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# RESEARCH BRIEF

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## New Frontiers of Chinese Defense Innovation: Artificial Intelligence and Quantum Technologies

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Will the Chinese military succeed in advancing new frontiers of defense innovation? China has already emerged as a powerhouse in artificial intelligence and quantum technologies. The continued advances in these dual-use technologies may be leveraged for military applications pursuant to a national strategy of military-civil fusion. At this point, the trajectory of technological developments is uncertain, and considerable challenges remain to the actualization of deeper fusion of China's defense and commercial sectors. However, if successful, China's ambitions to lead in these strategic technologies could enable it to pioneer new paradigms of military power.

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US–China strategic competition is intensifying at a time when a range of emerging technologies are poised to change the character of future conflict, perhaps even disrupting the current military balance. The recent trajectory of Chinese military modernization has enabled the Chinese People's Liberation Army (PLA) to achieve rapid advances and become a near-peer competitor to the United States. Increasingly, the PLA is not only seeking to catch up, but instead also competing in new frontiers of military power, even looking to leap ahead of the United States in future military competition. Xi Jinping has called for the advancement of military innovation, declaring that the PLA will emerge as a, perhaps even *the*, "world-class" (世界一流) military by mid-century.[1] Chinese leaders recognize that the pursuit of innovation in strategic technologies, particularly artificial intelligence (AI), is critical to achieve future competitive advantage.

Xi Jinping has highlighted ambitions to build China into a "science and technology superpower" (科技强国) capable of truly original, disruptive innovation. Traditionally, Chinese "indigenous innovation" (自主创新) has often relied upon the absorption of foreign technologies, but a new paradigm of Chinese defense innovation is emerging. Certainly, there will continue to be parallel "going out" (走出去) and "bringing in" (引进来) efforts that seek to leverage international "innovation resources" through targeted investments, acquisitions, joint ventures, and research centers abroad, while also seeking to draw top talent and critical technologies back to China. Increasingly, however, Chinese researchers and enterprises are at the forefront of the latest advances, from biotechnology to artificial intelligence and even quantum technologies. Recognizing the criticality of these technologies, China is mobilizing state support—including massive amounts of funding and efforts to recruit and educate top talent—with the ambition of to "lead the world" in future innovation in these dual-use strategic technologies.

The PLA's capability to leverage these dual-use advances for military applications will depend on the realization of a national strategy for civil-military integration (or "military civil fusion," 军民融合). To date, the private sector has been the primary engine for AI developments, while progress in quantum science is primarily occurring within academia. Although this concept has a long history of mixed success, there are now new levels of prioritization and momentum for its implementation, including the establishment of the CCP's Central Military Civil Fusion Development Committee (中央军民融合发展委员会), under the leadership of Xi Jinping himself.

Concurrently, a number of new plans and policies seek to break down traditional barriers to such "fusion."[2] Within the PLA, the Central Military Commission (CMC) Science and Technology Commission seeks to act as a "DARPA with Chinese characteristics" to catalyze disruption, exercising high-level leadership on these issues, in conjunction with the CMC Military Scientific Research Steering Committee. China's prospects for success in these new frontiers of defense innovation remain to be seen going forward, but these case studies of its approach to artificial intelligence and quantum technologies indicate initial progress.

## ARTIFICIAL INTELLIGENCE

China has rapidly emerged as a powerhouse in artificial intelligence. In this "rise" in AI, the rapid advances and dynamism of private enterprises, particularly such leading tech companies as Baidu, Alibaba, and Tencent, have predated the more recent plans and policies. However, China is rapidly building momentum to harness state support to accelerate innovation in next-generation AI technologies. In July 2017, the State Council released the New Generation Artificial Intelligence Development Plan (新一代人工智能发展规划), which articulated China's ambition to become "the world's premier AI innovation center" and build up an AI industry of 1 trillion RMB (about $150 billion) in the process.[3] In this endeavor, the pursuit of military-civil fusion is a clear priority, given the strategic potential of this dual-use technology.

It is striking just how rapidly and recently AI has emerged as a top priority for Chinese leaders. The decision to develop this recent plan appears to have been catalyzed in part by AlphaGo's triumph over Lee Sedol in March 2016, which might be characterized as a 'Sputnik moment' for China. Against the backdrop of US AI plans and strategies released in mid and late 2016 under the Obama administration, AlphaGo was seen as another indication of US advancement in disruptive technologies that could place China at a distinct disad-

1 "Striding Toward a World-class Military: The 19th Party Congress Report Draws a Blueprint for National Defense and Army Building" [阔步迈向世界一流军队—党的十九大报告擘画国防和军队建设], Xinhua, October 19, 2017, http://www.xinhuanet.com/politics/2017-10/19/c_1121826038.htm.

2 See, for instance, "Thirteenth Five-Year" Science and Technology Military-Civil Fusion Special Plan" Released Today" [〝十三五〞科技军民融合发展专项规划》近日印发], Xinhua, August 23, 2017, http://news.xinhuanet.com/politics/2017-08/23/c_1121531750.htm.

3 "State Council Notice on the Issuance of the New Generation AI Development Plan" [国务院关于印发新一代人工智能发展规划的通知], August 20, 2017, http://www.gov.cn/zhengce/content/2017-07/20/content_5211996.htm

vantage.[4] Since its release, China's national AI plan has acted as an impetus for new energy and motion across China's science and technology bureaucracies. This will be a whole-of-government endeavor involving no fewer than fifteen different entities, along with a range of related plans and projects.

Meanwhile, throughout China, cities and provinces have started to develop and release their own plans and policies for AI. For example, Beijing plans to build a 13.8 billion RMB ($2.12 billion) AI development park that could host up to 400 AI enterprises, and Zhejiang has released a five-year plan to build up core AI industry of over 50 billion RMB and recruit 1,000 "high-end" talents for AI development.

As the Chinese state throws its support and resources behind AI development, major Chinese technology companies will remain integral players in this endeavor. Characterized as national champions in this domain, several leading Chinese AI companies, acting as the "national team," will undertake the development of new "open innovation platforms" in AI. Baidu is responsible for autonomous vehicles, Alibaba Cloud (Aliyun) for smart cities, Tencent for medical imaging, and iFlytek for smart voice. Baidu is leading China's National Engineering Laboratory for Deep Learning Technologies, established in March 2017, which will pursue next-generation research in deep learning. Baidu will also contribute to the National Engineering Laboratory for Brain-Inspired Intelligence Technology and Applications, established in May 2017, which aims to develop AI technologies that learn from the mechanisms of the human brain and to promote brain-inspired neural chips and brain-inspired intelligent robotics.

This direct involvement of private companies in national laboratories that may pursue dual-use technologies and applications reflects their deep entanglement with the overall agenda of the party-state, at a time when the "party-corporate complex" is also deepening and China's national strategy of military-civil fusion is advancing. Indeed, the PLA recognizes and seeks to take advantage of the disruptive military potential of these dual-use technologies. According to Lieutenant General Liu Guozhi, director of the CMC's Science and Technology Commission, AI will accelerate the process of military transformation, causing fundamental changes to military units' programming, operational styles, equipment systems, and models of combat power generation, ultimately leading to a profound military revolution. He warns, "facing disruptive technology, [we] must… seize the opportunity to turn sharply to surpass (弯道超车); if you don't disrupt, you will be disrupted!"[5]

The PLA aspires to pioneer changes in paradigms of military power in the AI revolution, hoping to leapfrog the United States and achieve a decisive advantage relative to regional rivals in the process. The CMC Joint Staff Department has called for the PLA to leverage the "tremendous potential" of AI in planning, decision support, and operational command. In addition, the Joint Staff Department has called for the application of big data, cloud computing, AI, and other cutting-edge technologies in the construction of a joint operations command system. China is advancing in research and development for a range of military applications of AI, including intelligent and autonomous unmanned systems; AI-enabled data fusion, information processing, and intelligence analysis; war-gaming, simulation, and training; defense, offense, and command in information warfare; and intelligent support to command decision-making. Building upon its ongoing agenda of informatization, the PLA is seeking to advance "intelligentization" (智能化) as the next stage in its modernization beyond informatization (信息化), seeking to leverage AI as a force multiplier for its future combat capabilities.[6]

## QUANTUM TECHNOLOGIES

Within the past several years, Chinese researchers have achieved a track record of consistent advances in basic research and the development of quantum technologies. China's launch of the first quantum satellite, Micius (or *Mozi*, 墨子) in August 2016 commanded headlines and has since enabled major experimental advances in quantum key distribution, even allowing for a quantum-secured video call. Concurrently, China has progressed towards the construction of a national quantum communications infrastructure with the "Quantum Beijing-Shanghai Trunk" (量子京沪干线).[7]

Although Chinese efforts in quantum computing remain relatively

4 For instance, this initial match provoked multiple high-level workshops and sessions, such as the following: China Military Science Editorial Department [中国军事科学 编辑部], "A Summary of the Workshop on the Game between AlphaGo and Lee Sedol and the Intelligentization of Military Command and Decision-Making" [围棋人机大战与军事指挥决策智能化研讨会观点综述], *China Military Science* [中国军事科学], April 2, 2016. The participants included leading PLA thinkers from the Academy of Military Science, which directly advises the Central Military Commission; the National Defense University; and the National University of Defense Technology, among others.

5 "National People's Congress Representative Liu Guozhi: Artificial Intelligence Will Accelerate the Process of Military Transformation" [人大代表刘国治：人工智能将加速军事变革进程].

6 "The Era of Military Intelligentization Won't Await Us" [军事智能化时不我待], Ministry of National Defense, December 11, 2017, http://www.mod.gov.cn/jmsd/2017-12/11/content_4799575.htm.

7 "'Quantum Beijing-Shanghai Backbone' to Be Built This Year, Quantum Internet Can Be Expected" ["量子京沪干线"今年建成"量子互联网"可期], Xinhua, March 3, http://news.xinhuanet.com/politics/2016lh/2016-03/03/c_1118225683.htm.

nascent, Chinese researchers have reportedly achieved success in entangling 10 superconducting qubits, a key step towards future quantum computing that broke Google's prior record of 9. The Chinese defense industry has also reported advances in quantum radar and sensing. These dual-use technologies will also be leveraged for a range of defense applications.

Within the past several years, quantum science has emerged as a top priority for the Chinese leadership. In particular, leaks by former NSA contractor Edward Snowden that revealed the extent of US intelligence capabilities and operations within China appear to have elevated the perceived importance of quantum technologies to national security. In the fall of 2013, just a few months after the leaks, Xi Jinping and other Politburo members met with leading quantum physicist Pan Jianwei and viewed a demonstration of quantum communications technologies, which promise "absolute security," even if that may prove chimeric in actuality. Snowden has even been characterized in official Chinese media as one of two individuals with a primary role in the scientific "drama" of China's quantum agenda, along with Pan Jianwei himself. Since then, Chinese scientists have apparently had virtually unlimited resources at their disposal to pursue their research.

Indeed, the levels of interest in and funding for quantum science under national science and technology plans have increased considerably. The 13th Five-Year Plan (2016–2020) included quantum information science in the category of basic research related to national strategic requirements.[8] In August 2016, the new 13th Five-Year National Science and Technology Innovation Plan highlighted quantum control and quantum information as priorities.[9] Through this plan, quantum communications and computing have been designated as science and technology megaprojects prioritized for major advances by 2030, including metropolitan and inter-city free space quantum communications, the development of common-use quantum computing prototypes, and the manufacture of actual-use quantum simulators.

The National Key Research and Development Plan has provided funding for a range of research directions, and there is now support at the provincial level, with the new Anhui Quantum Science Industry Development Fund, which in December 2017 announced plans to devote 10 billion RMB (nearly $1.6 billion) in funding to quantum technologies.[10] The CMC Equipment Development Department is also supporting research in quantum technologies, including through the National Defense Science and Technology Key Laboratories Fund, which has provided funding for several projects involving quantum radar and sensing.

China's pursuit of primacy in quantum science has extended to the creation of new institutions to pursue cutting-edge research and development on these topics. In July 2017, the Chinese Academy of Sciences established the Quantum Information and Quantum Science and Technology Innovation Research Institute. As of September 2017, Chinese government is building the National Laboratory for Quantum Information Science, which will become the world's largest quantum research facility. This new national laboratory, which has received 7 billion RMB ($1.06 billion) in funding to start, will pursue advances in quantum computing and reportedly engage in research "of immediate use" to China's armed forces, according to Pan Jianwei. This centralization of resources and researchers is intended to enable synergies among the expertise and experience of talent across multiple disciplines in order to overcome current technical and engineering obstacles.

Looking forward, the PLA recognizes the disruptive potential of quantum technologies, and the Chinese defense industry is actively pursuing defense applications, in partnership with academic institutions. As early as 2015, Pan Jianwei claimed in an interview, "China is completely capable of making full use of quantum communications in a local war. The direction of development in the future calls for using relay satellites to realize quantum communications and control that covers the entire army."[11]

Within China Electronics Technology Corp., there are a number of research institutes involved in research and development of quantum radars, which the PLA hopes could become the "nemesis" of today's stealth fighter planes with "remarkable potential" on the future battlefield. In November 2017, the China Shipbuilding Industry Corporation (CSIC) and the University of Science and Technology of China signed an agreement to establish

8 " 'Thirteenth Five-Year' Plan Guidelines" [ "十三五" 规划纲要], Xinhua, March 18, 2016.

9 "Notice of the State Council on the Printing and Distribution of the Thirteenth Five-Year National Science and Technology Innovation Plan" [国务院关于印发"十三五"国家科技创新规划的通知], State Council, August 8, 2016, http://www.gov.cn/zhengce/content/2016-08/08/content_5098072.htm.

10 "Quantum Control and Quantum Information Key Project 2017 Program Application Guidance" [ "量子调控与量子信息" 重点专项 2017 年度项目申报指南], Ministry of Science and Technology, http://www.gov.cn/xinwen/2016-10/11/5117251/files/9466f710b972426386489511b7f727f9.pdf; "10 billion RMB Anhui Quantum Science Industry Development Fund Starts Operations" [百亿元安徽量子科学产业发展基金启动运营], China News Network, December 12, 2017, http://webcache.googleusercontent.com/search?q=cache:Yu9KlnNMrE0J:news.sina.com.cn/o/2017-12-12/doc-ifypnyqi4346545.shtml+&cd=4&hl=en&ct=clnk&gl=us.

11 Yu Dawei, "In China, Quantum Communications Comes of Age," Caixin, February 6, 2015.

three joint laboratories focusing on the development of quantum navigation, quantum communications, and quantum detection. According to a CSIC chief designer, next-generation submarines could be equipped with quantum navigation, while leveraging quantum communications underwater, thus reflecting "disruptive revolution in submarine technologies."[12] In the more distant future, quantum computing could enable attacks on the availability and integrity of the satellites and communications systems upon which modern warfare relies, in ways currently inconceivable.

## CONCLUSION

Beyond these technological dimensions of military innovation, the PLA is also starting to progress from speculation to experimentation and even, in some cases, initial implementation in its attempts to advance defense innovation. While closely tracking and seeking to learn from US defense innovation initiatives, Chinese defense academics are starting to come to their own conclusions on the potential changes in the character of conflict that could result from the introduction of AI and quantum technologies on the future battlefield.

Across such emerging technologies, the Chinese leadership appears to recognize a critical opportunity. Whereas the United States initially possessed an undisputed military-technical advantage and pioneered information-centric ways of warfare, the terrain of US-China technological competition in artificial intelligence and quantum technologies is far more level. The Chinese leadership thus recognizes an opportunity to pursue ambitious megaprojects that devote long-term, strategic investments to these domains.

Looking forward, the Chinese leadership sees an opportunity to surpass the United States to lead in these "strategic front-line" technologies, while pioneering new ways of warfare that change paradigms of military power to achieve a future decisive strategic advantage.

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12 "Expert: Disruptive Revolution for Next Generation Submarines" [专家：下一代潜艇颠覆性革命], *China Defense Times*, September 22, 2017, http://military.china.com/important/11132797/20170922/31499751_all.html.