GLOBAL CHINA
ASSESSING CHINA'S GROWING ROLE IN THE WORLD

"AI WEAPONS" IN CHINA'S MILITARY INNOVATION

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APRIL 2020

EXECUTIVE SUMMARY

As the Chinese People's Liberation Army (PLA) seeks to become a "world-class military," its progress in advanced weapons systems continues to provoke intense concern from its neighbors and competitors.[1] The Chinese military and China's defense industry have been pursuing significant investments in robotics, swarming, and other applications of artificial intelligence (AI) and machine learning (ML).[2] Thus far, advances in weapons systems described or advertised as "autonomous" (自主) or "intelligentized" (智能化) have built upon existing strengths in the research and development of unmanned (无人)[3] systems and missile technology.[4] While difficult to evaluate the sophistication of these emerging capabilities,[5] this initial analysis concentrates on indicators of progress in weapons systems that may possess a range of levels of autonomy.[6]

This paper reviews advances in the Chinese military and defense industry to date, evaluates the potential implications of Chinese approaches to arms control and governance, assesses potential future developments, and then considers the strategic implications, as well as policy options for the United States and likeminded democracies. Based on publicly available information, the PLA's trajectory in the development and potential employment of AI/ML-enabled and autonomous weapons systems remains uncertain. The maturity of these capabilities — as well as if, when, and to what extent weapons systems with greater levels of autonomy have been fielded — cannot be assessed with high confidence at this point. However, as technological competition emerges as an ever more prominent element of great power rivalry, it is clear the Chinese military and defense industry have undertaken active initiatives in research, development, and experimentation. Yet China's progress will remain contingent upon the capacity to operationalize emerging weapons systems, which will require overcoming current technological and organizational challenges in testing, training, and concepts of operations.[7]

Chinese advances in autonomy and AI-enabled weapons systems could impact the military balance, while potentially exacerbating threats to global security and strategic stability as great power rivalry intensifies.[8] In striving to achieve a technological advantage, the Chinese military could rush to deploy weapons systems that are unsafe, untested, or unreliable under actual operational conditions. The PLA's strategic choices about which capabilities could prove advantageous will influence the direction of Chinese military innovation. It is encouraging that Chinese military scientists and researchers are starting to debate and engage with safety issues and technical concerns, as well as legal and ethical considerations.[9] Nonetheless, People's Republic of China (PRC) arms sales to potential adversaries to the United States, and to militaries with little regard for the law of war, threaten U.S. values and interests, while accelerating the proliferation of these capabilities to non-state actors. Going forward, the United States should monitor these trends and pursue measures to mitigate such risks.

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INTRODUCTION

Advances in autonomy and AI-enabled weapons systems promise to increase the speed, reach, precision, and lethality of future operations.[10] Today, militaries worldwide, including in the United States and Russia,[11] are exploring and pursuing these capabilities.[12] Current definitions of autonomy and understanding of the characteristics of "lethal autonomous weapons systems" (LAWS) vary greatly.[13] The use of AI/ML techniques, while not required to achieve autonomy, can enable these capabilities.[14] In an era of high-tech warfare, the boundary between a "smart weapon" capable of great precision and a weapons system considered partly or fully autonomous can be complex and contested.[15] No consensus exists on how to manage issues of law, ethics, and arms control that arise with the development of such capabilities, other than emergent agreement that existing elements of international law do apply, including the law of armed conflict (LOAC).[16] Beyond this, the major militaries remain unwilling to accept any serious constraints on development due to the potential for future operational advantage.[17]

CURRENT CHINESE MILITARY CAPABILITIES

Chinese military initiatives in AI are motivated by an acute awareness of global trends in military technology and operations;[18] concerns about falling behind the U.S. military, which is perceived and often characterized as the "powerful adversary" (强敌);[19] and recognition of potential opportunities inherent in this military and technological transformation.[20] "China's military security is confronted by risks from technology surprise and a growing technological generation gap," according to the official white paper on "China's National Defense in the New Era," released in July 2019.[21] "Intelligent(ized) warfare is on the horizon," the assessment finds, and the ongoing "Revolution in Military Affairs" will change the very mechanisms for victory in future warfare.[22] Chinese military scientists and strategists, including from such authoritative institutions as the PLA's Academy of Military Science, National Defense University, and National University of Defense Technology, envision AI and intelligent weapons playing an increasingly important if not decisive role in future warfare. They closely examine antecedents in U.S. strategy and capabilities to inform their own assessments.[23]

The PLA's quest for innovation is an element of the Chinese national strategy to leverage science and technology in pursuit of great power status.[24] In the process, the Chinese military is developing more traditional and emerging capabilities, while concentrating on asymmetric approaches against the U.S. military. President Xi Jinping has emphasized, "under a situation of increasingly fierce international military competition, only the innovators win."[25] Moreover, on the importance of "aiming at the frontier of global military scientific and technological developments," he urged: "We must attach great importance to the development of strategic frontier technologies, striving to surpass the predecessor as latecomers, turning sharply to surpass."[26]

As early as 2011, the PLA's official dictionary included a definition of an "AI weapon" (人工智能武器), characterized as "a weapon that utilizes AI to pursue, distinguish, and destroy enemy targets automatically; often composed of information collection and management systems, knowledge base systems, decision assistance systems, mission implementation systems, etc."[27] Similarly, Chinese military strategists and scientists tend to discuss "AI weapons" or "intelligentized weapons" (智能化武器) more often than "autonomous weapons" (自主武器) in academic and technical writings.[28] This terminological difference is subtle but potentially significant, implying a focus on the "smartness" or "intelligence" of weapons systems in selecting and engaging targets.[29] For instance, techniques for adaptive or autonomous control can leverage a range of algorithms, including neural networks. Even as the function of certain weapons systems becomes "unmanned" (无人化) and to some degree automatic (自动化), greater degrees of autonomy or "intelligence" in function can remain elusive.

While Chinese leaders have prioritized advances in AI as an important direction for military modernization, China's Central Military Commission has yet to release any policy or official strategy that formally clarifies such plans and priorities. However, in July 2017, the New Generation Artificial Intelligence Development

Plan called for China to "strengthen the use of AI in military applications that include command decisionmaking, military deductions,[30] and defense equipment."[31] In the fall of 2017, Xi, in his address to the 19th Party Congress of the Chinese Communist Party (CCP), urged, "accelerate the development of military intelligentization, and improve joint operations capabilities and all-domain combat capabilities based on network information systems."[32] His remarks provided authoritative guidance to pursue military applications of AI that could be integrated across the whole system for future operations.[33] This emerging emphasis on "military intelligentization" (军事智能化), or the "development of an intelligent military,"[34] extends beyond AI-enabled systems and autonomy to include the development of weapons systems leveraging adaptive control or involving autonomy in various aspects of their operation.[35]

The PLA is actively pursuing AI-enabled systems and autonomous capabilities in its military modernization.[36] Across services and for all domains of warfare, it has fielded a growing number of robotic and unmanned systems, as well as advanced missiles with precision guidance, some of which may possess at least limited degrees of autonomy. For instance, the PLA Army (PLAA) has concentrated on military robotics and unmanned ground vehicles, which could be used for logistics.[37] The PLA Navy (PLAN) is experimenting with unmanned surface vessels that may operate with some autonomy and is reportedly developing autonomous submarines.[38] The PLA Air Force (PLAAF) operates advanced unmanned systems with limited autonomy that could be upgraded to include greater autonomy, while exploring options for manned-unmanned teaming.[39] The PLA Rocket Force (PLARF) may leverage use cases in remote sensing, targeting, and decision support,[40] and its missiles may be augmented to become more "intelligentized" in their capabilities, incorporating higher levels of automation to facilitate operations.[41] There are indications that the PLA Strategic Support Force (PLASSF) could apply advances in AI to its missions of space, cyber, electronic, and psychological warfare.[42] PLA capabilities and advancements very likely extend well beyond what is known and knowable from open sources.

The Chinese defense industry can build upon its apparent strengths in armed drones and advanced missiles to introduce greater autonomy into operations.[43] In particular, certain advanced unmanned aerial vehicles could be modified to operate with greater autonomy instead of under remote control.[44] Currently, China leads in export of medium-altitude long endurance unmanned aerial vehicles (UAVs).[45] PRC UAVs, such as the Wing Loong platform, from the Aviation Industry Corporation of China (AVIC), and the CH-4, developed by China Aerospace Science and Technology Corporation (CASC), are actively marketed for export.[46] In fact, CASC has even opened factories for the CH-4 platform in Pakistan, Myanmar, and Saudi Arabia.[47] This prominent ranking in arms sales reflects the relative affordability of Chinese drones over American ones, and that the Chinese defense industry has been less constrained in selling to militaries to which their U.S. counterparts have been unable or unwilling to sell.[48] Within the PLAAF, the GJ-1 and its successor GJ-2 are used for integrated reconnaissance and precision strike, including in support of joint operations.[49] According to its designer, the GJ-2 is "highly intelligentized" and capable of operating autonomously, including in identification of the enemy and judgement of threats.[50]

Yet an inherent challenge of evaluating progress and capabilities is that the level of autonomy, relative to possibility of remote control, cannot be readily assessed by appearance alone. Moreover, as China strives to close the gap with the United States, its efforts are complicated by persistent bottlenecks in its indigenous defense industrial capabilities.[51] While cyber theft and industrial espionage enabled by a range of techniques of tech transfer have enabled and accelerated Chinese military modernization, persistent obstacles and bottlenecks remain, including short-falls in the technical workforce and engineering experience.[52] Chinese leaders are cognizant of critical weaknesses, such as the semiconductors, particularly specialized developments in AI chips, necessary to enable and deploy AI/ML systems, and actively investing to overcome them.

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While there is currently no direct evidence that the PLA has formally fielded a weapons system fully consistent with the definition of "AI weapon," a number of systems are analogous or comparable in their functionality. The Chinese defense industry's attempts to make cruise and ballistic missiles more "intelligent" build upon work on automatic target recognition that predates the recent concern with autonomous weapons.[53] The Chinese military has reportedly converted older models of tanks to operate via remote control or with some degree of autonomy.[54] There are also reports that variants of aircraft have been modified to be operated via remote control or potentially autonomously, perhaps to overwhelm air defenses in a potential invasion scenario against Taiwan.[55] The PLAN has tested and operated a range of undersea gliders and unmanned underwater vehicle (UUVs) for scientific or military missions,[56] including the HN-1 glider used in exercises in the South China Sea in 2018.[57] Often, limited technical information is available, rendering the disclosure of capabilities and signaling — including the potential for misdirection or disinformation — important to evaluate carefully.[58]

FUTURE TRENDS IN RESEARCH AND DEVELOPMENT

These advances in PLA capabilities are taking shape through the efforts of Chinese military research institutes, the Chinese defense industry, and the emerging ecosystem of commercial enterprises supporting military-civil fusion.[59] For instance, the Key Laboratory of Precision Guidance and Automatic Target Recognition at the PLA's National University of Defense Technology researches a range of automatic target recognition techniques. The available technical literature also points to interest in applying neural networks to the guidance of hypersonic glide vehicles, enabling adaptive control and greater autonomy.[60] For new directions in research, the Tianjin Binhai Artificial Intelligence Military-Civil Fusion Center was established in partnership with the PLA's Academy of Military Science, and pursues developments in autonomy and the capacity for coordination of unmanned systems, such as in undersea drones.[61]

Future Chinese aerospace capabilities will be enabled and enhanced by research currently underway within the major state-owned defense conglomerates. Starting in 2015, the China Aerospace Science and Industry Corporation (CASIC) 3rd Academy 35th Research Institute began pursuing breakthroughs in core technologies including target detection and recognition techniques based on deep learning and deep neural network compression, and smart sensors, combining data from multiple radars.[62] Notably, in 2016, this CASIC team organized an innovation competition for "AI-Based Radar Target Classification and Recognition,"[63] the Chinese defense industry's first major event of this kind; it involved companies and universities with AI research proficiency applying that expertise to finding intelligent processing solutions for targeting.[64] According to a senior missile designer from CASIC, "our future cruise missiles will have a very high level of AI and autonomy," such that commanders will be able "to control them in a real-time manner, or to use a fire-and-forget mode, or even to add more tasks to in-flight missiles."[65] Future missiles might have increasingly sophisticated capabilities in sensing, decisionmaking, and implementation — even potentially gaining a degree of "cognition" and continual learning capability.[66] Significantly, the PLA's development of hypersonic weapons systems has also incorporated advances in techniques for greater autonomy and adaptive control.[67]

Chinese naval capabilities may be augmented by advances in military robotics and autonomy. During a September 2018 defense exhibition, a subsidiary of the China Shipbuilding Industry Corporation revealed "JARI," a multi-purpose unmanned surface vessel reportedly designed for use by the PLAN and also intended for export as a warship.[68] CSIC has also displayed the "Sea Iguana" (or Marine Lizard, 海蜥蜴),

an unmanned surface vehicle (USV) that could be leveraged in support of future amphibious operations.[69] Reportedly, the PLAN and Chinese defense industry are also developing AI-enabled submarines to advance Chinese capabilities in undersea warfare,[70] through a classified military program disclosed in English-language reporting, the 912 Project.[71] While fully autonomous submarines appear to remain a long-term objective, the introduction of AI/ML techniques for target detection and decision support — including to improve acoustic signal processing — could prove more feasible in the meantime.[72] Beyond state-owned defense conglomerates, a growing number of new contenders are pursuing advances in unmanned and autonomous weapons systems, from companies, such as Yunzhou Tech, to leading universities, including the Beijing Institute of Technology.[73]

PRC ARMS SALES AND APPROACHES TO GLOBAL GOVERNANCE

Increasingly, U.S. officials express concerns about Chinese development and potential proliferation of unmanned systems and the capabilities for autonomy. In November 2019, U.S. Secretary of Defense Mark Esper warned that Chinese weapons manufacturers were selling drones to the Middle East "advertised as capable of full autonomy, including the ability to conduct targeted strikes."[74] While not specifying which weapons systems provoked concern, it appears he may have had in mind a weapons system produced by the Chinese company Ziyan.[75] Only a month before, the Chinese delegation to the UN General Assembly Thematic Discussion on Conventional Arms Control argued, "China believes it is necessary to reach an international legally-binding instrument on fully-autonomous lethal weapons in order to prevent automated killing by machines."[76] Yet like other major powers, China does not seem eager to tie its own hands when it comes to the research, development, and potential deployment of autonomous weapons systems.[77]

This was not the first time China's diplomatic proclamations have contradicted its apparent intentions or activities around autonomous weapons systems. During the April 2018 session of the UN Group of Governmental Experts (GGE) on Lethal Autonomous Weapons Systems (LAWS), the Chinese delegation articulated an intention to ban "the use of fully autonomous lethal weapons systems."[78] However, the definition the Chinese delegation provided was convoluted enough to exclude the types of weapons systems most militaries, including the PLA, are actually developing.[79] This very restrictive definition includes the following characteristics: (1) lethality, (2) autonomy, defined as "the absence of human intervention and control during the entire process of executing a task," (3) "impossibility of termination" once the device is set in motion, (4) "indiscriminate effect," "regardless of conditions, scenarios and targets," and (5) "evolution," such that "the device can learn autonomously through interaction with the environment, expanding its functions and capabilities in a way exceeding human expectations."[80]

This definition of autonomy is perplexing yet revealing, given that no militaries appear interested in pursuing weapons systems that entirely remove the possibility of termination by a human operator.[81] Moreover, the phrasing "indiscriminate effect" implies the capability as defined would inherently violate the requirement of distinction from the law of armed conflict. Finally, the notion of "evolution" seems to envision online machine learning that is ongoing in the operational environment,[82] which could introduce vulnerabilities and challenges, including the potential for exploitation by adversaries attempting to manipulate that process of learning.[83] The Chinese delegation to the UN GGE on LAWS has not further clarified its position. By claiming to support a weapons systems ban with these extreme characteristics, the Chinese government appeared to be positioning itself in support of the ban movement,[84] while still continuing to pursue a broad array of autonomous weapons systems. China's approach to international law can be characterized by "legal warfare" (法律战), seeking to exploit legal mechanisms to constrain and delegitimize adversaries, while circumventing legal constraints itself.[85] The PRC position on these issues may evolve, given China's attempts to become more actively involved in shaping global governance of AI, from technical standards to debates on law, norms, and ethics.[86]

China's ambiguous definition of autonomous weapons systems also poses a potential challenge to arms control. The U.S. Department of Defense Directive 3000.09 regulates the development and use of autonomous and semi-autonomous functions in weapons systems, and defines autonomous weapons systems as those that "once activated, can select and engage targets without further intervention by a human operator."[87] The Chinese military, conversely, has no known parallel to DOD Directive 3000.09, and employs various definitions of autonomous weapons, AI weapons, or what the Chinese military has called "intelligentized" weapons. In some cases, Chinese military and defense researchers reference the concept of "levels of intelligence" (智能等级) when discussing the "intelligent capabilities" of a specific system.[88] Different concepts and terminology between the U.S. and PRC — for instance, the divergence between Chinese notions of human-machine collaboration (人机协同) and human-machine integration (人机融合),[89] and the American emphasis on human-machine teaming[90] — will merit clarification.[91]

IMPLICATIONS FOR GLOBAL SECURITY AND STABILITY

The advent of AI/ML systems and greater autonomy in defense will impact deterrence and future warfighting among great powers. This military-technological competition could present new threats to strategic stability, which Chinese military officers and strategists are starting to recognize and debate.[92] Given the emphasis of Chinese military leaders on pursuing innovation to catch up with and surpass more powerful militaries, namely that of the United States, there are reasons for concern the Chinese military may fail to dedicate adequate attention to issues of safety and testing in the process. The advent of greater autonomy in weapons systems introduces added complexity, and complex systems tend to be more prone to failures and accidents, particularly in contested environments.[93] The PLA has not yet released any public policies or official statements that describe its practices for testing.[94] However, at least a limited number of Chinese experts and military scientists are starting to dedicate more attention to risks associated with the development and use of autonomous weapons systems.[95]

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The Chinese military lacks contemporary operational experience, and its insufficient firsthand knowledge of the "fog of war' may result in mistakes or unrealistic expectations about the prospects for technology on the battlefield. For instance, Chinese assessments of American intentions and capabilities tend to be relatively exaggerated. The PLA does have a history of and experience with the testing and verification of weapons systems, including at several bases dedicated to these activities.[96] Yet a significant difference exists between testing and training compared to the unpredictability of accidents or unintended engagements that can occur on the battlefield.[97] The PLA appears to be relatively pragmatic about issues of safety and reliability with new technologies. However, a risk remains that it might be more likely to make mistakes given its lack of operational experience, for which realistic training and advanced simulations can only partially compensate.[98]

Absent official policy or guidance from Chinese military leaders, it is difficult to anticipate how the PLA will approach issues of human control over autonomous systems, particularly as these capabilities progress and evolve. Historically, Chinese leaders have prized centralized, consolidated control over the military. They may therefore be generally disinclined to relinquish control to individual humans, let alone machines, fearing loss of the Party's "absolute command."[99] At the same time, Chinese military scholars and scientists appear to be relatively pragmatic in how they approach and discuss the nuances of having a human in, on, or out of the loop. Given technical constraints and uncertainties, there are reasons to expect in the near term that the Chinese military will

keep humans "in the loop" or at least "on the loop," but it is harder to anticipate whether the PLA or any military will maintain that position if conditions and technical considerations change.[100] However, to date, discussion of meaningful human control appears to be less established in Chinese writings than in U.S. debates on these topics.[101]

There is no clear evidence indicating that the Chinese military is more inclined to pursue autonomy and/or automation in a manner that removes humans from decisionmaking relative to other militaries. In the near term, human involvement in command and control appears to be deemed necessary for technical reasons, and the Chinese military is actively exploring concepts that leverage synergies between human and artificial intelligence, such as that of "human-machine" intelligent integration (人机智能融合).[102] In the future, operational expediency concerns could supersede safety if having a human in the loop became a liability, as greater involvement of AI systems in command decisionmaking is considered potentially advantageous.[103] Yet at the level of strategic decisionmaking, including for decisions that involve the employment of nuclear weapons,[104] it is all but certain that one human will remain "in the loop," for the foreseeable future: Xi Jinping.

While the debate over lethal autonomous weapons systems raises complex legal and ethical issues, such concerns about the impact of advances in autonomy are less prevalent or prominent in Chinese military discourse and writing to date. The PLA lacks the U.S. military's overseas operational experience and its institutionalized architecture of legal expertise to apply the law of war in actual operations. Nonetheless, as the PLA looks to expand global operations and takes on new missions defending overseas interests, its attention to these concerns has necessarily increased. At present, the Chinese military lacks a specialty or career trajectory directly analogous to the U.S. military's Judge Advocate General's Corps.[105] However, certain Chinese military officers with legal expertise have advocated for a more direct incorporation of legal experts into the chain of command to provide legal support for operations and decisionmaking.[106] The PLA's Academy of Military Science also organized a conference in September 2019 to address the legal issues that arise with military applications of AI.[107]

The Chinese government has launched a charm offensive on AI ethics, including releasing new principles that echo debates on "AI for good."[108] Yet reasons remain to question whether Chinese leadership will actually prioritize and institutionalize these commitments in ways that create substantive constraints.[109] China's stated commitment to ethical AI use principles is contradicted by the CCP prioritization of AI as an instrument for maintaining social control and coercion, enabling crimes against humanity in Xinjiang and beyond.[110] Certain Chinese military scholars have criticized the ethics of the U.S. military's employment of unmanned systems, yet the Chinese government may also seek to use U.S. precedent as justification for similar PRC actions in the future.[111] Ultimately, the PLA itself is the armed wing of the CCP, bound to "obey the Party's command" and ensure regime security.[112] A notable nexus can exist between security/defense (安防) applications and the leveraging of these technologies for military purposes, including techniques for monitoring and manipulating public opinion with applications in influence operations.[113]

The proliferation of AI-enabled and/or autonomous weapons systems presents a range of risks to global security. China could export this technology to potential adversaries or militaries with poor human rights records, undermining U.S. values and interests. Occasionally, Chinese armed drones have experienced problems in their performance, including crashing in some cases[114] However, exports may facilitate data and metrics gathering for performance improvements.[115] Moreover, the availability of these technologies to non-state actors could empower terrorist organizations.[116] The Islamic State group has already used Chinese drones — manufactured by DJI — for surveillance and as improvised explosive devices.[117] Beyond stalwarts in the arms industry, a growing number of new enterprises are entering the field, advertising and exporting weapons systems said to possess some level of autonomy. To date, over 90% of armed drone sales have been by Chinese companies.[118] To the extent this trend continues, China will also drive the diffusion of AI-enabled and autonomous weapons systems.

POLICY OPTIONS AND RECOMMENDATIONS

The United States must confront the prospect of long-term competition, and at worst even the potential for conflict, with the People's Republic of China. At the same time, today's technological transformations present new risks of accidents or unintended escalation. In response to these challenges, the U.S. military and national security policymakers should consider the following recommendations:

- *Improve intelligence and awareness of Chinese military and technological advancements*. To mitigate the risks of surprise, the United States must continue to track and monitor new directions in Chinese military modernization. In particular, the U.S. intelligence community should improve its capacity to leverage open-source intelligence (OSINT) techniques and reprioritize targeting of collection activities as necessary.[119]
  - *Expand initiatives for forecasting and technological assessments.* For instance, the revival of institutions like the Office of Technology Assessment — and creation of new mechanisms to ensure adequate technical expertise — is needed to inform intelligence analysis and policy decisionmaking.[120]
  - *Scale up efforts to evaluate and translate Chinese military writings and technical literature.* The available materials are insufficiently leveraged in U.S. research and intelligence relative to the scope and scale of Chinese collection and leveraging of open source technical materials and policy and strategic debates. This information gap can result in poor or incomplete understanding of trends in China. To this end, the U.S. government should scale up and support large-scale initiatives in translation.
  - *Support language training and immersion.* Given the demands on expertise[121] to meet the intellectual challenges of great power competition, the U.S. government should expand existing initiatives and pipelines for training linguists and specialists.
- *Exercise caution in signaling and disclosure of new American capabilities.* In some cases, the announcement of new U.S. defense innovation initiatives, such as the Third Offset Strategy, may have triggered a redoubling of Chinese efforts to pursue military innovation in emerging technologies.[122] The Department of Defense should consider the potential externalities of its messaging regarding new programs and capabilities, especially in the areas of AI/ML and autonomy, taking care to recognize potential counterintelligence considerations.[123] At the same time, it is important to recognize that reports in Chinese state and state-linked media may be intended for purposes of misdirection.[124]
- *Actively reaffirm safety, surety, and security of U.S. military AI systems.* The U.S. military should continue to elevate the importance of the safety, surety, and security of AI systems.[125] As the character of conflict evolves and complexity increases, continued exploration of mechanisms for confidence-building and crisis management will become all the more critical. Hopefully, efforts to integrate discussions about safety and reliability of weapons systems with varying degrees of automation, autonomy, and applications of AI into existing risk reduction and communication mechanisms can help reduce the prospect of accidents or unintended escalation.[126] In particular, the United States should actively highlight the importance of avoiding accidents and ensuring operational effectiveness by discussing its own policies and approaches to testing and evaluation, while promoting best practices.[127]
- *Ensure American leadership in AI ethics.* The U.S. military should articulate its commitment to leverage AI in warfare in ways consistent with its values. The existing initiatives, such as the Defense Innovation Board's work on AI ethics,[128] are important measures that are starting to be institutionalized.[129] At the same time, as the Chinese government seeks to increase its "discourse power" (话语权), the U.S. government should continue to point out inconsistencies between China's apparent position and its actual activities on the world stage.

- *Engage with allies and partners to reinforce norms for the ethical employment of AI-enabled and autonomous systems in future military operations.* The U.S. military should continue to pursue productive conversations with like-minded democracies in order to establish initial consensus on legal and ethical parameters.[130] Such engagements can also extend to sharing lessons learned and reaching agreement on principles.
- *Pursue opportunities for pragmatic bilateral and multilateral cooperation on issues of AI safety and testing of complex systems.* While these conversations can be challenging, bilateral or multilateral dialogues hold real potential for setting technical standards for robustness and assurance of AI systems used for military purposes, including best practices for testing, evaluation, verification, and validation.[131] Such dialogues should also extend to adopting a more comprehensive framework to address the range of risk factors that could undermine safety and sharing information about best practices.[132]
- *Explore the potential for Track 2, Track 1.5, and eventually, Track 1 dialogues with defense and technical experts, including potential adversaries and competitors where feasible.*[133] These mechanisms can convene stakeholders with expertise on various elements of these issues to facilitate a more open and flexible conversation. Such dialogues can generate ideas and policy options more creative and unconstrained than those available via existing channels.
- *Pursue new opportunities for military-to-military engagement between the United States and China.* Despite strategic distrust, there is a need for and a history of military-to-military ties between the PLA and the U.S. military.[134] Such engagements with the PLA could signal reassurance, reduce the likelihood of misperceptions, and prevent unintended escalation.[135] The U.S. military can benefit from relative transparency about the strategic intentions, policies, and practices that inform its own approach to AI in military affairs in order to mitigate misperceptions. The lack of transparency in Chinese military thinking can lead to worst-case predictions or expectations among American military strategists and defense planners. It would behoove Chinese leaders to pursue greater transparency about their military strategy and intentions in the development of these capabilities.[136]
- *Explore options to constrain the diffusion of AI-enabled and autonomous weapons to non-state actors.* The proliferation of AI-enabled and autonomous weapons to non-state actors poses a threat to international stability, including the risk of serious accidents.[137] While major militaries are unlikely to cease their own development of these capabilities, their mutual interest in limiting the access of non-state actors to these systems could be leveraged. Existing export control mechanisms could also be adapted to address these emerging challenges. There may be potential for engagement among major arms exporters, including defense industry stakeholders, about principles or best practices for creating controls against the misuse of these capabilities by non-state actors.
- *Sustain investments in U.S. defense innovation initiatives.* The U.S. military should prioritize the fundamentals for creating a truly "AI-ready" force.[138] These necessary measures include improved integration across disparate databases, continuous modernization of military information technology, and construction of the requisite infrastructure for AI systems. To meet these objectives, the U.S. military needs to recruit, retain, and train individuals with the requisite skill sets and expertise.[139]

CONCLUSION

U.S.-China military competition centers upon the fight to innovate in emerging technologies critical to the future of warfare. This contest will shape the broader strategic competition between the two nations, as well as affect global security and stability through the potential diffusion of new weapons systems and capabilities. China's future progress in the development of autonomous and AI-enabled weapons systems must be contextualized by the uncertain trajectory of its military modernization. The creation of the requisite technologies will also depend upon advances in AI/

ML research and development across both civilian and military applications. The eventual realization of such capabilities will depend upon the PLA's capacity to integrate new capabilities into existing concepts of operations and create new theories of victory that recognize the ongoing changes in the character of conflict.[140] Chinese military advances in weapons systems autonomy could constitute an important component of the PLA's emergence as a world-class military aspiring to achieve an advantage in future warfare.

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3 Although the term "uninhabited" is generally preferable to "unmanned" as a more accurate characterization, the Chinese terminology is literally 'un-(hu)manned' (无人), which is the phrasing that this paper chooses to use. Certain unmanned systems that can be optionally operated as remotely controlled or autonomous. See, for instance: "天下谁人能识"机" [Who in the world can know the "machine"], *PLA Daily*, April 7, 2017, http://www.81.cn/jfjbmap/content/2017-04/07/content_174361.htm.

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5 For the purposes of this paper, the basic working definition involves adaptive control and automation to support various elements of the targeting process, as well as efforts to leverage AI /ML techniques to enhance precision in guidance and targeting.

6 From a technical perspective, "autonomy" can be enabled by many different techniques and is not necessarily synonymous with the use of AI/ML. The writings of Chinese military officers and technical literature of prominent scientists are not always precise about these distinctions.

7 Zhang Jie, Zhang Chi, and Zhao Xinghua, "军事人才培养与战争形态演进"[Military personnel cultivation and the evolution of patterns of warfare], 光明日报 [*Guangming Daily*], December 21, 2019, https://web.archive.org/web/20200215012903/https://news.gmw.cn/2019-12/21/content_33419288.htm.

8 For an early and insightful academic perspective on the topic, see Michael C. Horowitz, "Artificial Intelligence, International Competition, and the Balance of Power," *Texas National Security Review* 1, no. 3 (May 2018), https://tnsr.org/2018/05/artificial-intelligence-international-competition-and-the-balance-of-power/. However, there are also reasons to be skeptical about the actual impact that AI may have on the future balance of power, which will depend upon the progress in overcoming issues of safety and reliability that arise in its operationalization.

9 See, for instance: Liang Jie, "智能化作战法律问题漫谈"[Discussing the Legal Issues of Intelligentized Operations], 光明日报 [*Guangming Daily*], July 20, 2019, https://web.archive.org/web/20200215011803/http://news.gmw.cn/2019-07/20/content_33013497.htm.

10 See, for instance, research that is forthcoming from Dr. Margarita Konaev at the Center for Security and Emerging Technology at Georgetown University, which will explore these issues in greater detail.

11 See, for comparison: Margarita Konaev and Samuel Bendett, "Russian AI-Enabled Combat: Coming to a City Near You?" War on the Rocks, July 31, 2019, https://warontherocks.com/2019/07/russian-ai-enabled-combat-coming-to-a-city-near-you/. See also: Samuel Bendett, "The Development of Artificial Intelligence in Russia," in *AI, China, Russia, and the Global Order: Technological, Political, Global, and Creative Perspectives*, (Boston: NSI, January 2019), https://nsiteam.com/ai-china-russia-and-the-global-order-technological-political-global-and-creative-perspectives/.

12 See, for instance: Michael C. Horowitz, Gregory C. Allen, Elsa B. Kania, and Paul Scharre, "Strategic competition in an era of artificial intelligence," (Washington, DC: Center for a New American Security, July 25, 2018), https://www.cnas.org/publications/reports/strategic-competition-in-an-era-of-artificial-intelligence.

13 For reference, see that of the U.S. military in this position paper: "Characteristics of Lethal Autonomous Weapons Systems: Submitted by the United States of America," United Nations, November 10, 2017, https://www.unog.ch/80256EDD006B8954/(httpAssets)/A4466587B0DABE6CC12581D400660157/$file/2017_GGEonLAWS_WP7_USA.pdf. An estimated 154 or more weapons systems already exist around the world that incorporate some degree of autonomy. Thanks to Margarita Konaev for sharing her insights on this point, and see her forthcoming research on policy and strategic concerns for reference. See also: Vincent Boulanin and Maaike Verbruggen, "Mapping the Development of Autonomy in Unmanned Systems," (Stockholm: Stockholm International Peace Research Institute, November 2017), 24, 26, https://www.sipri.org/sites/default/files/2017-11/siprireport_mapping_the_development_of_autonomy_in_weapon_systems_1117_1.pdf.

14 Thank you so much to Lindsey Sheppard for highlighting the importance of this distinction.

15 See, for context: Paul G. Gillespie, *Weapons of Choice: The Development of Precision Guided Munitions* (Tuscaloosa: The University of Alabama Press, 2006).

16 For American legal academic perspective on the topic, see for instance: Marco Sassoli, "Autonomous weapons and international humanitarian law: Advantages, open technical questions and legal issues to be clarified," *International Law Studies/Naval War College* 90 (2014): 308-340, https://digital-commons.usnwc.edu/cgi/viewcontent.cgi?article=1017&context=ils; Kenneth Anderson and Matthew C. Waxman. "Law and ethics for autonomous weapons systems: Why a ban won't work and how the laws of war can," (SSRN, April 14, 2013), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2250126.

17 However, the U.S. Department of Defense has created and is starting to institutionalize ethical principles that will guide the use of AI in defense. See Patrick Tucker, "Pentagon to Adopt Detailed Principles for Using AI," Defense One, February 18, 2020, https://www.defenseone.com/technology/2020/02/pentagon-adopt-detailed-principles-using-ai/163185/; "AI Principles: Recommendations on the Ethical Use of Artificial Intelligence by the Department of Defense," Defense Innovation Board, https://media.defense.gov/2019/Oct/31/2002204459/-1/-1/0/DIB_AI_PRINCIPLES_SUPPORTING_DOCUMENT.PDF.

18 "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" [Xi Jinping: Accurately Grasp the New Trend in Global Military Developments and Keep Pace with the Times, Forcefully Advancing Military Innovation], Xinhua, August 30, 2014, http://news.xinhuanet.com/politics/2014-08/30/c_1112294869.htm.

19 Zheng Lianjie, "战斗力发展"弯道超车"，需要何种方略" [What strategies are needed for the development of combat effectiveness "overtaking around the curve"], China Military Network, January 19, 2017, http://www.xinhuanet.com/mil/2017-01/19/c_129453510.htm.

20 Not unlike the U.S. military, the PLA's interest in AI is not a recent phenomenon, and can be traced back to the mid-1980s to projects that involved robotics, intelligent computing, and applying expert systems to military operations research. These early antecedents are beyond the scope of this paper.

21 "China's National Defense in the New Era," Xinhua, July 24, 2019, http://www.xinhuanet.com/english/2019-07/24/c_138253389.htm.

22 Ibid.

23 See, for instance: Zhu Feng, Hu Xiaofeng, Wu Lin, He Xiaoyuan, and Guo Shengming, "Inspiration for battlefield situation cognition from AI military programs launched by DARPA of USA and development of AI technology," in *Theory, Methodology, Tools and Applications for Modeling and Simulation of Complex Systems*, eds. Zhang Lin, Song Xiao, and Wu Yunjie (Singapore: Springer, 2016), 566-577.

24 For instance, the national strategy for innovation-driven development: See the official strategy released on innovation-driven development, "中共中央 国务院印发《国家创新驱动发展战略纲要" [The CCP Central Commission and State Council Release the National Innovation-Driven Development Strategy Outline], Xinhua, May 19, 2016, http://news.xinhuanet.com/politics/2016-05/19/c_1118898033.htm. See also Xi Jinping's remarks on this approach in the context of military modernization: "习近平：全面实施创新驱动发展战略 推动国防和军队建设实现新跨越" [Xi Jinping: Comprehensively Advance an Innovation-Driven Development Strategy, Promote New Leaps in National Defense and Military Construction], Xinhua, March 13, 2016, http://news.xinhuanet.com/politics/2016lh/2016-03/13/c_1118316426.htm.

25 See, for instance Xi Jinping's remarks as quoted in this article: "科技创新，迈向世界一流军队的强大引擎" [S&T innovation, a powerful engine for the world-class military], Xinhua, September 15, 2017, http://www.gov.cn/xinwen/2017-09/15/content_5225216.htm.

26 Ibid.

27 全军军事术语管理委员会 [All-Military Military Terminology Management Committee], 中国人民解放军军语 [People's Liberation Army Military Terminology], (Beijing: 军事科学出版社 [Military Science Press], 2011).

28 By contrast, references to autonomous weapons are more prominent in Chinese writings on the global debate on LAWS. See, for instance: "主武器：技术与伦理的边缘" [Autonomous weapons: the edge of technology and ethics自], 中国科学报 [China Science Report], April 20, 2018, http://news.sciencenet.cn/htmlnews/2018/4/409772.shtm.

29 Yin Junsong, Li Minghai, Li Shijiang, and Gao Kaize, "积极应对战争形态智能化挑战"[Actively addressing the challenges of the intelligentization of the form of warfare], *PLA Daily*, February 6, 2020, http://www.mod.gov.cn/education/2020-02/06/content_4859784.htm.

30 This term (bingqi tuiyan, 兵棋推演) is used usually in reference to Chinese military wargaming and simulations.

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

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

33 "专家：军事智能化绝不仅仅是人工智能" [Experts: Military Intelligentization Is Not Merely Artificial Intelligence], *People's Daily*, December 6, 2017, http://military.people.com.cn/n1/2017/1206/c1011-29689750.html.

34 This latter translation is from the official English translation of China's national defense white paper, but the former is the more literal and consistent rendering of the phrase.

35 Elsa B. Kania, "Chinese Military Innovation in Artificial Intelligence."

36 Of course, many of the AI systems in question are not weapons systems per se, but this paper is scoped to concentrate primarily on weapons systems.

37 "陆军对照十九大要求完善陆军"十三五"装备建设规划" [Army to improve the Army's '13th Five-Year' Equipment Construction Plan in accordance with the requirements of the 19th Party Congress], People's Daily Network, January 9, 2018, https://xw.qq.com/cmsid/20180109C04CYW/20180109C04CYW00. See also:

“陆军加快推动无人化智能化运用发展” [Army accelerates the development of unmanned [systems and] intelligentization], *PLA Daily*, August 5, 2019, http://www.xinhuanet.com/mil/2019-08/05/c_1210228994.htm; “陆军举办无人化智能化建设运用论坛” [PLA Army hosts unmanned intelligent construction application forum], *PLA Daily*, August 5, 2019, http://www.81.cn/lj/2019-08/05/content_9578823.htm.

38 “中国首个实海况智能船艇竞赛在上海交大” [China’s First Real Sea State Intelligent Boat Competition Convened at Shanghai Jiaotong University], Shanghai Jiaotong University, October 14, 2019, https://news.sjtu.edu.cn/jdyw/20191014/112627.html.

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40 On relevant research from PLARF scientists, see, for instance: “证据推理与人工智能高峰论坛宣传册” [Evidential Reasoning and Artificial Intelligence Summit Forum], Tencent Cloud, December 26, 2017, https://new.qq.com/omn/20171226/20171226G0DFLD.html.

41 “火箭军导弹武器装备信息化程度大幅提升” [The Rocket Force’s missile weaponry and equipment has greatly improved the degree of informatization], *PLA Daily*, February 8, 2020, http://www.xinhuanet.com/2020-02/08/c_1210465719.htm.

42 For related research, see: “顶级科研院所齐聚“眼神杯”，探索AI+遥感影像科研应用新风向” [Top research institutes gather for the ‘Eye Cup,’ exploring new trends in AI+ remote sensing image research and applications”], 36 kr, June 5, 2018, https://xw.qq.com/cmsid/20180605A0B3AL/20180605A0B3AL00. For context on the potential of AI in cyber security, see: “一只章鱼改变了网络安全游戏规则”[An octopus has changed the rules of the cyber security game], 科技日报 [*S&T Daily*], May 28, 2019, http://www.cac.gov.cn/2019-05/28/c_1124549858.htm.

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66 Ibid.

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ACKNOWLEDGEMENTS

The author is grateful to two external reviewers, Paul Scharre and Larry Lewis, for their highly insightful comments and valuable perspectives on the paper. The author also thanks Tarun Chhabra, Margarita Konaev, Igor Mikolic-Torreira, and Lindsey Sheppard, among others, for providing very helpful feedback on the paper at various stages. The author is especially grateful to Dr. Konaev for sharing her insights and expertise in the course of the process and recommends her forthcoming research on related subjects. Thank you so much to Alexandra Vreeman and Ted Reinert for editing this paper, and to Rachel Slattery for providing layout. Any flaws or failings in the paper are her own.