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Artificial intelligence in China's revolution in military affairs

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ABSTRACT
The People's Liberation Army (PLA) seeks not only to equal but also to overtake the US military through seizing the initiative in the ongoing Revolution in Military Affairs (RMA). Chinese military leaders believe the form of warfare is changing from today's 'informatised' (信息化) warfare to future 'intelligentised' (智能化) warfare. The PLA's approach to leveraging emerging technologies is likely to differ from parallel American initiatives because of its distinct strategic culture, organisational characteristics, and operational requirements. This research examines the evolution of the PLA's strategic thinking and concepts of operations, seeking to contribute to the military innovation literature by evaluating major theoretical frameworks for the case of China.

Introduction

The Chinese People's Liberation Army (PLA) regards current advances in emerging technologies, especially artificial intelligence (AI), as a unique opportunity to achieve an operational advantage.[1] Chinese military leaders believe the form of warfare is evolving from today's 'informatised' (信息化) warfare to future 'intelligentised' (智能化) warfare. In the course of that transformation, artificial intelligence (AI) is anticipated to become as critical to victory on the future battlefield as information technology is

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[1]See, for instance, these remarks from the director of the Central Military Commission Science and Technology Commission 'Lt. Gen. Liu Guozhi: the development of military intelligentisation is a strategic opportunity for our military to turn sharply to surpass' [刘国治中将:军事智能化发展是我军弯道超车的战略机遇], CCTV News, 22 October 2017, http://mil.news.sina.com.cn/china/2017-10-22/doc-ifymzqpq3312566.shtml. See also Xi Jinping's remarks as quoted in this article: 'Scientific and technological innovation, a powerful engine for the world-class military' [科技创新, 迈向世界一流军队的强大引擎], Xinhua, 15 September 2017, http://www.gov.cn/xinwen/2017-09/15/content_5225216.htm.

today.[2] This research examines the early evolution of the PLA's strategic thinking and concepts of operations by leveraging the available open-source materials. The paper seeks to contribute to the existing literature on military innovation by applying and evaluating prominent theoretical frameworks for the case of China.

While there is a clear realist rationale for the PLA's pursuit of these emerging capabilities, the PLA's distinct priorities, strategic culture, and elements of its force structure will influence its approach to realising the potential of today's advances. Today, the PLA is exploring and experimenting with new concepts and capabilities to enhance its combat power. Chinese defence academics and military strategists are working to create new theories for intelligentised operations, seeking to determine new mechanisms for victory on the future battlefield.[3] The use of AI in wargaming and operations research can enable conceptual advancements, such as exploring new notions of human-machine coordination and integration.[4] In the process, the PLA is closely studying and adapting lessons learned from American concepts and initiatives. As this research will show, the PLA's initial efforts to develop and deploy the technologies of the fourth industrial revolution systems for a range of applications in the future operational environment could impact the balance of power in ways that risk undermining strategic stability and complicating the dynamics of deterrence in US-China military rivalry.

Review of the literature on military innovation and diffusion

This analysis first seeks to evaluate strategic rationales for the PLA's concern with AI by first raising several potential hypotheses, then reviewing factors that have enabled advances to date, and finally considering emerging indications of the prospects for progression in the stages of military innovation. The core questions that motivate this project are: how and why is the Chinese military seeking to innovate in these theories and technologies of intelligentised operations? The paper initially reviews the salient academic literature to consider the relative relevance of these potential hypotheses, informed by scholarship on military innovation. Then, I undertake a detailed discussion of the PLA's strategic thinking and programs to date.

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[2]Pang Hongliang [庞宏亮], 'The Intelligentisation Military Revolution Starts to Dawn' [智能化军事革命曙光初现], *PLA Daily*, 28 January 2016, http://www.mod.gov.cn/wqzb/2016-01/28/content_4637961. htm.

[3]Lu Zhisheng [陆知胜], 'The Typical Style of Intelligentised Operations: Human-Machine Cooperation!' [智能化作战的典型方式: 人机协同！] *PLA Daily*, 17 October 2018. http://www.81.cn/jwgz/2018-10/17/content_9315760.htm

[4]For an initial analysis of this trend, see: Elsa B. Kania, 'Learning Without Fighting: New Developments in PLA AI War-Gaming,' *China Brief*, 9 April 2019.

Realist learning

The realist frameworks for military learning predict the rapid adoption of military innovations due to the dangers of disadvantage. Against the backdrop of military competition, 'innovation and diffusion are inextricably linked,' considering militaries' tendencies to learn from each other, including in revolutionary technologies, as Goldman has observed.[5] Because security threats that arise with conflict and contention in the international system can be existential in nature, militaries tend to 'copy one another across state borders, and with good reason.'[6] This process of 'military emulation' is recognised by Resende-Santos as resulting from an international system that is inherently anarchic.

The competitive pressures force states to adopt those practices and technologies that are deemed most successful, influenced by demonstrations of the military innovations of great power militaries.[7] As a result, a high degree of similarity, even relative convergence, tends to emerge in the weapons systems, as well as military strategies, of major military powers worldwide, as Waltz has noted.[8] In peacetime, these dynamics can take the form of competitive strategies that center on the 'peacetime use of latent military power,' by which states seek to shape a competitor's calculus to advance its own interests, as Mahnken has highlighted.[9]

From this perspective, China's efforts to advance military innovation reflects a dynamic of realist learning, deeply informed by and likely tending to emulate US efforts. The relevance of realist learning can be tested based on such indicators as the extent of the PLA's focus on American initiatives, the timing and articulated rationales for the Chinese military's prioritisation of military innovation, along with the extent of direct mimicry or observed similarity between US and Chinese concepts and approaches. The explanation would predict relative congruence and tendency towards convergence between the US and Chinese initiatives, at least at first, though the extent for the long term remains to be seen.

Creative insecurity

As a related but distinct hypothesis, China's contestation of military and technological leadership in AI also could be impelled by the dynamics of 'creative insecurity.'[10] Under this paradigm, external threats serve as an

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[5]Emily O. Goldman and Thomas G. Mahnken (eds.), *The Information Revolution in Military Affairs in Asia*, Palgrave Macmillan, 2004.

[6]João Resende – Santos, 'Anarchy and the Emulation of Military Systems: Military Organization and Technology in South America, 1870–1930,' *Security Studies* 5, no. 3 (1996): 193–260.

[7]Ibid.

[8]Kenneth Waltz, *Theory of International Relations,* Addison-Wesley, 1979.

[9]See: Thomas G. Mahnken (ed.*), Competitive Strategies for the 21st Century: Theory, History, and Practice*, Stanford University Press, 2012.

[10]Mark Zachary Taylor, *The Politics of Innovation: Why Some Countries Are Better Than Others At Science and Technology*, Oxford University Press, 2016.

impetus for rapid progress, as informed by Taylor's framework for understanding global patterns of scientific and technological innovation. In such a case, the impetus of insecurity would impact the extant balance between external threats and domestic rivalries of distributional politics, overcoming any prior obstruction to greater investments and advancement.

Pursuant to this hypothesis, Chinese leaders' decision to prioritise military innovation in AI reflects a reaction to rising external threats but would not result from or necessarily involve direct learning from the US model. From this perspective, China's pursuit of primacy in AI, among a range of emerging technologies, would be impelled by US-China strategic competition and contentious regional dynamics, which would serve as a powerful impetus to overcome prior resistance to greater investments in science and technology.

This hypothesis can be evaluated based on indicators that include changes in the Chinese leadership's threat perceptions linked to the pursuit of military innovation, signs of a resulting change in prioritisation of domestic interests, and an apparent increase in resource allocation to defence technology and innovation. However, this causal mechanism does not predict parallels between US and Chinese priorities in and approaches to innovation.

Bureaucratic and organisational dynamics

The existing literature on military innovation has often looked to relevant dynamics organisations and bureaucracies. In practice, these factors tend to result in uneven, inconsistent adoption of new technologies and strategic approaches, as Posen has noted.[11] The inter-service competition within militaries can result in variable responses to innovations, based on the implications for different organisational actors' resources and autonomy, as Cotë has observed.[12] In some cases, pressures from civilians or other institutional actors within the military can also act as the necessary 'impetus, political incentive, and political opportunity' for a military's revaluation of assumptions and orthodoxies.[13]

Often, innovation even entails ideological or generational contention, such that its actualisation can require the establishment of new career paths through which to promote younger officers who have specialised in the new missions, as Rosen has argued.[14] Beyond such competition, the adoption of innovation can be constrained and conditioned by the organisational

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[11]Barry Posen, *The Sources of Military Doctrine: France, Britain, and Germany between the World Wars*, Cornell University Press, 1986.
[12]Owen R. Cote, 'The Politics of Innovative Military Doctrine: The US Navy and Fleet Ballistic Missiles,' PhD diss., Massachusetts Institute of Technology, 1996.
[13]Ibid.
[14]Stephen Peter Rosen, *Winning the next war: Innovation and the modern military*, Cornell University Press, 1994.

capacity, including the resources and adaptability, of the military in question, according to Horowitz's framework.[15]

According to this hypothesis, bureaucratic and organisational dynamics will deeply influence China's approach to military innovation in AI, particularly over the course its continuing experimentation and implementation. As the PLA undertakes reforms that are historic and highly disruptive, the equities of the organisations at stake will extend into questions of resource allocation associated with decisions on defence science and technology.

PLA leaders may continue to debate whether to devote greater resources to traditional hallmarks of military power, such as aircraft carriers, or more to emerging technologies and capabilities. In addition, even as the PLA seeks to create a more innovative culture and to mitigate persistent shortcomings in human capital, these challenges could continue to limit its capacity to succeed in the realisation of new capabilities. This hypothesis can be evaluated based on such indicators as signs of active debate within the PLA and of competition among services.

Strategic culture

China's strategic culture, as informed by historical, 'formative ideational legacies,' continues to influence its approach to defence and military innovation.[16] As the existing literature demonstrates, variation in different militaries' adoption of new ideas and technologies can be impacted by the 'presence or absence of a cultural and ideological orthodoxy,' as well as the commitment of elites to preserving, or alternatively overturning, beliefs and practices, as Adamsky has emphasised. To a certain degree, the PLA's strategic culture is informed by traditional prioritisation of science and technology as critical to military power. The notion 'technology determines tactics' (技术决定战术) is also a salient element of the PLA's thinking that reflects this attention to technology as a decisive factor.[17]

The PLA appears to be uniquely focused on the disruptive implications of technological advancements. For instance, aspects of the Soviet Union's strategic culture, including a holistic, dialectical cognitive approach, appears to have contributed to its success in recognising dynamics of military revolution that are often discontinuous, as Adamsky has recounted. Similarly, aspects of the PLA's cognitive style could result in a similar capacity to recognise the criticality of these technologies in future warfare. As a result,

[15]Michael C. Horowitz, *The Diffusion of Military Power Causes and Consequences for International Politics*, Princeton University Press, 2010.

[16]Dima Adamsky, *The Culture of Military Innovation: The Impact of Cultural Factors on the Revolution in Military Affairs in Russia, the US, and Israel*, Stanford University Press, 2010.

[17]Dennis J. Blasko, '"Technology Determines Tactics„: Relationship between Technology and Doctrine in Chinese Military Thinking', *Journal of Strategic Studies* 34/3 (2011), 355–381.

the PRC approach could be distinct from and divergent relative to that of the US military.

This hypothesis predicts China's ambitions and agenda for defence and military innovation in AI will tend to be shaped by salient aspects of its strategic culture in a manner that may be complementary to the factors discussed previously. While the impact of strategic culture is difficult to evaluate, potential indicators could include the salience of traditional concepts in current writings or the emergence of distinct features in Chinese military innovation relative to the US approach. Although strategic culture appears less likely to serve as a direct causal factor, ideational influences may serve to shape the features and trajectory of Chinese defence innovation.

This relevant literature and theoretical frameworks set the baseline for this paper, which will proceed to evaluate the relative explanatory relevance of these hypotheses and provide an assessment through a structured analytical framework.

China's reactions to the new revolution in military affairs

Chinese leaders assess that a new 'Revolution in Military Affairs' is underway. These changes present urgent challenges and historic opportunities for China. The Politburo devoted a study session to new trends in global military developments and promoting military innovation in August 2014. Xi Jinping personally emphasised the emergence of this 'new RMA.' He called for China to continue to advance military innovation in order to 'narrow the gap and achieve a new leapfrogging as quickly as possible.'[18] In his remarks, Xi urged the PLA to continue striving to develop new military theories, strategy and tactics, institutions, and equipment, as well as models for management, that could fulfil its missions in an era of informatised warfare.[19] China's emphasis on leveraging science and technology to rejuvenate its military (科技兴军) is central to the Party's 'powerful military objective' (强军目标) in the 'new era.'[20]

China's national strategy of 'innovation-driven development' could transform the PLA.[21] 'Under a situation of increasingly fierce international military competition, only the innovators win,' Xi Jinping has emphasised.[22] He called

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[18]'Xi Jinping: Accurately Grasp the New Trend in Global Military Developments and Keep Pace with the Times, Strongly Advancing Military Innovation' [习近平:准确把握世界军事发展新趋势 与时俱进 大力推进军事创新], Xinhua, 30 August 2014, http://news.xinhuanet.com/politics/2014-08/30/c_1112294869.htm.

[19]Ibid.

[20]'Launching the Engine of Innovation for Strengthening and Rejuvenating the Military'[发动强军兴军的创新引擎 – – 军队代表委员热议科技兴军], Xinhua, 12 March 2019, http://www.xinhuanet.com/mil/2019-03/12/c_1210079238.htm.

[21]'Scientific and technological innovation, a powerful engine for the world-class military' [科技创新, 迈向世界一流军队的强大引擎].

[22]Ibid.

for China to 'aim at the frontier of global military scientific and technological developments,' urging:

> We must attach great importance to the development of strategic frontier technologies . . ., select the main attack direction and breach, and intensify the formation of unique advantages in some domains of strategic competition, and strive to surpass the predecessor as latecomers, turning sharply to surpass.[23]

Xi Jinping has been consistent in highlighting the importance of leveraging advanced technologies.[24] This aspiration challenges American military-technological superiority. Whether such ambitions will be realised remains to be seen, however. PLA initiatives for military innovation and modernisation are continuing to progress through planning and armaments development. These new approaches are starting to become incorporated into strategy and doctrine.

Chinese military strategy has evolved and been adjusted in response to new assessments of the form or character of conflict throughout its history.[25] The most recent revision to China's 'military strategic guideline' (军事战略方针) to 'winning informatised local wars,' was confirmed in the 2015 defence white paper, *China's Military Strategy*. This paper also discussed a 'new stage' in the global RMA as resulting from the increasing prominence and sophistication of long-range, precise, smart [*sic*, or 'intelligent,' 智能],[26] stealthy, and unmanned weapons and equipment.'[27] At that point, China was concerned about the US Third Offset Strategy, which was believed to threaten to create a new 'generational difference' (时代差) between US and PLA capabilities.[28] US initiatives influenced and provided an impetus to intensify this imperative of innovation.

The concerns of Chinese defence academics and military strategists with the potential impact of AI in future warfare have been influenced by increased awareness of the rapid progress in AI.[29] In particular, AlphaGo's defeat of Lee Sedol in the game of Go in March 2016, which appeared to demonstrate the potential advantages that AI could provide in future

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[23]Ibid.

[24]See: 'Xi Jinping: Launching the engine of military scientific research and innovation at full speed'.

[25]For the best review of the impetus for changes in Chinese military strategy across its history, see: M. Taylor Fravel, *Active Defense: China's Military Strategy Since 1949*. Vol. 2. Princeton University Press, 2019. M. Taylor Fravel, 'Shifts in Warfare and Party Unity: Explaining China's Changes in Military Strategy.' *International Security* 42, no. 3 (2018): 37–83.

[26]Although the translation 'smart' is used in the official version of this Defence White Paper, I choose to use the translations 'intelligent' or 'intelligentised.'

[27]Mininstry of National Defense of the People's Republic of China [中华人民共和国国防部], 'China's Military Strategy' [中国的军事战略],' 26 May 2015. See also the official English translation of the white paper: http://english.gov.cn/archive/white_paper/2015/05/27/content_281475115610833.htm.

[28]See also: Li Bingyan [李炳彦], 'Major Trends in the New Global Revolution in Military Transformation and the Form of Future Warfare' [世界新军事变革大势与未来战争形态], 24 February 2016. Li Bingyan is a member of the National Security Policy Committee (国家安全政策委员会).

[29]See this series in *China Brief*, organized by Peter Wood for early analyses on these issues: 'China & the Third Offset,' https://jamestown.org/programs/cb/china-third-offset/.

Timeline of relevant milestones in Chinese military innovation (2014–2019).

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2014	In May, the Department of Justice charged five Chinese military hackers from the Unit 61398 in the first of what would become a campaign of indictments as an element of efforts to 'name and shame' cyber espionage in the years to come. In August, Xi Jinping discussed the Revolution in Military Affairs in Politburo study session. In November, Secretary of Defense Hagel announced the American Defense Innovation Initiative.
2015	In April the penetration of the Office of Personnel Management by Chinese hackers is first discovered. In May, Made in China 2025 was launched, setting in motion a new era of Chinese industrial policy. Also in May, then-Secretary of Defense Ashton Carter warned China over ongoing efforts in land reclamation in the South China Sea. In September, Xi Jinping announced plans to downsize the PLA as the start of a new phase of reforms. In December, the reforms continued with the creation of the PLA Strategic Support Force, elevation and inauguration of the PLA Rocket Force, and establishment of a new headquarters for the PLA Army.
2016	In January, the PLA formally established its new joint operations command structure, which Xi Jinping visited and inspected in April, when he was first officially described as commander-in-chief. As of March, the Thirteenth Five-Year Plan officially underway. In May, the National Strategy for Innovation-Driven Development released. In August, China launched Micius, the world's first quantum satellite. In October, the National Artificial Intelligence Research and Development Strategic Plan was released by the US National Science and Technology Council. In November, Donald Trump was elected president after a campaign in which his remarks had often featured attacks on China, especially pertaining to trade.
2017	In April, President Trump hosted Xi Jinping at Mar-a-Lago. In July, The State Council released the New Generation Artificial Intelligence Development Plan. In October, Xi Jinping calls for the PLA to 'accelerate military intelligentisation' in his remarks at the 19th Party Congress. In December, the US National Security Strategy characterised China as a revisionist power.
2018	In January, the new National Defense Strategy concentrated on great power competition. In March, the Trump administration announced major tariffs against Chinese imports in response to concerns over IP theft and other 'predatory' economic behaviour, and the Chinese government's retaliatory measures starting in April marked the start of the trade war. In October, a speech by Vice President Mike Pence In December, Canada arrested Huawei executive Meng Wanzhou.
2019	In August, China's Ministry of National Defence releases China's latest national defence white paper, titled "China's National Defense in the New Era. In October, China's military parade raises concerns by highlighting new weapons systems, including drones, hypersonic missiles, and new nuclear capabilities. In December, the first reports of the coronavirus pandemic emerge from Wuhan.

command decision-making, shaped these assessments, prompting high-level attention.[30] Starting around this period, the PLA writings highlighted with increased frequency the assessment that today's 'informatised' warfare was undergoing a transformation towards future 'intelligentised' warfare, catalysed by the rapid advances in these emerging technologies, a conclusion that has since received ever more official imprimatur.[31]

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[30]See: 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 Intelligentisation 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], 2 April 2016. Note that the journal's own English language translation of the title of the workshop is not the direct or literal translation.

[31]The potential alternative spellings and translations of 智能化 include intelligent, intelligencization, smartification, and/or AI-ification. The notion of 'cognification' has also been used in English-language descriptions of a similar phenomenon. I have chosen to render this term 'intelligentisation' for consistency with some of the official translations of the term in authoritative journals, such as *China Military Science*,
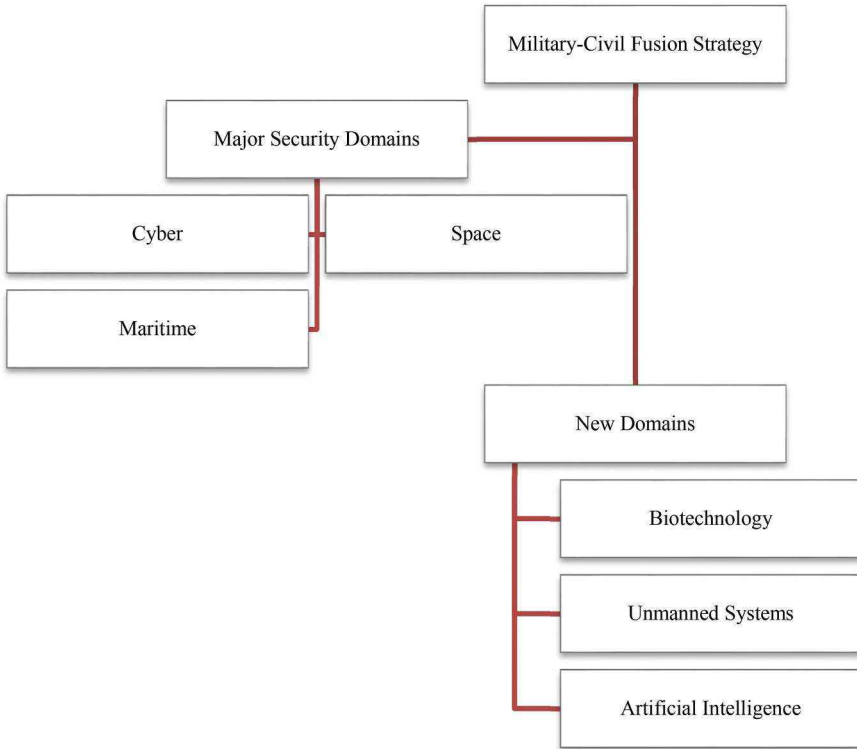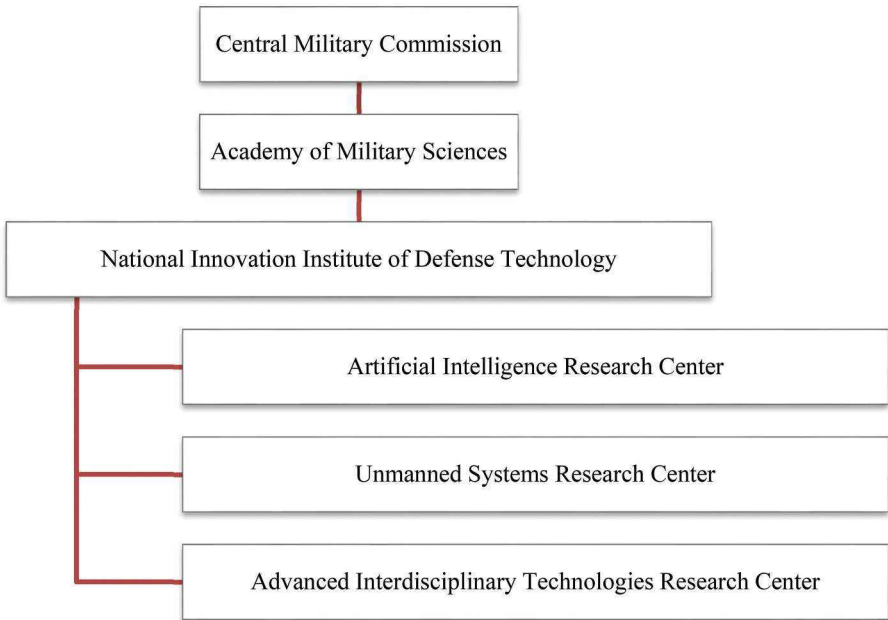
Depiction of select priorities in military-civil fusion.
Source: Author
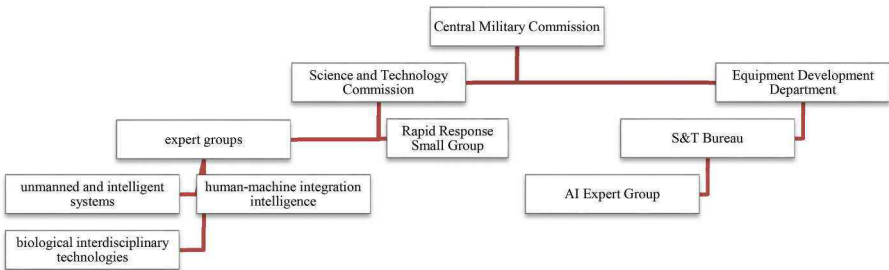
Approximate stakeholders in PRC military science, technology, and equipment.
Source: Author

but I am open to debating alternative translations and conceptualizations with those concerned. Not unlike 'informatization,' the notion of 'intelligentisation' is difficult to define with precision and appears to be used in a varying and sometimes somewhat inconsistent manner by PLA writings on these issues. My understanding of this concept has evolved since I first discussed it in published writing and testimony in February 2017. See also: Elsa B. Kania, 'Testimony before the US-China Economic and Security Review Commission: Chinese Advances in Unmanned Systems and the Military Applications of Artificial Intelligence – the PLA's Trajectory towards Unmanned, "Intelligentised" Warfare,' US-China Economic and Security Review Commission, 23 February 2017, https://www.uscc.gov/sites/default/files/Kania_Testimony.pdf.

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Several relevant institutions at academy of military science.
Source: Author

Writing in an authoritative commentary in August 2016, the CMC Joint Staff Department called upon the PLA to leverage the 'tremendous potential' of AI for operational command, planning and deductions, and decision support, while urging the advancement the application of big data, cloud computing, artificial intelligence, and other cutting-edge technologies to the construction of the PLA's command system for joint operations.[32] Significantly, in October 2017, in his report to the 19th Party Congress, Xi Jinping urged that the PLA, 'Accelerate the development of military intelligentisation' (军事智能化), and improve joint operations capabilities and all-domain operational capabilities based on network information systems.'[33]

This authoritative exhortation has elevated 'intelligentisation' as a guiding concept for the future of Chinese military modernisation. The PLA's apparent enthusiasm to embrace AI reflects a recognition of the potential dividends of success or leadership in this new RMA. Whereas the PLA was a spectator and latecomer to the early stages of RMA, this new RMA presents an opportunity

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[32]CMC Joint Staff Department [中央军委联合参谋部], 'Accelerate the Construction of a Joint Operations Command System with Our Military's Characteristics [加快构建具有我军特色的联合作战指挥体系], *Seeking Truth*, 15 August 2016, http://www.qstheory.cn/dukan/qs/2016-08/15/c_1119374690.htm.

[33]'Xi Jinping's Report at the Chinese Communist Party 19th National Congress' [习近平在中国共产党第十九次全国代表大会上的报告].

for the PLA to perhaps emerge as the first to realise disruptive capabilities, including based on breakthroughs in new theories for intelligentisation.[34] Although the PLA continues to confront particular challenges in catching up,[35] its relative backwardness also presents the potential for certain advantages in the process of 'leapfrog development' (跨越发展) in its technological advancement.[36] In particular, the PLA possesses fewer legacy weapons and platforms and appears to be prioritising investments in next-generation weapons systems, such that it could prove capable of introducing new systems more rapidly, for instance, than the US military.

China's leaders believe AI is a strategic technology that will be critical across all dimensions of national competitiveness, with the potential to transform current paradigms of military power. Beijing's decision to prioritise AI to enhance China's economic development and military capabilities is evident across a growing number of plans, policies, and authoritative statements.[37] In July 2017, the New Generation Artificial Intelligence Development Plan elevated AI as a core priority, catalysing what has become a whole-of-nation strategic initiative.[38] Since then, this agenda has progressed at all levels of government and through the efforts of a range of stakeholders. China's AI efforts have built upon and harnessed the robust efforts of China's dynamic technology companies. This plan also discussed the implementation of a strategy of military-civil fusion (军民融合) in AI, calling for strengthening its use in military applications that include command decision-making, military deductions (e.g., wargaming), and defence equipment.[39]

Today, as Xi Jinping calls upon the PLA to pursue military innovation, such efforts are redoubling. The stakeholders that have a designated involvement

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[34]'Lt. Gen. Liu Guozhi: the development of military intelligentisation is a strategic opportunity for our military to turn sharply to surpass'.

[35]For an excellent academic evaluation of the challenges of catching up, see: Andrea Gilli and Mauro Gilli. 'Why China Has Not Caught Up Yet: Military-Technological Superiority and the Limits of Imitation, Reverse Engineering, and Cyber Espionage.' *International Security* 43, no. 3 (2019): 141–189.

[36]For an academic perspective on the notion of leapfrogging, see for instance: Takashi Hikino and Alice H. Amsden, 'Staying behind, stumbling back, sneaking up, soaring ahead: late industrialization in historical perspective' *Convergence of productivity: Cross-national studies and historical evidence* (1994): 285–315.

[37]See, for instance: 'Four Departments Issued a Notice Regarding the '"Internet Plus" Artificial Intelligence Three-Year Action Implementation Plan' [四部门关于印发《'互联网+'人工智能三年行动实施方案》的通知], China Government Network, 25 May 2016, http://www.miit.gov.cn/n1146290/n1146392/c4808445/content.html. '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], 20 August 2017, http://www.gov.cn/zhengce/content/2017-07/20/content_5211996.htm'MIIT's Notice Regarding the Release of the Three Year Action Plan to Promote the Development of New-Generation Artificial Intelligence Industry (2018–2020) [工业和信息化部关于印发《促进新一代人工智能产业发展三年行动计划（2018-2020年）》的通], 14 December 2017, http://www.miit.gov.cn/n1146295/n1652858/n1652930/n3757016/c5960820/content.html.

[38]For the full translation, see: Graham Webster, Rogier Creemers, Paul Triolo, and Elsa Kania, 'Full Translation: China's "New Generation Artificial Intelligence Development Plan" (2017),' https://www.newamerica.org/cybersecurity-initiative/digichina/blog/full-translation-chinas-new-generation-artificial-intelligence-development-plan-2017/.

[39]See again China's 'New Generation Artificial Intelligence Development Plan.'

in promotion and implementation of China's New Generation Artificial Intelligence Development Plan include the Central Military-Civil Fusion Development Commission Office, the Central Military Commission (CMC) Science and Technology Commission, and the CMC Equipment Development Department.[40] The PLA's Central Military Commission (CMC) Science and Technology Commission is guiding and supporting research in such 'frontier' technologies, including through a new 'rapid response small group' for national defence innovation that seeks to leverage commercial technologies.[41] The CMC Equipment Development Department, which is responsible for defence armaments development, is also funding and promoting research involving unmanned systems and artificial intelligence, including supporting dual-use technological developments with guidance from an 'AI Expert Group.'

PLA reforms and initiatives in innovation

The PLA's military reforms since late 2015 have involved historic restructuring intended to increase its capacity for military innovation.[42] In the course of these reforms, the PLA Strategic Support Force (战略支援部队) consolidated Chinese military capabilities for space, cyber, electronic, and psychological warfare. The PLASSF has been directed to undertake innovation and develop capabilities to contest new domains of military power.[43] These reforms have included the establishment of the Central Military Commission (CMC) Science and the Technology Commission (S&TC). The CMC S&TC has launched new plans, funds, and contests that concentrate on emerging technologies and promoting defence science and technological innovation.[44] In October 2017, Lieutenant

[40]'New Generation AI Strategic Advisory Committee Established' [新一代人工智能战略咨询委员会成立], 21 November 2017, http://www.ia.cas.cn/xwzx/ttxw/201711/t20171121_4896939.html.
'The New-Generation Artificial Intelligence Development Planning Promotion Office Convened a 2019 Working Conference' [新一代人工智能发展规划推进办公室召开2019年工作会议], 20 February 2019, http://www.most.gov.cn/tpxw/201902/t20190221_145137.htm.
[41]The details are available upon request.
[42]For a noteworthy commentary from Lt. Gen. Gao Jin, then president of the Academy of Military Science and later the inaugural commander of the PLA Strategic Support Force, see: 'Academy of Military Science President: Reforms Must Resolve the Restraints Upon Systematic Assurance for a Powerful Military' [军事科学院长:改革要解决决羁绊强军的体制性障碍], *PLA Daily*, 2 November 2015, http://www.chinanews.com/mil/2015/11-02/7600724.shtml.
[43]For the authoritative assessment of the PLASSF, see: John Costello and Joe McReynolds, 'The Strategic Support Force: A Force for a New Era,' National Defence University, 2 October 2018.
See also: Elsa Kania and John Costello, 'The Strategic Support Force and the Future of Chinese Information Operations,' *Cyber Defence Review*, Spring 2018, https://cyberDefencereview.army.mil/Portals/6/Documents/CDR%20Journal%20Articles/The%20Strategic%20Support%20Force_Kania_Costello.pdf?ver=2018-07-31-093713-580.
For primary source documentation highlighting the PLA's role in innovation, see: 'How Can the Strategic Support Force Forge New Quality Weapons' [战略支援部队如何锻造新质利器], *PLA Daily*, 11 March 2016, http://www.chinanews.com/mil/2016/03-11/7792939.shtml.
[44]For a basic description of the CMC Science and Technology Commission's mandate, see: 'Shoulder the functional mission of strengthening the military through science and technology' [肩负起科技强军

General Liu Guozhi (刘国治), director of the CMC Science and Technology Commission, emphasised the imperative of promoting intelligentisation, arguing, 'This is a rare strategic opportunity for our nation to achieve innovation surpassing and to achieve a powerful military, and it is also a rare strategic opportunity for us to achieve turning sharply to surpass (弯道超车).'[45]

The PLA's premier academic and research institutions have been tasked to prioritise innovation in disruptive and emerging technologies. During his visit to the PLA's Academy of Military Science in May 2018, Xi Jinping called for the AMS to concentrate on 'increasing the intensity of innovation in emerging domains, and strengthening the incubation of strategic, frontier, and disruptive technologies.'[46] His remarks emphasised the importance of placing innovation in a prominent position and pursuing innovation in military theories, national defence science and technology, military science and research work on organisational models. During his visit, Xi also spoke to Major General Li Deyi (李德毅), who has beena research fellow with the AMS Systems Engineering Research Institute, focusing on unmanned systems and artificial intelligence.

The PLA's National University of Defence Technology (NUDT) is considered an 'important highland for indigenous in national defence science and technologies' that is concentrating on 'developing the key technologies for national defence in the intelligent era.'[47] In particular, NUDT has built upon its existing research in automation through the Academy of Intelligent Sciences (智能科学学院), which is pursuing research that includes intelligent robotics, bionic robotics and autonomous control, such as swarm intelligence. The PLA's National Defence University has also started to explore the impact of AI in its research and teaching, including through wargaming.[48]

Concurrently, the PLA's Academy of Military Science (AMS) has transformed itself in ways that position this institution. Traditionally, AMS has been responsible for the formulation of PLA strategy and doctrine; today, AMS is also concentrating on advancing theoretical and technological innovations. Notably, the AMS has established a new National Defence Science

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的职能使命], *PLA Daily*, 28 April 2016, http://www.mod.gov.cn/topnews/2016-04/28/content_4651316.htm.

[45]This concept (弯道超车), which often recurs in PLA writings, alludes to idea of two cars racing towards a corner, of which one cuts the turn more sharply and takes the inside track, thus passing by the other. I'm open to other suggestions on how to translate this term.

[46]'Xi Jinping: Strive to build a high-level military scientific research institution to provide strong support for the party's strong military objective in the new era' [习近平: 努力建设高水平军事科研机构 为实现党在新时代的强军目标提供有力支撑], Xinhua, 16 May 2018, http://www.xinhuanet.com/2018-05/16/c_1122843283.htm.

[47]'President Xi came to the military school for the first time' [习主席第一次到军校视察就来到这里], China Military Online, 20 March 2018, https://new.qq.com/omn/20180320/20180320A1G5SK.html .

[48]'Chief Engineer Hu Xiaofeng, General Manager of China's Bingqi Program, Delivered a Lecture: the Challenge of the Intelligentisation of Command information Systems' [中国兵棋工程总师胡晓峰少将演讲: 指挥信息系统的智能化挑战], 13 July 2016, 2016, http://chuansong.me/n/434595151184.

and Technology Innovation Research Academy (国防科技创新研究院, or 'National Innovation Institute of Defence Technology,' NIIDT, in its typical English translation).[49] NIIDT has been actively recruiting hundreds of military scientists and civilian personnel. NIIDT's Artificial Intelligence Research Center has concentrated on research in deep learning and human-machine integration.[50]

Emerging concepts of intelligentisation

The concept of intelligentisation involves the development and operationalisation of artificial intelligence and the enabling of interrelated technologies that are required for its realisation for military applications.[51] Intelligentisation is intended to build upon prior stages of mechanisation and 'informatisation,' the process through which the PLA has introduced information technology and undertaken the development of its C4ISR (command, control, communications, computers, intelligence, surveillance, and reconnaissance) capabilities.[52] For the PLA, force construction requires the simultaneous undertaking of all three processes, which may present distinct difficulties but also enables the leveraging of synergies among them.[53]

Inherently, the concept of military intelligentisation is not only about AI. Instead, it 'refers to the overall operational description of the force systems consisting of people, weapons equipment, and ways of combat,' according to one PLA scholar.[54] This new 'system of systems' consists of not only intelligent weapons but also a new military 'system of systems' that involves human-machine integration and with (artificial) intelligence in a 'leading' or dominant (智能主导) position.[55]

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[49]'Academy of Military Science National Defence Science and Technology Innovation Research Academy – 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], PLA Daily, 2 April 2018, http://www.81.cn/jfjbmap/content/2018-04/02/content_202957.htm. See also: 'Academy of Military Science National Defence Science and Technology Innovation Research Academy Has Taken Measures to Gather Top Talents' [军科院国防科技创新研究院多措并集聚顶尖人才], China Military Network, 4 February 2018, http://webcache.googleusercontent.com/search?q=cache:WDwlAWmc6agJ:www.81.cn/jwgz/2018-02/04/content_7931564.htm+&cd=8&hl=en&ct=clnk&gl=us.

[50]'The Academy of Military Sciences has amassed and selected 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, 1 January 2018, http://www.xinhuanet.com/mil/2018-01/25/c_129798773.htm.

[51]This is the author's attempt to provide the simplest possible definition of the concept, and I am very open to other suggestions and interpretations.

[52]For context, see: Andrew S. Erickson and Michael S. Chase. 'Informatization and the Chinese People's Liberation Army Navy,'in Phillip Saunders, Christopher Yung, Michael Swaine, and Andrew Nien-Dzu Yang, *The Chinese Navy: Expanding Capabilities, Evolving Roles*, Washington, DC: Institute for National Strategic Studies (2011): 247–287.

[53]This concept (弯道超车), which often recurs in PLA writings, alludes to idea of two cars racing towards a corner, of which one cuts the turn more sharply and takes the inside track, thus passing by the other. I'm open to other suggestions on how to translate this term.

[54]'Experts: Military Intelligentisation Is Not Merely Artificial Intelligence' [专家: 军事智能化绝不仅仅是 人工智能].

[55]Ibid.

Military learning and conceptual evolution

Chinese military science and research on the dynamics of future intelligentised operations are informed by the close study of US ways of war-fighting and are intended to 'offset' or undermine current American military advantages.[56] As an authoritative commentary in *PLA Daily* urged, 'Keep an eye on future opponents, adhere to using the enemy as the teacher, using the enemy as a guide, and using the enemy as a target ... We must develop technologies and tactics that can break the battle systems of powerful adversaries and counter the high-end combat platforms of powerful adversaries.'[57] Although the PLA has not finalised or formalised new doctrinal concepts, such as for intelligentised operations, a review of semi-authoritative and authoritative writings that are openly available can reveal initial insights about the current trajectory and continued evolution of this thinking among the community of scholars and scientists who are engaged with these issues.

The PLA's traditional concentration on devising capabilities designed to target perceived weaknesses in an adversary's ways of warfare will likely persist in conceptual and technological developments that leverage these emerging technologies. For instance, Zhang Zhanjun (张占军), a senior researcher with the Academy of Military Science's Theory and Operational Regulations Research Department,[58] who also serves as editor-in-chief of its journal *China Military Science*, wrote a lengthy commentary in October 2017 on how the PLA might compete to seize the initiative in future maritime combat, arguing, 'using new-type combat forces to fight in new domains such as networks and space, we must implement asymmetric autonomous operations.'[59]

It is noteworthy that the latest edition of *The Science of (Military) Strategy* released in 2017 by the PLA's National Defence University has added a new section on 'military competition in the domain of (artificial) intelligence' (智能领域军事竞争), in an unusual, off-cycle revision of this authoritative textbook,[60] of which Lt. Gen. Xiao Tianliang (肖天亮), who remains the vice commandant of the PLA's National Defence University, is the editor.[61] The section discusses the 'new military intelligentisation revolution' underway

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[56]The PLA does not describe what it is doing as an 'offset' per se, but that could be the effect in practice.
[57]Ke Zhengxuan [科政轩], 'How to build a military scientific research system with our military's characteristics' [我军特色军事科学研究体系如何构建形成], *PLA Daily*, 8 August 2017, http://www.81.cn/jmywyl/2017-08/04/content_7703373.htm.
[58]This is the department that has had direct responsibility for the PLA's formulation of its equivalent to doctrine, operational regulations.
[59]Zhang Zhanjun [张占军], 'How to compete for future maritime combat initiative' [如何争夺未来海上作战主动权], *PLA Daily*, 24 October 2017, https://web.archive.org/save/http://www.xinhuanet.com/mil/2017-10/24/c_129725534.htm.
[60]The prior edition of the NDU's SMS dated back to 1999, and it is unusual for a revision of the text to occur so soon.
[61]Note: Although the 2013 edition of the Science of Military Strategy is often seen as more authoritative, it is the author's contention that the 2015 and this revised 2017 versions merit greater attention. Xiao Tianliang (ed.), *The Science of Military Strategy* [战略学], National Defence University Press, 2017.

that involves strategic competition among nations worldwide that are seeking to 'seize this new strategic commanding heights in military affairs.'

Beyond the trend of the increased prominence of intelligent unmanned systems, intelligent operational systems are expected to become 'unavoidably 'the dominant forces on the battlefield in future warfare. As a strategic guidance for the character of competition in this new frontier:

> *Military intelligentisation advances new and higher requirements for armed forces construction; it is providing a rare opportunity for latecomer militaries [to undertake] leapfrog development, achieving turning sharply to surpass (弯道超车). It is necessary to actively confront the challenge of intelligentisation, planning and preparing a strategy for the development of military intelligentisation [and] seizing the commanding heights of future military competition.*

As the PLA continues to concentrate on revising military policies and doctrine, these research activities may contribute to future revisions to PLA military strategic guidelines (and the next generation of the PLA's operational regulations (作战条令), which are still under development.[62] The inclusion of discussions of competition in artificial intelligence in this authoritative textbook reflects a further formalisation of the PLA's strategic thinking on the importance of military intelligentisation.

While the PLA's process of adjusting some aspects of its equivalent to doctrine remains ongoing, there are indications that new theories and concepts involving AI could be incorporated into future revisions. According to Wang Yonghua (王永华), a scholar with the Academy of Military Science's Operational Theories and Regulations Department:

> *At present, to research and develop concepts of operations, it is necessary to focus research on the profound influence of such high-tech groups as artificial intelligence, big data, and Internet of Things upon the methods and routes for combat victory. [We must] research the development of changes to the winning factors of information, forces, time, space, and spirit; study the impact of the interactions of space, cyber, electromagnetic, deep sea and other spaces' with traditional combat spaces on future operations, developing new operational concepts though future combat research and design.[63]*

Such ideas and concepts of operations cannot be regarded as official until their incorporated into the PLA's 'operational regulations' to inform more directly future military campaigns and training. The PLA's process of transforming concepts into doctrine has required a more formal process of evaluation and authoritative assessment, and there appear to have been delays over time. In this regard, to say that the PLA has clear policies established on

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[62]For context, see: Elsa B. Kania, 'When Will the PLA Finally Update Its Doctrine?,' *The Diplomat*, 6 June 2017, https://thediplomat.com/2017/06/when-will-the-pla-finally-update-its-doctrine/.

[63]Wang Yonghua [王永华], 'How to get through the whole link of combat concept development?' [如何打通作战概念开发的完整链路？], China Military Network, 29 November 2018,http://www.81.cn/jwgd/2018-11/29/content_9360140.htm.

questions of autonomy and artificial intelligence would be premature. Nonetheless, this theoretical research is informative of the direction that these initiatives are taking.

There is often a recurrence of the assessment that the tempo and complexity of operations will increase to an extent, changing the role of humans on the battlefield. Already, informatised warfare has placed a premium upon competition in the domain of cognition. Future warfare is expected to demand rapid processing of information and evaluation of the operational environment.[64] Consequently, the place of humans in that endeavour could change from being 'in' the loop, to 'on' the loop, and perhaps even out of the loop.[65] There is no evidence to conclude that the PLA is likely to take humans 'out of the loop' entirely. However, there is an expectation of a future point at which 'the rhythm of intelligentised operations will be unprecedentedly accelerated,' beyond the capabilities of human cognition.[66] At the same time, PLA thinkers appear to recognise the importance of balancing human and machine elements in decision-making. This dynamic is even characterised as an important 'dialectical relationship,' as Chen Dongheng (陈东恒) and Dong Julin (董俊林) researchers with the PLA Academy of Military Science have highlighted.[67]

The promotion of intelligentisation involves and requires various supporting and interrelated technologies. For instance, cloud computing is recognised as critical to realising intelligentisation, including to improve the management of military data.[68] The recent advances in AI chips and the requisite hardware can enable improved analytic and processing capabilities 'at the edge.'[69] China's continued difficulties in the development of indigenous semiconductors could remain a significant impediment on that front. In practice, such future warfare could involve a range of intelligentised weaponry, enabled by the Internet of Things (IoT), and leveraging networked information systems that are integrated across all domains.[70] Some military scientists have emphasised 5G will be vital to enabling the process of

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[64]Chen Hanghui [陈航辉], 'Artificial Intelligence: Disruptively Changing the Rules of the Game' [人工智能: 颠覆性改变'游戏规则], China Military Online, 18 March 2016, http://www.81.cn/jskj/2016-03/18/content_6966873_2.htm. Chen Hanghui is affiliated with the Nanjing Army Command College. Please note that I do not assess this to be an official or entirely authoritative perspective, though I do believe that the recurrence of similar sentiments in a range of reasonably authoritative.

[65]These concepts (i.e., of humans being in, on, or out of the loop) originate in US discussions of the role of humans in decision-making, reflecting the PLA's close attention to US policies and debates.

[66]'Exploring the winning joints of intelligentised operations' [探究智能化作战的制胜关节], PLA Daily, 29 March 2018, http://military.people.com.cn/n1/2018/0329/c1011-29896429.html.

[67]Chen Dongheng [陈东恒] and Dong Julin [董俊林], 'Military Intelligence Development Should Emphasize and Seize Upon Several Dialectical Relationships' [军事智能化发展应着重把握的几个辩证关系], PLA Daily, 14 May 2019, http://www.81.cn/theory/2019-05/14/content_9502765.htm.

[68]'Exploring the winning joints of intelligentised operations' [探究智能化作战的制胜关节].

[69]'Unmanned Systems: New Opportunities the Development of Military-Civil Fusion in Artificial Intelligence' [无人系统: 人工智能军民融合发展新契机].

[70]Hao Yaohong [郝耀鸿], '5 G, One Step Closer to the Military Internet of Things' [5 G,离军事物联网更近一步], Confidential Work 《保密工作》 July 2017, http://www.cnki.com.cn/Article/CJFDTotal-

intelligentisation. Such increases in connectivity can allow for improvements in data sharing and new mechanisms for command and control.[71]

In particular, 5G is anticipated to allow for machine-to-machine communication among sensors, drones, or even swarms on the battlefield, as well as improvements in human-machine interaction.[72] As China looks to construct a more integrated information architecture, 5 G could become critical to this new 'system of systems.'[73] Ultimately, it is not AI alone but the synergies of AI as a force multiplier for a range of weapons systems and technologies, also including directed energy, biotechnology, and perhaps even quantum computing, that could prove truly transformative.

Chinese military scholars and scientists are also focused on the challenges that data presents. From a practical perspective, data, recognised as a 'pivotal strategic resource.' In July 2018, the PLA's first 'military big data forum' had been convened by the Chinese Academy of Sciences, Tsinghua University, and Chinese Institute of Command and Control in Beijing.[74] The symposium concentrated on the importance of military big data, including to emphasise ways the military could learn lessons from enterprises and government in the management of big data. For instance, Song Jie, vice president of Alibaba Cloud (Aliyun), who discussed how Alibaba had leveraged big data to achieve a major advantage relative to traditional business infrastructure.[75] At the time, He You (何友), who is director of PLA Naval Aeronautical University's Information Fusion Research Institute argued that defence competition 'is centering on cognitive advantages and decision-making advantages' that require data.[76]

Data is recognised as a critical resource for modern operations. Data is expected to become 'an important foundation for the creation of the intelligentised battlefield.' In a prominent commentary in February 2019, PLA scholar Zuo Dengyun (左登云) emphasised, 'data is the "blood" of

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BMGZ201707033.htm. Hao Yaohong is an expert on military communications with the PLA Special Operations Academy (特种作战学院).

[71]Zhang Qingliang [张清亮] and Zhang Guoning [张国宁], '5 G Promotes the Acceleration of Military Intelligentisation' [5　G推动智能化作战提速], *China National Defence Report* [中国国防报], 12 March 2019, http://www.81.cn/gfbmap/content/2019-03/12/content_229076.htm.

[72]See: 'What is driving warfare to become more intelligentised?' [是什么在推动战争向智能化演变?], *People's Daily*, 6 November 2018. 'How does national Defence mobilization embrace the 5 G era?' [国防动员如何拥抱5 G时代], China Military Network, 27 June 2018, http://www.81.cn/gfbmap/content/2018-06/27/content_209482.htm.

[73]Hao Yaohong [郝耀鸿], '5 G, One Step Closer to the Military Internet of Things' [5 G,离军事物联网更近一步].

[74]'Big data builds the strongest "military brain"' [大数据构筑最强'军事大脑], *Qiushi*, 12 July 2018, https://web.archive.org/web/20190505163610/http://www.qsjournal.com.cn/junshiguofang/46518.html.

[75]The participation of Alibaba executives in a seminar of this nature is noteworthy and may be indicative of the company's current or intended future engagement in supporting military innovation.

[76]He You is also a professor with the Northwestern Polytechnical University, which is closely linked to military research. The propensity of influential researchers to take on many roles and multiple affiliations simultaneously could be characterized as a feature of technological development in China that contributes to easier exchange of ideas between military and technical communities.

maritime operations … It is necessary to obtain massive amounts of information through data deposits, grasp the weaknesses of enemy systems through data mining, share the operational situation through data presentation, and open up multi-domain joint channels, activating the "sense" of "smart" network empowerment.'[77] In the future, 'without data, (you) can't (fight) a war' (无数据不战争), and the PLA is concerned with improving its collection, management, and processing of data.[78] The commercial advantage that China may have given the depth and quantity of data available to its start-ups will hardly translate into military applicability except in select use-cases.

Chinese strategic thinkers have argued the advent of AI could change the fundamental mechanisms for winning future warfare.[79] The increasing prominence of intelligent could result in 'remote, precise, miniaturised, large-scale unmanned attacks' becoming the primary method of attack, according to Yun Guanrong (游光荣) of the Academy of Military Science.[80] Considering the ways in which AI could increase the tempo, accuracy, efficiency of operations, certain Chinese military strategists even expect that '[artificial] intelligence will transcend firepower, machine power, and information power, becoming the most critical factor in determining the outcome of warfare.'[81] Potentially, superior algorithms could dispel the 'fog' of the battlefield and enable decision-making advantage, while increasing the efficiency of operations.[82] In future intelligentised operations, today's 'system of systems confrontation' could become instead a 'game of algorithms' in which algorithmic advantage is a dominant determinant of operational advantage, as Li Minghai (李明海) of the PLA's National University of Defence Technology, has anticipated.[83] At present, however, such exuberant anticipation remains premature.

With the advent of intelligentisation, the human element of conflict remains critical and potentially vulnerable. Future command decision-making could leverage the respective strengths of human and machine cognition, while leveraging a 'cloud brain' that allows for swarm and distributed decision-making, enabled by deep neural networks. AI is also expected

[77]Zuo Dengyun [左登云], 'Where is the road to intelligent transformation of maritime operations?' [海上作战智能化变革路在何方], *PLA Daily*, 12 February 2019. http://military.people.com.cn/n1/2019/0212/c1011-30624347.html.

[78]Liu Zhanyong [刘战勇], 'Data: The Lifeblood of Informatized and Intelligentised Warfare' [数据: 信息化智能化作战血液], *PLA Daily*, 19 February 2019, http://www.81.cn/jfjbmap/content/2019-02/19/content_227628.htm.

[79]The range of books and textbooks on the topic illustrate the PLA's interest in the topic. See, for instance: Wu Mingxi [吴明曦], Intelligent Wars [智能化战争—AI军事畅想], National Defense Industry Press (Beijing), 2020; and Shi Haiming [石海明] and Jia Zhenzhen [贾珍珍], Artificial Intelligence Disrupts Future Warfare [人工智能颠覆未来战争], People's Press (Beijing), 2019.

[80]Yun Guangrong [游光荣], 'AI Will Deeply Change the Face of Warfare' [人工智能将深刻改变战争面], *PLA Daily*, 17 October 2018, http://www.81.cn/jfjbmap/content/2018-10/17/content_218050.htm.

[81]Ibid.

[82]Ibid.

[83]'Where is the winning mechanism of intelligent warfare? ' [智能化战争的制胜机理变在哪里?]

to contribute to more far-reaching transformations that could result in the intelligentisation of logistics support, models of combat power generation, organisational mechanisms, and education and training.[84] Pursuantly, Chinese military strategists expect that new styles of operations could emerge, particularly penetrating the cognitive and information domains.

Going forward, the capability to counter or subvert an adversary's capabilities in AI could become a critical domain of competition. PLA academics and strategists have discussed options for countermeasures against adversary's military employment of AI.[85] Such measures might include interference, damage, and destruction through kinetic or non-kinetic (e.g., electromagnetic, microwave weapons) means, or even attempts to make the enemy lose control of its AI and modify its procedures.[86] In particular, 'counter-intelligentised operations' would involve to 'paralyse the enemy's artificial intelligence, this the 'brain'; cutting the enemy's combat network, this the 'nerve'; and draining the enemy's combat data, this the 'blood,' as Maj. General Li Dapeng (李大鹏) of the PLA's Naval Engineering University has argued, calling for research on such techniques as counter-swarm combat, adaptive electronic warfare, and intelligent cyber warfare.[87] The use of AI can identify weak links and important targets in an adversary's system for joint operations, including to enable assaults intended to collapse an opponent's system of systems architecture.[88]

AI/ML projects in PLA research and development

The PLA has been actively pursuing research, development, and experimentation with an array of applications of artificial intelligence in recent years. The PLA's interest in AI/ML is hardly a recent phenomenon. Chinese research and development of dual-use advances in robotics and early artificial intelligence can be traced back to the mid-1980s, at which time the 863 Plan also launched a project that involved robotics and intelligent computing.[89]

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[84]Li Dapeng [李大鹏], 'How should we deal with the challenges of intelligent warfare' [我们该如何应对智能化战争挑战], *China Youth Daily* [中国青年报], 4 April 2019, http://www.xinhuanet.com/mil/2019-04/04/c_1210099555.htm.

[85]Zhu Qichao [朱启超], Wang Jingling [王婧凌], and Li Daguang [李大光], 'Artificial Intelligence Opens the Door to Intelligentised Warfare' [工智能叩开智能化战争大门], *PLA Daily*, 23 January 2017, http://military.china.com.cn/2017-01/23/content_40158456.htm.

[86]Chen Yufei (陈玉飞) and Xia Wenjun (夏文军), 'Intelligentised Warfare Quietly Strikes' [智能化战争悄然来袭], *PLA Daily*, 16 February 2017, http://www.81.cn/jfjbmap/content/2017-02/16/content_169593.htm.

[87]Li Dapeng [李大鹏], 'How should we deal with the challenges of intelligent warfare' [我们该如何应对智能化战争挑战].

[88]Zuo Dengyun [左登云], Gong Jia [龚佳], Huang Peirong [黄培荣], 'Why do informationized operations go to intelligized operations' [信息化作战何以走向智能化作战], *PLA Daily*, 20 September 2018, http://www.xinhuanet.com/mil/2018-09/20/c_129957478.htm. Huang Peirong is a professor at the Naval Command Academy.

[89]This program was contemporaneous with in response to the US Strategic Computing Initiative and Japan's Fifth-Generation Computing. Alex Roland, Philip Shiman, and William Aspray. *Strategic computing: DARPA and the quest for machine intelligence, 1983–1993*. MIT Press, 2002.

Certain initiatives to apply expert systems to military operations research also date back to the late 1980s and 1990s.[90] Chinese military researchers who are active in work on decision support systems, such as Major General Liu Zhong (刘忠) of the PLA's National University of Defence Technology, have been leveraging what might be considered 'AI' in their research since at least the mid-2000s.[91]

Certain initiatives in weapons development, such as the application of advanced algorithms to work on hypersonic glide vehicles can also be traced back to the mid-2000s.[92] For instance, the Chinese defence industry's attempts to make cruise and ballistic missiles more 'intelligent' build upon advances in Automatic Target Recognition (ATR) that also predate the recent concern with autonomous weapons. The swarms and suicide drones that have been already developed and subject to operational experimentation highlight

PLA support for AI has been and will be included in the PLA's plans for weapons development. The PLA Army, Navy, Air Force, Rocket Force, and Strategic Support Force are all pursuing their own service-specific projects and initiatives through their respective equipment departments and through their research institutes and partnerships. To date, each service in the PLA has started to field and deploy a number of unmanned (i.e., remotely piloted) systems, of which some have at least a limited degree of autonomy.[93]

The PLA's pursuit of military intelligentisation is intended to enhance and augment existing weapons systems, while also enabling novel capabilities. The patents, funding, and technical publications that are often openly published and demonstrated provide initial indications of the direction of these developments, and there are also certainly classified programs underway about which no or fewer details are known. The PLA should be expected to employ AI across an array of applications in all domains of warfare and a range of missions in combat and to support operations, including for maintenance, automatic target recognition, and support to command decision-making, among others.[94]

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[90]Deborah R. Harvey and Barbara R. Felton, 'Military Operations Research in China: A Defence S&T Intelligence Study,' March 1994, DST-1820S-187-94. This document was regarded as unclassified and released in March 1998.

[91]'National University of Defence Technology's Liu Zhong: Creating a Powerful "External Brain" for Command and Control' [国防科大刘忠:为指挥控制打造强大'外脑'], *People's Daily*, 28 December 2015, http://military.people.com.cn/n1/2015/1228/c401735-27986608.html.

[92]For an authoritative assessment, see: Lora Saalman, 'China's Integration of Neural Networks into Hypersonic Glide Vehicles,' December 2018, https://nsiteam.com/social/wp-content/uploads/2018/12/AI-China-Russia-Global-WP_FINAL.pdf.

[93]See this report from the China Aerospace Studies Institute: Elsa Kania 'The PLA's Unmanned Aerial Systems New Capabilities for a "New Era" of Chinese Military Power,' China Aerospace Studies Institute, 8 August 2018, https://www.airuniversity.af.edu/CASI/Display/Article/1596429/the-plas-unmanned-aerial-systems-new-capabilities-for-a-new-era-of-chinese-mili/.

[94]Upon request, more details on these projects based on open sources are available from the author.

Potential challenges in chinese military innovation

While the PLA's ambitions and advances in robotics, autonomy, and a range of applications of artificial intelligence should not be dismissed or underestimated, nonetheless certain difficulties and apparent will likely impede its implementation of this agenda. Not unlike the US military or any bureaucracy, the PLA will confront constraints and challenges in the process. It remains to be seen whether attempts to overcome such impediments will prove successful, and the theoretical frameworks from the literature can contribute to our evaluation of the likely challenges.

The PLA's capacity to innovate may be impeded by bureaucratic politics and its culture as an organisation. The Chinese military, similar to any bureaucracy, has struggled to adopt and adapt new technologies that may, in some cases, present threats to existing interests. The PLA has been assessed to be an organisation that is highly hierarchical, operating in a top-down manner with a high degree of centralisation of power. These features, such as the low levels of trust often considered characteristic of authoritarian militaries, could impede more junior officers and enlisted personnel from having the opportunity to exercise initiative and experiment with new technologies and techniques.

These typical difficulties could be exacerbated by the disruption that has resulted from the significant organisational restructuring that remains ongoing. For these reasons, despite the CCP's and PLA's rhetorical commitment to innovation, its implementation may be impeded by such dynamics. Moreover, if the slowdown of China's economy constrains the resources available for military modernisation, the trade-offs between the development of new capabilities and sustainment of existing platforms could become more acute.

The PLA's capability to leverage AI could be hindered by continued challenges in talent and human capital. The PLA has attempted to overcome prior difficulties to expand the recruitment of 'high-quality' talents, including by targeting those with higher levels of education. For instance, as of spring 2019, over 2,500 colleges and universities nationwide have reportedly established recruitment workstations.[95] There have also been reforms to the PLA's personnel management to shift from 'civilian cadre' to civilian personnel, who receive benefits comparable to those of civil servants. The new rounds of recruitment for these civilian positions have aimed to attract candidates with MA and PhD degrees who have backgrounds in computer science and artificial intelligence. The PLA's actual success in recruiting and retaining those with such technical proficiencies remains to be seen. The PLA will be competing for high-tech talent against intense demands from a growing private sector.

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[95]'Military Delegates Hotly Discussed Accelerating and Improving Innovative Development of National Defence Mobilization' [军队人大代表热议加速推进国防动员创新发展], China Military Network, 15 March 2019, https://web.archive.org/save/http://www.legaldaily.com.cn/army/content/2019-03/15/content_7802049.htm.

There are particular bottlenecks in the availability of AI talent to date that have also presented significant challenges to technology companies. The application of an approach of military-civil fusion to talent development could contribute to resolving this problem, including through dedicated programs that leverage closer collaboration with the tech sector. For instance, Beihang University has launched a new degree program in AI to which Baidu is contributing, and the Beijing Institute of Technology has also established a new program for intelligent weapons development.[96] As Chinese universities expand educational programming in AI research, and as plans and programs for the recruitment of overseas talents continue to expand, the PLA may manage to create a more sizable pool of talent to draw from. These attempts to cultivate 'first-class talent' continue, but progress will take time to realise and may prove limited in some cases.[97]

While the PLA has concentrated on increasing the realism of its training, the PLA may struggle to match the sophistication required for preparations for future warfare. The PLA's training was once highly scripted and has improved in sophistication, but further challenges will intensify considering the complexities and challenges of future intelligentised operations. Chinese military officers and researchers recognise the importance of innovation in training in response to new challenges. However, the adoption of new techniques to be incorporated into the PLA's official Outline of Military Training and Education, which was last revised in 2017, could prove challenging.[98] The PLA's experimentation with the use of virtual reality and artificial intelligence training, as well as active efforts for AI systems in wargaming, could enable improvements in realism that could facilitate preparation for actual combat, which is a critical concern considering the PLA's lack of operational experience. In particular, the complexities of managing human factors in training with complex systems could present particular challenges for the PLA.

The PLA has seemed to struggle with revising its doctrine and may confront difficulties in adopting new theories and concepts in practice. The Chinese military does not appear to have fully revised its doctrine since 1999, even though ongoing, rolling revisions that have involved some updates. The new 'fifth-generation' of operational regulations (作战条令), including campaign guidelines (战役纲要), which has been under development since 2004, was nearly, but not fully or officially, launched in 2008 at its intended completion. Despite ongoing research activities, the PLA was slow

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[96] Artificial Intelligence Research Direction 2017 Double Certificate Master's Degree [人工智能研究方向 2017年双证硕士], http://soft.buaa.edu.cn/BuaaPublic/html/ShowNews_60_4896.html.

[97] 'A First-Class Military; New-Type Military Talent Cultivation' [一流军队, 新型军事人才咋培养], *PLA Daily*, 2 January 2018, http://www.xinhuanet.com/mil/2018-01/02/c_129780635.htm .

[98] For context on the trajectory of these developments, see: Department of Defence, 'Military and Security Developments Involving the People's Republic of China 2018,' https://media.Defence.gov/2018/Aug/16/2001955282/-1/-1/1/2018-CHINA-MILITARY-POWER-REPORT.PDF.

to progress in completing and implementing these doctrinal changes, which appears to indicate a lack of consensus or institutional impediments. The apparent complications also raise questions about whether the PLA will be able to incorporate new theories and concepts of intelligentised operations into this framework in practice, such as through facilitating increasing connectivity between scientists and strategists, or could confront comparable difficulties in the process.

In this regard, while China may appear to possess a data advantage given the aggregate amount of data that it possesses as a nation, that edge may prove limited in actuality and unlikely to directly translate into a military advantage. The relative fragmentation across bureaucracies could obstruct progress. Chinese military researchers have expressed concern that there are current inadequacies in data mining, analytic processing capabilities, awareness of security and secrecy, and support of training data.[99] The PLA will have to manage practical challenges in cleaning and labelling disparate sources of data for use, which can be time and labour intensive, but these efforts could be facilitated access to cheap services for data labelling such as available in China.[100] The PLA will be required to adopt shared infrastructure, including cloud computing, to enable deployment and promote an integrated approach. However, if the inefficiencies redundancies, even corruption, that arose during the implementation of informatisation arise again in the process of intelligentisation, the PLA may be hindered from effective utilisation of these technologies.

The PLA's lack of operational experience could result in a failure to appreciate the challenges of operating highly complex automated or autonomous systems under actual combat conditions. The PLA approaches warfare through the lens of military science. Lacking operational experience in its recent history, the PLA has confronted the unique challenge of 'learning without fighting,' often based on engaging in theoretical research that examines trends and technologies. Traditionally, military innovation in peacetime has been considered particularly challenging, and the PLA is unlikely to be an exception in that regard. Nonetheless, the sense of threat and urgency that comes with facing a 'powerful adversary' appears to have overcome the inertia that often impedes change. The progress in 'actual combat' training, including confrontations between blue and red forces, could compensate for the lack of operational experience. Nonetheless, the PLA may fail to appreciate the extent to which the full complexity of warfare can extend beyond that anticipated in theories or exercises.

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[99]Liu Zhanyong [刘战勇], 'Data: The Lifeblood of Informatized and Intelligentised Warfare' [数据: 信息化智能化作战血液], *PLA Daily*, 19 February 2019, http://www.81.cn/jfjbmap/content/2019-02/19/content_227628.htm.

[100]'Data-labeling: the human power behind Artificial Intelligence,' *Xinhua*, 17 January 2019, http://www.xinhuanet.com/english/2019-01/17/c_137752154.htm.

Whereas initial American enthusiasm about the notion of a Revolution in Military Affairs was tempered by the realities of combat and the failures of certain capabilities to materialise as anticipated, the PLA's focus on the notion of the RMA has persisted, seemingly without a comparable recalibration of expectations. For instance, certain Chinese military writings go so far as to claim that these advances could render the battlefield 'clear and transparent,' lifting or perhaps lessening the fog of war. In actuality, the advent of AI could change that fog, perhaps creating new sources of confusion and novel cognitive challenges, particularly given the likely limitations of AI. In this regard, the PLA's efforts could be undermined by 'hot thinking' on AI that is not always qualified by the 'cooler' realities.[101]

The particular ideological constraints and characteristics for the PLA as a Party army may impede or condition its development in ways that could prove unique. The PLA is a Party army, not a national military, and that reality could influence its approach to AI. Xi Jinping has consistently reiterated that the PLA must adhere to the Party's 'absolute leadership,' expanding and emphasising the importance of innovation in 'political work' that is intended to ensure that obedience. At first glance, these imperatives of capability and controllability could appear to be at odds in some cases. For instance, time dedicated to political activities is time taken away from training, and the imposition of ideological indoctrination seems unlikely to be conducive to the creativity that can enable innovation. Moreover, certain idiosyncrasies might be introduced into the PLA's approach to AI as a result of the ideological environment within which it is being developed. Some writings have called for a dialectical approach to AI or emphasised the importance of ensuring that AI possesses certain political qualities and adhere to the necessary ideological requirements, avoiding any disloyalty.[102]

Implications for US-China rivalry

As US-China military rivalry intensifies at a time of technological transformation, these trends may present new risks to strategic stability under complex geopolitical circumstances. Chinese military strategists are seeking to seize the initiative, believing 'first-class militaries design warfare, second-rate militaries are trailing in warfare, and third-rate militaries have to contend with warfare.'[103] The PLA's ambitions to be a truly world-class military imply its intention to be at the forefront of shaping and 'designing' the conditions of

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[101]For instance, certain Chinese military writings have articulated a more skeptical perspective, and it is likely there is still some disagreement among PLA stakeholders.

[102]For translation and discussion, see: 'Intersections of Ideology with China's Approach to Military Applications of Artificial Intelligence,' https://www.battlefieldsingularity.com/musings-1/intersections-of-ideology-with-china-s-approach-to-military-applications-of-artificial-intelligence.

[103]Ke Zhengxuan [科政轩], 'How to build and form a military scientific research system with our military's characteristics' [我军特色军事科学研究体系如何构建形成].

future battlefields.[104] However, there are reasons to question and regard sceptically the PLA's capacity to realise its aspirations given the challenges that remain. Even as American observers fear that China may have surpassed the US military on some fronts, the PLA itself continues to regard it as a powerful adversary that sets the benchmark for its own advances.

Looking forward, while the disruption that AI may introduce may be the subject of exaggerated expectations in the near future, the transformations that such emerging information technologies could create in the decades to come may extend beyond anyone's anticipation. 'AI' is best considered a general-purpose enabling technology that has a diverse array of applications that cannot be characterised through a single facet. This disparate and qualitative character of how AI can enhance various military capabilities may create a degree of uncertainty that could impede assessments of relative advances. The impact on the military balance may be merely perceived, rather than adequately evaluated.

Since the contributions of AI to military power are essentially intangible, there are incentives for militaries to signal, display, and demonstrate relevant capabilities, such as swarming, in attempts to bolster deterrence, including through activities that may be intended for purposes of deception or misdirection. This trend can be exacerbated by the consistent tendency towards worst-case scenario thinking and overestimation of a potential adversary's capabilities. However, it is encouraging that military specialists and technology stakeholders in the United States and China alike appear to be cognizant on such concerns.[105] Ultimately, the frequent framing of an 'AI arms race' is also problematic,[106] insofar as this conceptualisation can be misleading and has significant limitations. As the US-China military-to-military relationship evolves going forward, there may be opportunities to progress towards greater clarity and transparency through dialogue on shared concerns of strategic stability, including questions of risk mitigation and crisis management.

Disclosure statement

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[104]'Xi Jinping's Report at the Chinese Communist Party 19th National Congress' [习近平在中国共产党第十九次全国代表大会上的报告], Xinhua, 27 October 2017, http://www.china.com.cn/19da/2017-10/27/content_41805113_3.htm.

[105]China Institute of Information and Communications (CAICT), 'AI Security White Paper' [人工智能安全白皮书], September 2018, http://www.caict.ac.cn/kxyj/qwfb/bps/201809/P020180918473525332978.pdf.

[106]For an excellent assessment of this issue see: Heather Roff, 'The frame problem: The AI "arms race" isn't one,' *Bulletin of the Atomic Scientists*, 29 April 2019, https://thebulletin.org/2019/04/the-frame-problem-the-ai-arms-race-isnt-one/.

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