology Innovation Rapid Response Team [Shenzhen], 2020).

That 2020 Unlimited Smart Communication Challenge also points to another core aspect of the MCF information project reflected in the Rapid Response Team data set: These requests and competitions do not simply entail converting civilian inputs to military use cases. They also suggest an effort to use civilian outputs to project military-relevant power. The 2020 Unlimited Smart Communication Challenge revolved around using flexible broadband communication and dynamic networking capabilities in an urban environment. Participating teams connected competition equipment—distributed in buildings, across city blocks, and in underground passages—to a test access platform; their scores were determined by video and voice transmission capability as well as average transmission delay. (National Defense Science and Technology Innovation Rapid Response Team [Shenzhen], 2020). This contest took place in a civilian environment, leveraging commercial technology, but was organized by military entities under the mandate of national defense innovation.

The Ground Sentinel Challenge, also held in 2020, tells a similar story. The Rapid Response Team's description of the competition describes it as "focusing on the needs of security prevention and control in the core area of the city and the detection and identification of ground threats." Accordingly, the challenge revolved around intelligent video and image analysis solutions in "natural surveillance scenarios" to "promote the rapid development of smart security technology" for urban areas. Goals included unconstrained face recognition, suspicious object recognition, and dangerous behavior recognition. In determining the participating entities, priority was given to applicants who had past histories of supporting national ministry and provincial security systems (National Defense Science and Technology Innovation Rapid Response Team, 2020). This contest, too, took place in a civilian environment, focused on civilian subjects, leveraging commercial technology.

This blurred line between national defense innovation and civilian-focused applications is by no means surprising. It underlines a critical nuance of China's MCF strategy. MCF is not only about fusing military and civilian inputs for the sake of Beijing's power projection—using commercial UAV technologies in military operations, for example. The MCF project also fuses military and civilian *outputs*, whether industrial positioning or technological applications, in order to bolster China's power projection. In this data set, China's smart city technology, information collection, and control stands out as a ripe example. The point applies more broadly, especially across emerging infrastructures, networks, and platforms (de La Bruyere, 2020b).

The Rapid Response Teams' technological requests also point to the other direction in which MCF can work: transfer of resources from the military to the civilian. Four of the requests issued in 2020 focus on technologies to be used in COVID-19 response, ranging from personal protective equipment to UAVs for operation in areas affected by the epidemic (see Table 4). Perhaps the most interesting element of these requests is their timeline: The vast majority of other technological requests call for delivery within a 12-month window. The shortest time frame for non–COVID-19 relevant technological requests, appearing only on three occasions, is 6 months. However, three of the four COVID-19 relevant requests call for delivery in a matter of days, including as few as 5. These requests provide an example of Defense Production Act–like Chinese acquisition. They also suggest the timing with which such rapid acquisition might take place.

Table 4. COVID-19 Relevant Technology Requests

Date	Request	Timeline (months)
1/30/20	Research on the prediction of the spread of harmful microorganisms	6
2/8/20	Emergency operation UAV in epidemic area	>1 (5 days)
2/11/20	A batch disinfection system for personal protective equipment that can be quickly deployed	>1 (30 days)
2/11/20	Protective clothing that can be re-sterilized and used	>1 (20 days)

Conclusion: Implications for U.S. Acquisition

An appropriate response to the asymmetric threat of China's MCF strategy will require a prioritization framework. The United States, and the U.S. acquisition system, will have to determine what technologies to protect, what resources and manufacturing capabilities to develop, and through what infrastructures to compete. Those determinations must be informed by U.S. goals, factoring in U.S. strengths and weaknesses—what is effective and ineffective, efficient and inefficient in the U.S. system.

The determinations must also be informed by the adversary—by how China operates, to what ends, and with what resources. The United States must understand

- those technologies and applications that Beijing prioritizes for the great power competition;
- those technologies and applications for which Beijing relies on the civilian sector; and
- those actors within the Chinese system that play the most critical roles in the process.

This paper leverages the technological demands of China's National Defense Science and Technology Innovation Rapid Response Teams in order to begin to answer those questions—and to provide an example of the sort of data sets, and analysis, that might be used to answer them more comprehensively moving forward. This single data set and this paper's findings are only one piece of the overall puzzle. Still, direct implications emerge for an adversary-informed prioritization framework.

- Beijing's MCF innovation ecosystem clearly prioritizes information technology, broadly.
- More specifically, entities charged with fusing commercial and military cutting-edge technology appear to prioritize autonomous systems (e.g., UAVs, UUVs), sensing and network technologies to dock into and connect them, and information aggregation and

analysis platforms more specifically. Advanced algorithms and software do not feature prominently in this data set. That may be a function of information availability (e.g., stricter confidentiality protocols around their development) or time frame (i.e., they may require more lead time and, therefore, not fall under the purview of rapid innovation). The gap could also reflect a difference in prioritization.

- The MCF innovation ecosystem relies on participation and support from a range of government, industrial, and academic players, both military and civilian—local governments as well as military organs; state-owned defense industry conglomerates (e.g., NORINCO) as well as private, commercial companies (e.g., Shenzhen Pusheng Intelligent Technology Co., a subsidiary of Guangzhou Hengchuang Intelligent Technology Co.); state and military research institutes (e.g., the Chinese Academy of Sciences) as well as universities.

These findings can directly inform DoD acquisition processes. Defensively, the DoD might take particular efforts to protect those technological areas that Beijing both focuses on and leverages the commercial sector in developing. Defensive measures can include screening of commercial DoD partners (e.g., Small Business Innovation Research [SBIR] applicants). Defensive measures can also include more systemic efforts, like the Trusted Capital Program. The DoD might also use the taxonomy of players contributing to MCF innovation efforts to inform monitoring of, and restrictions on, Chinese entities, including expansion of the companies identified under Section 1237 of the 1999 National Defense Authorization Act and corresponding actions. More offensively, these findings—and the more granular details of the technologies being requested and developed—might assist U.S. efforts to identify, and exploit, weaknesses of the Chinese defense apparatus.

Today's great power competition has been described as a technological race. Before we start running, let's figure out where the finish line is. And how to stop our adversary from drafting off of us.

Appendix. Rapid Response Team Technology Requests, 2018–2020

Date	Request	Timeline (months)
4/11/18	Conformal antenna and circuit integration rapid manufacturing technology	12
4/11/18	High-pressure hydraulic control terminal control technology	12
4/11/18	Video-based maritime intelligent target recognition technology	12
4/11/18	High voltage, strong pulse current flexible coaxial cable	12
4/11/18	High-precision, high-reliability, low-cost servo drive controller	12
4/11/18	Intelligent human–computer interaction module	12
4/11/18	Micro system heat sink	12
7/24/18	Shipborne 3D printing "first aid kit" intelligent rapid repair manufacturing technology	-
6/3/19	Deepwater heavy-duty manipulator	12
6/3/19	Deep water, high power density, high reliability, brushless propulsion motor	12
10/15/19	Low-cost small air-to-surface missile technology	-
11/12/19	Low-cost small aircraft that can be deployed at high altitudes	-
11/12/19	High-altitude flying technology research	-
11/12/19	Vertical takeoff and landing aircraft dense and rapid deployment system	-
12/23/19	Self-protecting solder paste for high-reliability three-dimensional packaging	-

12/23/19	0.6-inch high resolution silicon-based OLED microdisplay	-
12/23/19	Strong special-shaped tempered glass	-
12/23/19	Servo for high-overload low-cost missiles	-
12/23/19	Research on low-cost, high-temperature, infrared and low-radiation technology for vehicles	-
12/23/19	High rigidity and impact resistance precision reducer	-
1/7/20	Long-distance fishing net detection technology	-
1/7/20	Wide temperature semiconductor laser research	-
1/7/20	High voltage, high current pulse inductor coil assembly	6
1/7/20	High-reliability DC brushless special motor with hollow cup	-
1/7/20	Anti-strong magnetic field and high overload DC brushless special motor	-
1/13/20	Integrated communication system and terminal for indoor distributed communication and positioning based on illumination light	12
1/13/20	Hand-thrown micro aircraft	-
1/21/20	Shallow surface target CT system	12
1/21/20	Research on shallow surface target detection technology	6
1/30/20	Research on the prediction of the spread of harmful microorganisms	6
2/8/20	Emergency operation UAV in epidemic area	>1 (5 days)
2/11/20	A batch disinfection system for personal protective equipment that can be quickly deployed	>1 (30 days)
2/11/20	Protective clothing that can be re-sterilized and used	>1 (20 days)
2/24/20	Software-defined multifunctional sonar	12
2/24/20	Research on the preparation technology of ceramic-based material metal coating microstructure	6
3/9/20	“Low, slow, small” drone detection technology in urban complex environment	12
3/9/20	“Low, slow, small” drone agile disposal technology in complex urban environment	12
3/9/20	“Low, slow, small” UAV link takeover technology in urban complex environment	12
3/12/20	Development and application of on-site fatigue damage testing technology under extreme conditions	-
3/12/20	High-speed UUV near-field track electromagnetic passive measurement system	12
3/12/20	New aircraft anti-bird strike coating	12
3/20/20	Formation collaborative navigation technology of underwater man-machine hybrid system	12
3/20/20	Environmental perception adaptive underwater acoustic mobile ad hoc network technology	12
3/20/20	Multi-domain and cross-media integrated communication and networking technology	12
3/20/20	Intelligent detection and recognition technology for typical targets of divers	12
3/20/20	Smart diving mask integration optimization technology	-
3/26/20	UAV rapid obstacle avoidance technology	8
3/26/20	UAV rapid target recognition and tracking technology	12
3/26/20	Enhanced low-light scope	12

3/26/20	Personnel identification technology in dark environment	12
4/16/20	Configurable RF chip	12
4/16/20	Modular robot	12
4/26/20	Underwater special connector	12
4/26/20	Lightweight high-performance electromagnetic shielding paint	9
4/30/20	Underwater distributed optical fiber sensing technology	12
4/30/20	High-performance four-quadrant laser receiver components	12
4/30/20	High-performance high-voltage DC/DC power supply module	10

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