EUROPEAN LEADERSHIP NETWORK

Emerging and disruptive technologies, nuclear risk, and strategic stability

Chinese literature review

Fei Su

Dr Jingdong Yuan

December 2022

About the Authors

Fei Su
Researcher with SIPRI's China and Asia Security Programme

Fei Su is a Researcher with SIPRI's China and Asia Security Programme. She joined SIPRI as a Research Assistance in March 2015 and was based in Beijing. Prior to joining SIPRI, she lived and studied in Seoul for three years, where she strengthened her fluency in Korean. She holds an MA in Public Administration from the Graduate School of Public Administration at Seoul National University, focusing on governance. She wrote her Korean-language dissertation on the impact of government size on corruption in China.

Fei's research interests focus on regional security issues in East Asia with a special interest in North Korea, China's foreign and security policy, and maritime security. Her other research interest is within the field of geo-economics and cybersecurity.

Dr Jingdong Yuan
Associate Professor, University of Sydney

Associate Senior Fellow, SIPRI's China and Asia Security Programme

Dr Jingdong Yuan is an Associate Senior Fellow at Stockholm International Peace Research Institute. Dr. Yuan's research focuses on Indo–Pacific security, Chinese foreign policy, Sino–Indian relations, China-EU relations, and nuclear arms control and nonproliferation. He is the co-author of Chinese Cruise Missiles: A Quiet Force-Multiplier (2014) and China and India: Cooperation or Conflict? (2003), and co-editor of Trump's America and International Relations in the Indo-Pacific (2021) and Australia and China at 40 (2012). His publications have appeared in Asian Survey, Australian Journal of International Affairs, Contemporary Security Policy, International Affairs, International Journal, Journal of Contemporary China, Journal of International Affairs, Nonproliferation Review, Washington Quarterly, and in many edited volumes. His co-edited volume on the fifty years of Australia-China relations will be published by the University of Sydney Press in 2023.

Contents

I. Introduction

The last revolutionary military development that changed the nature and character of war was the onset of the nuclear age. With emerging and disruptive technologies (EDTs) increasingly becoming a new field of military competition among great powers, serious questions have been raised about whether the emergence of EDTs and their integration into military doctrines, procurement, training, and operations will fundamentally change the ways modern warfare will be conducted, especially whether they will undermine the relevance of nuclear deterrence.[1] Will the application of EDTs lead to a new revolution in military affairs? And how might this development affect the strategic stability between potential nuclear adversaries?

With these questions in mind, this review paper aims to contribute to the European Leadership Network's project on understanding the development of EDTs and their implications on nuclear risk and strategic stability. It seeks to introduce Chinese perspectives by annotating analyses drawn from Chinese academic and professional publications to explore new ways forward for mitigating the risks posed by EDTs.

To make a comprehensive assessment of current developments in China, we have focused on open-source publications in the Chinese language. These include primarily publications accessed through China National Knowledge Infrastructure (CNKI), a prominent comprehensive database of Chinese academic journals, newspapers, research papers, and other openly available documents and papers.

Based on the overall content and focus of the literature, we make several general observations:

1. While the Chinese literature indicates that science and technology have always been an area of focus, there was a noticeable surge between 2015 and 2016 in Chinese literature on EDT-related research based on the CNKI database. This was roughly the same time 'Made in China 2025' was announced and the US's 'Third Offset Strategy' was rolled out.[2] By using keywords such as '新兴与颠覆性技术 (Emerging and disruptive technology)', '政策 (policy)', '战略稳定 (strategic stability)' and '核 (nuclear)', the search results show that the majority of the research focuses on general conceptual rather than policy specific issues, especially on discussions directly related to China's own military strategy. Our search for specific technologies, from 人工智能 (artificial intelligence) and 量子技术 (quantum technology), to 太空 (space) and 5G/网络 (5G/Cyber), has yielded analyses of both technical perspectives and policy-relevant discussions. Given the large volume of literature, and in order to focus on current Chinese debates on EDTs and implications for policy, we have mainly focused on the Chinese language literature from 2020 to 2022.[3]

2. The concept of EDTs in the Chinese literature often refers to the established understanding as framed by western scholars/analysts and stated in official western documents. In particular, the term and phenomenon of disruptive innovation, which was introduced and defined by Harvard Business School professor Clayton M. Christensen in 1995, has been largely quoted by Chinese scholars.[4] While there are analyses on conceptual discussion related to EDTs, there is no clear distinction when

This paper introduces Chinese perspectives by annotating analyses drawn from Chinese academic and professional publications to explore new ways forward for mitigating the risks posed by EDTs.

it comes to specific technologies. A given technology can be defined both as emerging and/or disruptive in different articles during the same time period.

3. The existing Chinese literature is dominated by analyses of specific technologies and their implications for military affairs, with much less focus on the interplay between multiple EDTs and their impacts on strategic stability and even less on nuclear stability. In particular, the development and application of Artificial Intelligence (AI) receives enormous attention in China. This analysis is fairly comprehensive, covering all aspects, from economic to national security. The military application of biotechnology, compared to other EDTs, is the least discussed area in open-source publications. This does not mean that biotechnology is not considered an important domain in modern warfare in China, especially considering that biotechnology is a key priority in China's policy on military-civil integration which would enable China's military to readily leverage developments in civil biotechnology.[5]

4. Instead of detailing its own development and planning on EDTs, most Chinese analyses describe, explore, and explain other countries' developments in this area. In particular, there is a preference to research the developments and policies in the US, Russia, India, Korea, Japan, and overall discussion at the North Atlantic Treaty Organization (NATO). This could be because countries, such as the US, are front-runners in military applications of EDTs, and because all these countries are taking steps to accelerate the development and application of EDTs in military affairs. Another factor that might skew Chinese analysis towards foreign developments is that the subject's sensitive nature also leads to a transparency issue regarding how much information can be disclosed openly or accessed through online databases and public information. Some of the more sensitive articles, while listed in the CNKI database, are not accessible due to the confidential nature of what appears to be in them. Many journals published by the People's Liberation Army (PLA) services only have volumes/issues from over a decade ago. More recent ones are not included in the database and are presumably only accessible as hard copies in Chinese libraries.

5. Much of the existing literature discusses major power competition in EDTs, focusing on Sino-US competition in future warfare and analyses of developments in major military powers, including Russia and NATO countries. The possible confidence-building measures and crisis management mechanisms are seldom discussed and are usually contained in general political science and international relations journals. In addition, there is less focus on identifying the escalation pathway in which militarised EDTs could increase the risk of nuclear escalation and threaten the strategic stability between China and other nuclear-armed states. Such discussions are likely to exist; however, due to their sensitivity, they are not included in the CNKI database or published in open-source online mediums.

The existing Chinese literature is dominated by analyses of specific technologies and their implications for military affairs, with much less focus on the interplay between multiple EDTs and their impacts on strategic stability and even less on nuclear stability.

The following section (Chapter II) of this paper presents Chinese observations of EDTs in general and explores the prospects of their military applications. This is followed by Chinese discussions of

general trends and recent developments in EDTs of major powers (in particular, the US), especially where they concern strategies and policies of these powers (Chapter III). Chapter IV focuses on the implications of EDTs in the nuclear realm and for strategic stability before ending the paper with a brief summary of the debates in China on how to mitigate such risks and Chinese views on addressing them through international arms control mechanisms. In particular, this paper focuses on AI and automation, quantum technology, 5G and counterspace capabilities, among other EDTs. For each proposition below, one or more quotes are given for illustration.

II. Prospects for applying EDTs in the military domain

The military application of EDTs has great potential in every field – land, sea, air, space, and cyber. Li Daguang, a professor at the PLA National Defense University, discusses how EDTs could bring revolutionary changes to a number of areas with significant military implications. These include AI, 3D printing, big data processing technology, hypersonic, and advanced materials. EDTs not only facilitate and speed up the 4th industrial revolution, but they will also result in the development of disruptive military technologies with transformative impacts on modern warfare:

> 'Disruptive military technologies will not only change the mode of generating combat power but also trigger disruptive changes in combat theory and forms, alter the organisational structure of the military and military regulations, reshape the military system and lead to a new worldwide revolution in military affairs. A technological revolution can often spawn new military revolutions, while disruptive military technologies, with their unconventional development mode, can further improve capabilities for asymmetric warfare. There is no doubt that small states view disruptive military technologies as an important weight against military great powers. [颠覆性军事技术不仅会改变战斗力生成模式，还会引发作战理论、作战样式、军队组织结构、军事制度等颠覆性变化，重塑军事体系，引发世界性的新军事变革。科技革命往往催生新的军事革命，而颠覆性军事技术以其非常规的诞生和发展模式，更能有效提高非对称作战能力，无疑是小国对抗军事强国的重要砝码。]'[6]

> 'Disruptive technologies continue to emerge and have become the driving force and powerful engine behind a new wave of military reforms. By seizing the opportunity for development brought about by disruptive technologies, not only will it pave the way for "curve overtaking" and "change-lane overtaking" to obtain critical core technologies, but it will also provide important support for innovative development in tactical theory. [颠覆性技术不断涌现，已成为推动新一轮军事变革浪潮的强力引擎。抓住颠覆性技术带来的发展机遇，不仅为关键核心技术实现"弯道超车"和"换道超车"提供有效途径，而且为战术理论创新发展提供重要支撑。]'[7]

The following points present what has been highlighted in the Chinese literature as opportunities for enhancing one's military capabilities and the associated challenges:

1. Gain information dominance (or achieve information superiority)

- *Increase efficiency and reduce manpower in intelligence gathering and information processing*
- *Improve the ability for intelligence, surveillance, and reconnaissance (ISR)*

'The fast, accurate, and fatigue-free characteristics of machine algorithms make them useful in the field of big data analysis, demonstrating capabilities far beyond human beings. [机器算法的快速、准确、无疲劳等特点使其在大数据分析领域大展身手，展现出远超人类的能力。]'[8]

Disruptive military technologies, with their unconventional development mode, can further improve capabilities for asymmetric warfare.

'In the field of intelligence and reconnaissance, since AI has powerful capability in image and speech recognition, it can greatly improve strategic and tactical reconnaissance capability, satellite photo interpretation, optical/electronic reconnaissance, and efficiency of underwater sound detection and identification, with the adoption of various sensors. [在情报与侦察领域，由于人工智能在图像、语音识别方面具有强大能力，其与各类传感器的结合能够大幅提升战略与战术侦察能力，提升卫星照片判读、光学/电子侦察、水声探测识别的效率].'[9]

'The competition in big data processing is intensifying. In the information age, big data technologies such as storage and processing are known as big data processing technology. Big data has scale (volume), variety (variety), high velocity (velocity), uncertainty (veracity [sic]), and information value (value), the so-called five characteristics ("5v"). [大数据处理技术竞争日趋激烈。在信息时代，对大数据存储和处理等技术被称为大数据处理技术。大数据具有规模(volume)、形式多样(variety)、高速(velocity)、不确定性(veracity) 和信息价值(value) 五大特点("5v")。]'[10]

'5G technology will have an important impact on the military field and reconstruct the future battlefield. In addition, it will be closely integrated with emerging technologies such as artificial intelligence and the Internet of Things to accelerate the arrival of intelligent warfare. First, 5G technology will effectively improve battlefield communication capabilities. Second, 5G technology effectively promotes the interconnection of weapons platforms in war zones. Third, 5G technology accelerates military intelligentization. Fourth, 5G will promote the construction of a resilient combat system. Fifth, 5G technology will bring changes in military training. Sixth, 5G technology will change the military management model. [5G通信技术将对军事领域产生重要影响，重构未来战场。此外，它还将与人工智能、物联网等新兴技术紧密结合，加速推进智能化战争的到来 。 第一，5G通信技术将有效提升战场通信能力。第二，5G通信技术有效推动战场区域武器平台的互联互通。第三，5G通信技术加速推进智能化作战应用。第四，5G将推动弹性作战体系的构建。第五，5G通信技术将带来军事训练的变革。第六，5G通信技术改变部队管理模式。]'[11]

'As a new generation of mobile communication technology, the military application of 5G technology will significantly impact the battlefield and accelerate the process of unmanned and intelligentized military. This has great military value. In the future, the combatant can use 5G networks to transmit massive amounts of data much quicker and more efficiently. The military 5G technology will tightly connect the conventional weapons systems, unmanned systems, and combat units into an integrated battlefield network. This will dramatically change the information environment on the battlefield and have a profound impact on the forms of future warfare and combat mode. [作为新一代移动通信技术，5G在军事领域的应用将对战场产生重大影响，并加速无人化、智能化军事应用进程，军事价值巨大。未来，作战人员可使用5G网络快速、高效地传输海量数据， 将各种常规武器平台、无人作战平台和作战单元紧密整合在战场网络中，使战场信息环境发生极大改变，也将对战争形态、作战模式产生深远影响。]'[12]

2. Support the decision-making process

- *Improve the ability to manage overloaded information and predict enemy's actions*
- *Provide rapid decision-making in time-sensitive situations*

'Under the condition of informationized warfare, the requirement for effective and accurate decision-making and command and control have become more stringent. This requires an AI-enabled command and control system to support decision-making. AI can analyse and process a large amount of information, select suitable targets, make evaluation plans, and remove the "fog of war". It can provide timely and reliable support for military operations. …through its own algorithms, AI can simulate and prepare for possible future scenarios, predict the enemy's actions, and assist commanders in making correct decisions. [信息化战争条件下, 对作战指挥决策的时效性、准确性要求变得更加严格。这就要求指挥与控制系统应具有智能决策支持能力, 通过指挥与控制系统提供的智能化辅助决策, 能够分析处理大量情报, 智能化优选确定目标和评估方案, 拨开"战争迷雾", 为联合作战指挥决策和部队行动提供及时可靠的辅助支持功能。…通过自身的算法, 人工智能进行多次计算机模拟, 提前设置各种想定, 对敌方行动进行预判, 协助指挥官做出正确决策。]'[13]

'…through certain algorithm design, it [AI] can process massive data much faster than human beings. It can support military weapons by rapidly analysing images or processing confidential databases. It can improve the speed and accuracy of military decision-makers, thereby improving the ability of decision-makers in military operations to maintain military advantages. Meanwhile, the application of AI can reduce military expenditure and the risk of life for soldiers in combat. […通过一定的算法设计, 在海量数据的处理速度上超越人类, 能给军事武器装备提供一种快速解析图像或机密数据库处理的助力, 能够提高军事决策者的决策速度和决策精准度, 从而提高军事行动中决策者的决策能力以保持其军事优势, 同时, 能够消减军事支出和降低士兵在作战中的风险。]'[14]

'The high-precision quantum military technology represented by quantum satellites, quantum radars, quantum computers, and quantum positioning systems has achieved breakthrough development, making quantum technology widely used in the military field and promoting new global military reforms and changes in warfare … and the progress of quantum communication, quantum sensing and quantum positioning technologies is mainly driven by national security interests. The confidentiality and anti-jamming capabilities of various military command systems will be significantly improved, bringing disruptive changes to future warfare. [以量子卫星、量子雷达、量子计算机、量子定位系统为代表的高精尖量子军事武器装备技术已经获得了突破性发展, 使得量子技术在军工领域广泛应用, 推动了全球新军事变革和战争形态变化。… 而量子通信、量子传感和量子定位技术的进展则主要是由国防安全推动, 将大大提高各式军事指挥系统保密性和抗干扰能力, 给未来战争形态带来颠覆性变化 。]'[15]

AI can simulate and prepare for possible future scenarios, predict the enemy's actions, and assist commanders in making correct decisions.

> ‘As a complex mega system, information warfare and integrated joint operations supported by massive data are inseparable from massive computing at all times, making quantum computing a broad application prospect in the military field. [战争作为复杂巨系统，以海量数据为支撑的信息化战争和一体化联合作战，时刻离不开海量计算，使得量子计算在军事领域具有十分广阔的应用前景。]’[16]

> ‘The main advantage of quantum communication is that it subverts the traditional encryption and hacker technology so that military communication can, in principle, achieve absolute security and confidentiality. In the future, the battlefield will not be divided into front and rear. It is possible to create a new type of military communication network that is efficient, safe and concealed, as well as an integrated combat platform consisting of military equipment, identification of friend and foe and targeting systems, through specific quantum communication, quantum cryptography, and other technologies. Officers can grasp the big picture at a glance and make the right decisions. [量子通信的主要优势在于，它颠覆了传统的保密与窃密技术，使军事通信在原理上实现无条件安全和保密。未来战场没有前方后方之分，通过特定的量子通信、量子密码等技术，可以打造高效、安全、隐蔽的新型军事通信网络，将武器装备、敌我识别、锁定攻击等构成一体化作战模式，让指挥官一目了然地掌握全局并做出正确决策。]’[17]

Considering the current development level of EDTs, however, there is a risk of strategic miscalculation due to compressed decision-making time within the fog of war:

> ‘Since war is non-cooperative, and with the “fog of war” data obtained on the battlefield is incomplete and opaque, it is likely to receive data generated by adversaries through deception. [由于战争是非合作的且存在“ 战争迷雾”，在战场上获取的数据是不完整不透明的，而且很可能收到对手通过欺骗手段产生的数据。]’[18]

> ‘AI can speed up decision-making processes. However, due to AI-enabled rapid responses, it can also fail to adapt to the complexity of warfare and can lead to potential risks of decision-making mistakes. AI may not be able to distinguish as accurately and precisely as humans between civilians and combatants, as well as threats and system anomalies. [人工智能可以加速决策速度，但这同时也正因为人工智能助力军事系统可能导致决策速度太快或系统无法适应战争的复杂性，致使人工智能犯下危险错误。人工智能系统可能无法准确区分作战人员与非战人员以及威胁和系统异常，最终不能像人类作战人员那样准确和精确。]’[19]

The main advantage of quantum communication is that it subverts the traditional encryption and hacker technology so that military communication can, in principle, achieve absolute security and confidentiality.

3. Enable cross-domain synergy and integration of capabilities

- *Further improve the precision of existing weapon systems*
- *Strengthen deterrence for nuclear-armed states who are technologically advanced*

> ‘By integrating AI, conventional anti-satellite capability will become more accurate, destructive, and difficult to trace, thereby increasing the motivation to “preempt” and seek

first-mover advantage. This easily undermines the military security and global strategic stability of space-faring countries. Attacking satellites, especially early warning satellites, is often regarded as a precursor to launching a nuclear strike. [在人工智能的加持下, 传统的反卫星手段将变得更加精准、更具破坏性、更难追溯, 从而加大 “先发制人” 的动机, 寻求先发优势。这容易破坏航天国家的军事安全和全球战略稳定, 因为攻击卫星尤其是预警卫星往往被视为发动核打击的前兆。]’[20]

‘With AI technology, a state will be able to assess the possibility and destructiveness of a nuclear retaliation from another state. The state with more advanced technologies will have more strategic flexibility, while the second-strike credibility of the state with relatively backward technology will be undermined. In an era of weak artificial intelligence, only by integrating AI into nuclear weapon systems can one form an effective deterrent system. [拥有人工智能技术的一方将具有清晰评估对方进行核反击的可能性及破坏性的能力, 从而拥有更加灵活的战略选项, 而技术相对落后的一方, 其核反击能力将变得不再具有可信性。在弱人工智能时代, 只有人工智能技术与核武器的结合才能形成有效的威慑系统。]’[21]

This will, however, increase the difficulties in identifying promptly and with confidence who is responsible for certain types of military operations:

‘The application of AI in the military domain increases the ambiguity and complexity of the current operations, and it has become more difficult to trace the source of the attack. [由于人工智能技术的军事应用, 使得军事斗争形势更趋模糊、复杂, 攻击溯源更加困难。]’[22]

Chinese analysts also note the complexity and difficulties in developing the relevant infrastructure/networks in military applications, especially in the transition from 4G to 5G:

‘As an emerging technology, 5G’s military applications still have many difficulties. While 5G’s communication capability is expected to be much more robust than 4G, it requires a large amount of infrastructure and depends on the support of high energy consumption and high-bandwidth wireless technology. [作为新兴技术, 5G在军事上的应用还存在不少困难。5G各种强于4G的通信能力均需要铺设大量的基础设施, 依靠很高的能源消耗和大带宽无线技术的支持。]’[23]

‘There is a serious shortage of high-quality technical talents due to the ultra-high requirements of quantum technology at the professional level… The connection between various fields of talent training is not strong, and it is difficult to meet the needs of quantum technology for technical talents in multiple fields. As a highly comprehensive industry, quantum technology involves mathematics, physics, computer science, engineering design, and other disciplines, so it has high requirements for the knowledge level of talents. [高精尖技术人才严重短缺, 难以达到量子科技对人才专业水平和能力素质的超高要求。… 人才培养各领域之间联系不强, 难以达到量子科技对多领域技术人才的需求。量子科技作为一个学科综合性极强的行业, 涉及数学、物理、计算机科学、工程设计等多个学科, 因此其对人才的知识水平有着很高要求。]’[24]

III. Concerns over strategies and policies of EDTs development by other powers

The literature on the development and policies of EDTs in the US mainly suggests that the US:

- *Seeks technological hegemony to consolidate its global leadership;*
- *Views China as a rival and competitor in the field of EDTs and aims at containing China's development in EDTs;*
- *Prioritises cooperation with allies and like-minded countries while ensuring its own technological superiority.*

> 'In global technological competition, the first mover may gain some advantages over the latecomer. If the pioneers apply new technologies to the military field first, they may gain a comparative advantage in military strength. In the eyes of the adversary, the military advantage of the first mover will be a potential security threat, which will bring security pressure. … In some cases, fears of first-mover advantage can drive security dilemmas and arms races, even when competing parties may not necessarily understand the extent and effects of the adversary's military technological developments. [在国际技术竞争中,先行者相对于后来者可能获得一些优势。先行者如果抢先将新技术应用于军事领域,就可能在军事实力上获得相对优势。在对手眼里, 先行者的军事优势会是潜在的安全威胁,进而带来安全压力。… 在一些情况下,即使竞争各方未必了解对手军事技术发展的实际程度与效果,对先行者优势的担心本身也会推动安全困境和军备竞赛的发展。]'[25]

> 'After Biden was elected, he promised to increase investment in key technologies that enhance the competitiveness of the United States and to pay more attention to the advancement of military AI. Not only to regard AI as a key technology for maintaining national security and winning future wars, but Biden also emphasises the military threat posed by other competitors in the field of AI. The US seeks to consolidate global hegemony by leading in the field of AI and to contain and suppress competitors. [拜登当选后, 承诺对提升美国竞争力的关键技术加大投资力度, 更为重视且不遗余力地推进军用人工智能的发展, 不仅将人工智能技术视为维护国家安全和打赢未来战争的关键技术之一, 而且也刻意强调其他竞争对手在人工智能领域对美国构成的军事威胁, 力图通过谋取人工智能领域的领先地位来巩固全球霸权, 遏制、打压竞争对手。]'[26]

> 'The Biden administration emphasised the importance of working with allies on containing China. In the Interim National Security Strategic Guidance, China is the country that appears the most (15 times). In this document, allies and alliances appear 34 times, and partners and partnerships appear 38 times. The document emphasises that the US will work with allied partners in the Indo-Pacific, Europe, and the Western Hemisphere to promote common interests and values for addressing future common threats. It also defines China as the "only competitor potentially capable of combining its economic, diplomatic, military, and technological power to mount a sustained challenge to a stable and open international system" and "the greatest geopolitical test of the 21st century". So far, the United States has regarded China as a direct opponent of AI development at the strategic level. It is clear that the long-term objective is about competition and containment. [拜登强调与盟友合作共同扼制中国。在《指南》中,中国(China)是《指南》中出现最多的国家, 共出现15 次。《指南》

If the pioneers apply new technologies to the military field first, they may gain a comparative advantage in military strength.

中, allies(同盟国)与alliances(联盟)共出现 34 次, partners(伙伴)与 partnerships(伙伴关系) 共出现 38 次。《指南》强调, 美国将与印太、欧洲与西半球的盟邦伙伴携手, 促进共同的利益与价值来应对未来的共同威胁。《指南》同时还将中国定义为 “唯一有综合实力持续挑战国际秩序的竞争对手” 和 “21世纪最大地缘政治考验” 。至此, 美国在战略层面已经将中国当成了人工智能发展的直接对手, 长期竞争扼制的目标明确。]’[27]

‘The US’s national strategy on AI sets the precondition for international cooperation. It emphasises its leadership in collaboration with allies and partners to ensure that the development of AI fits with American values and interests. [美国国家人工智能战略设定了开展人工智能领域国际合作的前提条件, 即强调美国在与外国盟友和伙伴合作中的领导地位, 以确保人工智能技术发展符合美国的价值观和利益。]’[28]

‘To ensure its own competitive advantage and consolidate its status as a great military power, the US Department of Defense outlines four fundamentals identified in its 5G implementation plan: promote the development of 5G technology; assess, explore and reduce existing 5G systems loopholes, and exploit the loopholes in 5G technology to conduct operations; develop influential 5G technology standards and policies; and seek partner engagement. [为了确保自身竞争优势与巩固自身军事强国的地位, 美国国防部在5G实施计划中确定了四个基本任务方向: 促进5G技术的发展; 评估、发掘与减少现有5G系统存在的 漏洞, 并利用5G技术存在的漏洞进行作战; 制定有影响力的5G技术标准和政策; 寻求合作伙伴参与。]’[29]

‘More and more countries are making a quantum technology development strategy and a special-purpose plan. The world has officially entered an era of strategic competition in a comprehensive push for the development of quantum technology. The great-power competition is intensifying. Each major power and organisation has formulated a corresponding strategy for quantum technology development in accordance with the country’s national development strategy. At the same time, some innovative plans have been proposed. [越来越多的国家竞相制定量子科技发展战略和专向计划, 世界正式进入全面推动量子科技发展的战略竞争时代, 量子科技方面的大国博弈日趋白热化, 各大国及各组织都制定了相应的量子科技发展战略, 在适应本国国家发展战略的同时又提出了一些创新型计划。]’[30]

‘In 2007, the US Defense Advanced Research Projects Agency included quantum technology as the main core technology in its strategic plan. In 2016, the US Department of Defense began to support the development of military quantum technology, and quantum technology officially entered the military development plan. The National Quantum Initiative Act, signed by former US President Trump in 2018, officially launched the US “Moon Landing Program” in the quantum field’. [2007年, 美国 防部高级研究计划局将量子科技作为主要核心技术列入了其战略规划。2016年, 美国防部开始支持军用量子科技技术发展, 量子科技正式进入军队发展计划之中。美国前总统特朗普在2018年签署的《国家量子倡议法案》, 正式开启了美国量子领域的 “登月计划” 。]’[31]

Similarly, major powers, including Great Britain, Japan, the collective approach at the European Union level and its Member

States such as France and Germany, have all invested heavily in quantum technology and rolled out specific plans for its development.[32]

Chinese analyses also pay attention to EDT developments in other major powers and discuss where China could emulate these in improving its military capabilities. Given the close military collaboration between the Chinese and Russian militaries, EDT developments or breakthroughs are of particular interest, not least because of the potential for technology transfers and/or joint research and development:

> 'Science and technology cooperation is an important part of Sino-Russian strategic cooperation. 2020-2021 is also the "Sino-Russian Year of Scientific and Technological Innovation". Both Xi and Putin sent congratulatory letters at the beginning of the Year… The vast majority of scholars support Sino-Russian cooperation in science and technology for two main reasons: first, there is mutual demand. The decline of Russia's economic power has seriously affected the investment in science and technology, and it needs "foreign support."… The Sino-US tech competition has intensified with technology restrictions the US imposed on China, and China is also urgently looking for new technological partners. Thus, there is a strong desire for collaboration in science and technology between China and Russia. Second, China has become a qualified partner with its technological advancement as its progress in scientific and technological development has changed Russia's views. The industrial community highly affirms China's scientific and technological achievements. This is the basis for Russia's willingness to cooperate with China. [科技合作是中俄战略合作的重要组成部分, 2020-2021年还是"中俄科技创新年",两国元首分别发了贺信。…从学界看, 绝大多数人支持中俄科技合作, 主要理由有二:一是互有需求, 俄经济实力下降对科技投入严重不足, 需要"外援"… 而中美科技博弈加剧, 美国对中国进行科技限制, 中国也亟待寻找新的科技合作伙伴。因此, 中俄两国都有开展科技合作的强烈诉求。二是中国具备了资格, 中国科技进步改变了俄罗斯人的看法, 业界人士对中国科技成就给予高度肯定, 这是俄愿意与中国合作的基础。]'[33]

> 'Changing roles and learning from China is probably the biggest shift in Sino-Russian cooperation on science and technology. …China and Russia both have profound cultural heritage and unlimited potential in science and technology. Both sides have their own advantages. The combination of Russia's active, innovative ideas and China's efficient market commercialisation will not only improve the lives of the people in the two countries but also change the world's competitive landscape in science and technology. [转换角色, 向中国学习, 这恐怕是中俄科技合作中最大的变化。…中俄都有深厚的文化底蕴和无限的科技潜力, 双方各有优势, 俄罗斯活跃的创新思想与中国的高效市场转化力相结合, 不仅能改善两国人民的生活, 也将改变世界科技竞争的格局。]'[34]

> 'China and Russia share similarities in strategical status, strategic threats, and strategic environment, among others. As a great military power, Russia's hypersonic weapons development started early, and the actual results are better than other countries worldwide. It has made remarkable achievements in the development of its hypersonic weapons.

The vast majority of scholars support Sino-Russian cooperation in science and technology.

Its experience developing hypersonic weapons could provide useful lessons and references for us. [中俄两国在战略地位、战略威胁、战略环境等方面具有相似性，俄罗斯作为世界军事大国和军事强国，高超声速武器发展起步早，现实成果相对于世界其他国家更胜一筹，取得了比较瞩目的成绩，其高超声速武器的发展经验可以为我提供借鉴和参考。]'[35]

'Russian hypersonic weapons and their development have the following key characteristics: (1) seek asymmetric advantages and maintain a deterrent effect; (2) build a complete range of strike systems to achieve comprehensive development; (3) carry out multi-technology exploration to avoid transformation risks; (4) focus on combat application and improve combat effectiveness; and (5) balance quality and quantity and focus onsustainability.[俄罗斯高超声速武器及其发展主要有以下特点：（1）寻求不对称优势，保持威慑作用；（2）构建种类齐全的打击体系，实现全面发展；（3）开展多技术探索，规避转化风险；（4）着眼作战运用，提升作战效果；（5）平衡质量和数量，着眼可持续。]'[36]

'Strategic deterrence is the cornerstone for major powers, especially nuclear powers, to ensure national security. The high speed and the necessary mechanisms for hypersonic weapons, along with dynamic capability, can further strengthen countries' existing strategic strike capabilities. By creating a 'trinity' of hypersonic missiles system, Russia enhances its strategic strike capabilities and ensures effective breakthroughs in US missile defences. The missile and air defence systems form a realistic strategic deterrent to the United States. It has the actual effect of achieving maximum impact with relatively small input. [战略威慑是大国，特别核大国保证国家安全的战略基石。高超声速武器特有的高速度和必要的机动能力可以进一步加强各国现有的战略打击能力。俄罗斯通过打造“三位一体”的高超声速导弹打击体系，增强战略打击能力，确保有效突破美军的导弹防御体系和防空系统，形成对美现实的战略威慑作用，起到四两拨千斤的实际效果。]'[37]

'Only when the hypersonic missile is effectively combined with the platform can it be ensured that it plays a strategic deterrent role. It can be said that Russia's launch platform construction has spared no effort and achieved remarkable results. Russia strives to achieve high. The comprehensive integration of the supersonic missile and the launch platform is organically combined. In terms of the integration of hypersonic missiles with combat aircraft and combat ships, Russia is at the forefront of the world, and it is worth emulating and learning from. [高超声速导弹只有和平台有效结合，才能够确保发挥战略威慑作用。俄罗斯在发射平台建设方面可以说是不遗余力，成绩斐然。俄罗斯努力实现高超声速导弹与发射平台的综合集成，有机结合。特别是将高超声速导弹与作战飞机、作战舰艇的集成方面，俄更是走在了全世界的前列，非常值得借鉴和学习。]'[38]

IV. Implications of EDTs in the nuclear realm and for strategic stability

The literature suggests that the application of EDTs in the military domain presents more of a destabilising factor than *vice versa*. In particular, it poses challenges to proliferation, nuclear deterrence, and strategic stability.

1. Proliferation challenges

- *Increases the difficulties in preventing proliferation due to the dual-use nature of EDTs, reduced and affordable cost, and wide availability*
- *Increases the accessibility for states that are lagging in EDTs development and non-state actors, especially terrorist groups*

> 'Different from nuclear and conventional weapons in other high-tech fields, AI will continuously be improved through the achievement of military-civil fusion and the advancement of dual-use technologies. Its research platform is much more extensive, the technology is widely available, and its technical threshold is low. Therefore, it is difficult to prevent its proliferation either horizontally or vertically. [与核武器和其他高新技术领域的常规武器不同，人工智能技术可通过军民融合、军地两用途径不断得到研发和提升，其研究平台更加广泛，技术门槛更加低下，因此其“水平扩散”和“垂直扩散”的倾向也更加明显。]'[39]

> 'AI application in the form of plugins have not yet received attention by the Arms Trade Treaty. Considering its dual-use nature, it is [concerning] that some AI technologies can even be exported as civilian goods, which are not restricted by the Arms Trade Treaty in terms of the end-use of such items. The absence of restrictions [and instrument to govern the trade] in AI technologies may lead to a further increase in arms trade and the misuse of related weapons, with these technologies falling into the hands of terrorist groups or criminal organisations. [由于人工智能技术的军民两用性质，可以作为插件存在的人工智能模块尚未受到条约的重视，某些人工智能技术甚至能够作为民用品出口，完全规避《武器贸易条约》对最终用途的约束，这有可能进一步强化相关武器的交易与滥用，导致此类武器或技术向恐怖主义或犯罪组织非法扩散。]'[40]

2. Destabilise nuclear deterrence

- *Increases incentives of first strike and weakens the ability of second strike*
- *Threatens the survival of adversary's nuclear deterrence forces*
- *Increases the risks of unwanted escalation with preemption*

> 'The negative effects of AI technologies on mutual threats, capabilities, and the decision-making credibility of nuclear states will exacerbate the risk of miscalculation, misunderstanding, and first strike among adversary states. …In the era of artificial intelligence, states leading in technological development are more inclined to use intelligent weapons to initiate a preemptive attack. Meanwhile, the weaker states are also prone to launch preemptive strikes. This similar value of initiating a first strike constantly increases the possibility of intentional or unwanted conflict or a nuclear war. [人工智能技术对核国家彼此间威胁、能力和决策可信度产生的不利影响，将加剧敌对国家间误判、误解及首先发动攻击的风险。…在人工智能时

The negative effects of AI technologies on mutual threats, capabilities, and the decision-making credibility of nuclear states will exacerbate the risk of miscalculation, misunderstanding, and first strike among adversary states.

代，拥有领先技术的国家更倾向于使用智能化武器首先攻击对方，而相较弱势的国家同样易于发动先发制人的打击，双方在危机中有意或无意发生冲突或核战争的可能性将不断增加。]'[41]

'The integration of AI, machine learning, and big data analytics can significantly improve the ability of nuclear warfare systems to locate, track, target, and destroy an enemy's nuclear forces, especially nuclear-armed submarines and tactical missile forces.... Meanwhile, the development of unmanned autonomous systems empowered by AI has strengthened the reconnaissance capability and even strike capabilities on strategic targets and facilities. In particular, the unmanned maritime system will greatly threaten the survivability of sea-based nuclear weapons. [人工智能、机器学习和大数据分析的整合可显著提高核作战体系定位、跟踪、瞄准并摧毁敌方核威慑力量(尤其是核武装潜艇和机动导弹部队)的能力。…同时人工智能赋能的无人自主系统的发展，加强了对战略目标和设施的侦察甚至是打击能力，尤其是海上无人系统将使水下作战域透明化，对海基核武器的生存能力构成威胁。]'[42]

'If AI is incorporated into nuclear command and control and early warning systems, it will pose a potential risk to nuclear strategic stability between major powers. A failure or error in the AI system may lead to major nuclear accidents, decision-making errors, or even a nuclear war. [人工智能系统如被纳入核指挥与控制系统、早期预警系统中，将对大国之间的核战略稳定构成潜在风险，如果人工智能系统失效或失误，将可能造成重大核意外事件或决策失误，甚至引发核战争。]'[43]

3. Threaten strategic stability

- *Undermines arms race stability*
- *Lowers the threshold for initiating war*
- *Raises the risks of pre-emptive war*

'In the era of AI, the progress of a specific technology made by a nuclear-armed state will trigger a chain reaction in other countries, which is regarded as an unstable arms race... The evolution of military technology triggered by AI makes the nuclear capability of all nuclear countries more vulnerable, and the willingness and motivation of countries to carry out an arms race is significantly increased... Considering AI's strategic advantages and benefits, it is difficult for major countries to restrain themselves from, and slow down the pace of, an arms race on AI. The world is more likely to be trapped in a chaotic and vicious competition. [在人工智能时代，一个拥有核武器的国家在某一特定技术上的进步，都会对其他国家产生连锁反应，被视为不稳定的军备竞争…人工智能引发的军事技术变革使所有核国家的核力量变得愈加脆弱，各国开展军备竞赛的意愿和动机明显加深…考虑到人工智能技术所带来的战略优势和红利，世界各主要国家很难凭借自身理性来克制和减缓人工智能军备竞赛的步伐，全球更有可能陷入无序和恶性竞争的不稳定状态。]'[44]

The evolution of military technology triggered by AI makes the nuclear capability of all nuclear countries more vulnerable.

'If every nation hopes to gain an operational advantage through military AI, it could escalate an arms race and proliferation. During wartime, autonomous weapons may not be sensitive enough to political considerations, and they may launch or intensify attacks in certain places, leading to escalation. From a casualty perspective, AI may reduce the cost of war, leading

commanders to be more willing to take greater risks and more aggressive actions, further exacerbating conflicts. [如果每个国家都追求军事人工智能，以期获得作战优势，这可能导致军备竞赛升级和扩散。在战争中，自主武器可能对政治考虑或冲突升级的底线不够敏感，它们可能会在某些地方发动攻击或加强攻击，导致冲突升级。从人员伤亡的角度来看，人工智能可能会降低战争成本，致使指挥官更愿意承担更大的风险而采取更激进的行动，进一步加剧冲突。]'[45]

'Currently, many countries have already developed, or are developing, a variety of lethal autonomous weapon systems (Lethal Autonomous Weapon Systems, referred to as LAWS). With the rapid development of artificial intelligence and robotics, there are increasing concerns over the possibility of losing control over robots. [目前，多国已经或正在研发多种致命性自主武器系统（Lethal Autonomous Weapon Systems，简称LAWS）。随着人工智能和机器人技术的快速发展，这种军事技术的升级增加了人们对于"机器人失控"的忧虑。]'[46]

'While autonomous weapon systems bring huge military benefits, they also cause many problems. The autonomous capabilities of autonomous weapons are limited, unable to effectively distinguish between soldiers and civilians, and are therefore prone to indiscriminate killing and accidentally injuring innocent civilians, causing humanitarian disasters. This has drawn attention to debates on the use of unmanned autonomous weapon systems in the field of arms control. [自主武器系统在带来巨大军事效益的同时，也带来了诸多问题。由于自主武器的自主能力有限，无法有效区分士兵与平民，容易滥杀和误伤无辜，导致交战国平民面临巨大的人道主义灾难，引发军备控制领域对无人自主武器系统使用的关注与争论。]'[47]

'The continuous interaction between cyberspace and physical space has led to new impacts on strategic stability. First, information technology can significantly enhance nuclear weapons systems' launch and early warning capabilities. At the same time, it also increases risks of cyber attacks on nuclear command-and-control systems. Second, cyber weapons are very suitable for preemptive first-round strikes, destroying the enemy's domain awareness of its environment. This can seriously undermine strategic stability and easily lead to the escalation of the crisis. The third is traditional nuclear warfare. Strategic stability is based on a clear understanding of the overall situation and good communication between the opposing sides; concealment and deception are the main characteristics of cyber attacks, contrary to the principle of strategic stability. [随着网络空间与物理空间不断交融，网络对战略稳定带来了新的影响。一是信息技术可以大幅度提升核武器系统的发射与预警能力，但同时也增加了核武器的指挥与控制系统被网络攻击的风险。二是网络武器很适合用于先发制人的首轮打击，摧毁敌方对现状的感知能力，这对稳定性的破坏较大，容易引起危机升级。三是传统的核战略稳定建立在对整体形势的清晰了解，且敌对双方有良好沟通的基础之上，而隐蔽与欺骗是网络攻击的主要特征，这与战略稳定原则是背道而驰的。]'[48]

'Its vulnerability becomes apparent when nuclear, space, and conventional armed capabilities are highly dependent on cyber technology. Effective disruption of these capabilities can be achieved through cyber operations. For example, nuclear command and control systems and space communication

systems are highly dependent on network facilities and can be controlled and destroyed through network operations. [当核、太空以及常规武装能力高度依赖网络技术的时候，它的脆弱性变得非常明显。通过网络行动可以实现对这些能力的有效破坏。例如，核指挥控制系统、太空通信系统都高度依赖网络设施，通过网络行动可以进行控制和破坏。][49]

V. Measures for mitigating risks resulting from EDTs

The literature focuses on three fields of discussion for mitigating the security risks posed by the development and military application of EDTs:

1. Arms control

- *Improve the non-proliferation, transfer, and export control regime on EDTs*
- *Establish a code of conduct on the military application of EDTs*
- *Develop a consensus on EDTs arms control through a bottom-up approach, as the progress through a top-down approach is slow*

> 'Chinese experts have also actively participated and shared views in global governance and dialogue... Since 2019, the Arms Control Association has conducted relevant dialogues with the Geneva "Humanitarian Dialogue Center" experts from China, the United States, and Europe to discuss a draft code of conduct on military AI systems. This includes design and development, testing and evaluation, deployment and use, accountability mechanisms, confidence building, and international cooperation. [中国专家和学者也积极参与全球治理和对话进程，提出有益的看法和建议…自2019 年以来，军控协会与日内瓦 "人道主义对话中心" 开展了相关对话，来自中、美、欧等专家学者还 初步探讨了来自中、美、欧等专家学者还初步探讨了人工智能军事系统的行为准则草案，包括设计开发、测试评估、部署使用、问责机制、建立信任和国际合作等内容。]'[50]

> 'Given that the top-down model led by sovereign states has made slow progress in promoting AI arms control, a bottom-up approach can also be considered. This approach is taken by achieving consensus that the development of certain armament is hazardous among intellectual elites. Through this type of bottom-up knowledge dissemination, it could, in turn, shape norms and facilitate arms control agreements among major countries. [鉴于由主权国家主导的自上而下的模式在推动人工智能军控方面进展缓慢，还可以考虑自下而上的军控进路，即由知识精英形成对某种军备发展危害性的 "认知共同体"，进而塑造规范，并以自下而上的知识传播方式影响、促进主要国家间达成军备控制协议。]'[51]

> 'On 13 December 2021, the Sixth Review Conference of the United Nations Convention on Certain Conventional Weapons opened in Geneva. At the meeting, Chinese Disarmament Ambassador Li Song presented China's "Position Paper on Regulating the Military Application of Artificial Intelligence". The document focuses on the important aspects of research and development, deployment, and use of artificial intelligence military applications. It also proposes solutions for responsibly developing and utilising artificial intelligence technology in the military field. [2021年12月13日，联合国《特定常规武器公约》第六次审议大会在日内瓦开幕。会上，中国裁军大使李松提交了中国《关于规范人工智能军事应用的立场文件》。该文件聚焦人工智能军事应用涉及的研发、部署、使用等重要环节，就如何在军事领域负责任地开发和利用人工智能技术提出解决思路。]'[52]

> 'The dominant powers usually want the disadvantaged countries to stop developing cyber weapons, but the disadvantaged countries hope to gain bargaining chips by developing offensive and defensive cyberweapons, thus

Given that the top-down model led by sovereign states has made slow progress in promoting AI arms control, a bottom-up approach can also be considered.

forming an arms race in cyberspace. [在网络空间军备竞赛中，处于优势地位的大国通常希望处于劣势地位的国家不发展网络空间武器，但是处于劣势的国家希望通过发展进攻与防御性的网络武器，争取讨价还价的资本，因此形成了网络空间的军备竞赛。]'[53]

'Public opinion on the development of technologies related to autonomous weapon systems is still controlled by the United States, Britain, and other military powers. They have policies in place to ensure the development and use of autonomous weapons in compliance with relevant laws, to promote their independent technology research and the legitimate use of such weapons, while taking the opportunity to inhibit other countries' technological development. [有关自主武器系统相关技术发展的舆论风向还控制在美国、英国等军事强国手中。他们制定了相关政策来确保自主武器系统的发展和使用符合有关法律，并宣扬自主技术研究和使用的合法性，同时借机抑制其他国家自主技术的发展。]'[54]

Notwithstanding the professed interest discussed above, Chinese analysts suggest:

'There are two obstacles to engaging China in arms control. One is traditional thinking within China, traditional insistence on secrecy and lack of transparency, and the traditional suspicion of arms control. That type of obstacle can only be removed if you have the support and blessing from China's top leadership on arms control research. So you must engage with the top leader, the importance of that cannot be overstated.

But second, today, we also need to start engaging with China to discuss specific options. So that in case there is political support and blessing, we can have concrete options to work out. On that front, there is a need to have expert level discussions on specific options. It can be bilateral or trilateral, but as long as we have concrete discussions, it may help pave the way for future progress.'[55]

2. Crisis management, confidence building, and global governance

- *Accelerate confidence-building measures to maintain strategic stability and manage war risks*
- *Increase the transparency of EDTs development*
- *Establish information-sharing mechanisms to enhance strategic stability*
- *Establish track 2 dialogue and bilateral strategic talks between great powers*

'At present, the global risk of strategic instability caused by the military application of AI is only discussed among academics. There is a lack of corresponding crisis management and confidence-building measures among nuclear-armed states... In the nuclear realm, nuclear-armed states must strengthen cooperation and ratify relevant bilateral and multilateral agreements on arms control as soon as possible to prohibit the use of AI technology in nuclear command and control systems and ensure human control of all launch platforms for nuclear weapons. [目前国际上关于人工智能军事应用引发的战略不稳定风险，只停留在学术探讨层次，核国家之间缺乏相应的风险管控和建立信任机制…在核领域，拥核国家须强化合作，尽快签订相关双边和多边军控协定，禁止将人工智能技术用于核

指挥控制系统中，确保人类控制所有核武器发射平台。]'[56]

'Crisis management has also increasingly become an important factor affecting the stability of major power relations in cyberspace. The timing and process of crises in cyberspace are unpredictable. If a country wants to effectively conduct a network attack, its preparations are often not discovered by others, so it is difficult to produce hard evidence that a country is ready to attack other countries. And when other countries are attacked, crises occur quickly and are likely hard to guard against. Under such circumstances, how to deal with a crisis and determine the corresponding plan based on the level of the crisis is vitally important. Cyber security crisis management in the field of nuclear weapons and space weapons is particularly important. [危机管理也越来越成为影响网络空间大国关系稳定的重要因素。网络空间中的危机产生时间和过程具有不可预测性。因为某国若要有效进行网络打击，其准备工作往往不为他人所发现，从而难以产生反映一国准备攻击他国的确凿证据。而当他国受到攻击时，危机迅速发生且很可能防不胜防。在这种情形下，如何应对危机以及根据危机的等级决定相应的预案也十分关键。核武器与太空武器领域的网络安全危机管控尤为重要，对网络空间的稳定具有非常重要的影响。]'[57]

'Improve the transparency of AI algorithms at the global level and explore unified interpretable standards for military AI in all countries. [提高全球层面人工智能算法的透明性，探寻适用于各国人工智能军事化应用科学统一的可解释标准。]'[58]

'Consolidate consensus, enhance mutual trust through Track 2 dialogue, and gradually advance to formal cooperation between governments. [通过二轨对话的方式凝聚共识、增进互信，逐步推进到政府间的正式合作。]'[59]

'At the CCW expert meeting, China was the first country to express its support for regulating LAWS and others through a legally binding treaty. … In August 2018, China called for a new CCW agreement, the Lethal Autonomous Weapons Protocol (Draft), to ban the use of fully autonomous weapons. This proposal was strongly opposed by the US, Russia, UK, Israel and Japan, among others. [在CCW专家会议上，中国是第一个表态支持通过制定具有法律约束力的条约对LAWS等进行管制的国家。… 2018年8月，中国呼吁制定一项新的CCW协议，即《致命性自主武器议定书 （草案）》，禁止使用完全自主武器系统，但遭到美国、俄罗斯、英国、以色列和日本等国的强烈反对。]'[60]

VI. Ways forward

This literature review shows there is significant Chinese interest in EDTs, their military applications, policies, and developments by other major powers, in particular, the United States and, to some extent, Russia. Our search in the CNKI database has yielded a large number of publications on several EDTs, with AI, quantum, 5G/cyber, and autonomous weapons among the more researched and analysed technologies. We recognise that CNKI, while it is the single largest open-source database in China, is not comprehensive, especially for our purposes. There are many more military, defence technology, and industry publications that may contain more relevant articles and analyses that could reveal more clearly how China views EDTs and their potential as force multipliers in China's pursuit of becoming a world-class military power. Unfortunately, these are beyond our reach. In fact, even some articles contained in CNKI are inaccessible due to their apparent sensitive nature. As a result, our presentation of the Chinese literature is inevitably limited and confined to what is available and accessible.

Even with this limitation and full disclosure that we have confined our search to publications between 2020 and 2022, several general patterns emerged that allow us to make some preliminary observations. First, most Chinese publications tend to focus on a single EDT, for instance, quantum computing, or AI, rather than comprehensive treatises of EDTs as an aggregate. This may be understandable as EDTs continue to evolve and advance apace and so whether one or the other qualifies as 'disruptive' may not always garner ready consensus. Exceptions to this general pattern exist and can be catalogued in appendices in future projects.

Second, most publications – except those in more technical journals – are written in a popular science genre, drawn from Western literature, if not direct translations of published academic works and government documents. These are written in easy-to-understand language with little jargon, and are informative and reasonably up-to-date. They provide a good service to their audience, including those working in the military and national security, where updates on developments are summarised, digested, analysed, and implications discussed.

Third, Chinese publications closely follow developments in other major powers, especially the United States. Some articles suggest a focus on greater interactions and integration between different technologies in multi-domains which will further strengthen military operations, while others are equally aware of the risks of such integration for an escalation in conflicts. It is important to note that discussions of developments in other major powers can reveal where China is positioned on various EDTs, even though China is not the focus of the analysis. For instance, by detailing the advances and sophistication of certain EDTs in military applications by the US military and the resources that the US government has been investing in developing these EDTs, one can infer that China may be behind and trying to catch up in this area.

Discussions of developments in other major powers can reveal where China is positioned on various EDTs, even though China is not the focus of the analysis.

Fourth, most EDT analyses focus on their implications for military applications, modern combat, and scenarios of military engagements but, by and large, are confined to conventional warfare. Only a few consider the potential risks EDTs pose to strategic stability, nuclear escalation, risk reduction, and deterrence failure, among others. However, there is recognition that some

EDTs and their potential for undermining strategic stability require discussion, introduction, and development of crisis mitigation, crisis management, confidence building, and arms control mechanisms. Such discussions exist, but they tend to focus on the political and diplomatic aspects rather than the technical aspects of strategic stability and nuclear risk reduction. We suspect the more technical analyses are confidential and hidden from the public view.

Fifth, while this paper focuses on the literature review of Chinese experts from academia and think tanks, many of them are affiliated with PLA institutions or government think tanks, as listed in appendix 1. This review reflects then, to some extent, the debate at the official level. On the issues related to mitigating risks resulting from the development of EDTs for strategic stability, there is a clear convergence of views at the academic and official levels. Selected government documents and statements are presented in appendix 2 as an elaboration on this point. A comparative study of the views between the expert community and the official positions would be useful to identify areas of convergence and divergence. This would enable us to understand better whether and to what extent there is a perception gap and whether this gap is widening further.

On the issues related to mitigating risks resulting from the development of EDTs for strategic stability, there is a clear convergence of views at the academic and official levels.

Appendix 1: Author affiliations cited in the paper*

1. Academy of Military Science
   [军事科学院]
2. Advisory Committee for State Informatization
   [国家信息化专家咨询委员会]
3. Army Engineering University of PLA
   [中国人民解放军陆军工程大学]
4. Beijing Aerospace Long March Science and Technology Information Institute
   [北京航天长征科技信息研究所]
5. Carnegie Endowment for International Peace
   [卡内基国际和平研究所]
6. The Charhar Institute
   [察哈尔学会]
7. Central Military Commission of China
   [中央军事委员会]
8. Chengdu Library of the Chinese Academy of Sciences
   [中国科学院成都文献情报中心]
9. Chengdu Skydefense Technology Co. Ltd.
   [成都空御科技有限公司]
10. China Academy of Electronic and Information Technology
    [中国电子科学研究院]
11. China Arms Control and Disarmament Association
    [中国军控与裁军协会]
12. China Institute of International Studies
    [中国国际问题研究院]
13. Dalian Maritime University
    [大连海事大学]
14. Guangdong Longyuan photoelectrics Co., Ltd
    [广东隆源光电有限公司]
15. Guangdong Xi'an Jiaotong University Academy
    [广东西安交通大学研究院]
16. PLA National Defense University
    [中国人民解放军国防大学]
17. PLA National University of Defense Technology
    [中国人民解放军国防科技大学]
18. Party School of the Central Committee of CPC (National Academy of Governance) [中共中央党校（国家行政学院）]
19. Renmin University of China [人民大学]
20. Tsinghua University [清华大学]
21. University of Aerospace Engineering
    [航天工程大学航天信息学院]

* Some author affiliations cannot be identified.

Appendix 2: Key Chinese official documents and statements related to EDTs

1. Notice of the State Council on Printing and Distributing 'Made in China 2025' [国务院关于印发《中国制造2025》的通知] [61]

2. 'Internet+' Artificial Intelligence Three-Year Action and Implementation Plan ['互联网+' 人工智能三年行动实施方案][62]

3. Xi Jinping: Strive to build a world power in science and technology [习近平: 为建设世界科技强国而奋斗][63]

4. 13th Five-Year Plan for the Development of Strategic Emerging Industries [国务院关于印发 '十三五' 国家战略性新兴产业发展规划的通知][64]

5. SASTIND Publishes Guide to Publicise Military Industrial Intelligent Manufacturing Special Action Plan for Defense S&T Industry Strong Basic Project [国防科工局公开发布国防科技工业强基工程军工智能制造专项行动计划项目指南][65]

6. The 13th Five-Year Special Plan for S&T Military-Civil Fusion Development ['十三五' 科技军民融合发展专项规划][66]

7. Opinions of the General Office of the State Council on Promoting the Deep Development of Military-civilian Integration of National Defense Science and Technology Industry [国务院办公厅关于推动国防科技工业军民融合深度发展的意见][67]

8. Xi Jinping: Speech at the Symposium of Scientists [习近平: 在科学家座谈会上的讲话][68]

9. Global Data Security Initiative [全球数据安全倡议][69]

10. Tianjin Biosecurity Guidelines for the Codes of Conduct for Scientists [科学家生物安全行为准则天津指南][70]

11. China's Positions on International Rules-making in Cyberspace [中国关于网络空间国际规则的立场][71]

12. Position Paper of the People's Republic of China on Regulating Military Applications of Artificial Intelligence [中国关于规范人工智能军事应用的立场文件][72]

13. China's Space Program: A 2021 Perspective [2021中国的航天白皮书][73]

14. Remarks by Ambassador Zhang Jun at the UN Security Council Briefing on Technology and Security [常驻联合国代表张军大使在安理会技术与安全公开会上的发言][74]

15. Xi Jinping: Improve the new national system for tackling key core technologies [习近平: 健全关键核心技术攻关新型举国体制][75]

16. Position Paper of the People's Republic of China on Strengthening Ethical Governance of Artificial Intelligence [中国关于加强人工智能伦理治理的立场文件][76]

17. '14th Five-Year' Plan for the Development of the Big Data Industry ['十四五' 大数据产业发展规划][77]

Endnotes

1 Durkalec, J. et al., Nuclear decision-making, complexity, and emerging and disruptive technologies: a comprehensive assessment. European Leadership Network. London: ELN, 2022. <https://www.europeanleadershipnetwork.org/wp-content/uploads/2022/01/LLNL.pdf>; Horowitz, M.C. and Pindyck, S., 'What is a military innovation and why it matters', Journal of Strategic Studies, <https://doi.org/10.1080/01402390.2022.2038572>.

2 State Council of the People's Republic of China, 'Made in China 2025 [中国制造2025]', 8 May 2015, <http://www.gov.cn/zhengce/content/2015-05/19/content_9784.htm>; U.S. Department of Defense, 'Remarks by Deputy Secretary Work on Third Offset Strategy', 28 Aprl. 2016, <https://www.defense.gov/News/Speeches/Speech/Article/753482/remarks-by-deputy-secretary-work-on-third-offset-strategy/>.

3 We are prepared to go back and dig deeper in literature of earlier years if/when needed.

4 Bower, J. and Christensen, C. M., 'Disruptive Technologies: Catching the Wave', Harvard Business Review, Jan-Feb 1995, pp. 43-53.

5 Kania, E. and VornDick, W., 'China's Military Biotech Frontier: CRISPR, Military-Civil Fusion, and the New Revolution in Military Affairs', China Brief, 19, Issue 18, 8 Oct. 2019, https://jamestown.org/wp-content/uploads/2019/10/Read-the-10-08-2019-CB-Issue-in-PDF2.pdf

6 Li, D., 'Disruptive Technologies and Sci-Tech Security' [颠覆性技术与科技安全], Chinese Military-Civilian Conversion [中国军转民], 2020, pp. 18.

7 Ibid., p. 19.

8 Wen L. and Long K., 'Opportunities and Challenges Brought by Artificial Intelligence to Military Security [人工智能给军事安全带来的机遇与挑战]', Information Security and Communications Privacy,2021(5):18-26.

9 Li X. and Luo T., 'Military Application of Artificial Intelligence and its International Law Issues [人工智能军事应用及其国际法问题]', Information Security and Communications Privacy, 2021(1):99-108.

10 Li, D., 'Disruptive Technologies', p. 16.

11 Zhuang, C., Jia L., and Zhu, Y., 'Influence of 5G technology on the military' [5G技术对军事领域的影响及思考], National Defense Technology [国防科技], 43, no. 1 (Feb. 2022), pp. 22-23.

12 Yu, P., Wang, Y., Yu, A., and Niu, Y., '5G and Blockchain military applications: exploration and analysis' [5G+区块链" 军事应用探索与分析], National Defense Technology [国防科技], 42, no. 6 (Dec. 2021), p. 49.

13 Zhou W. and Chen Y., 'Application of artificial intelligence technology in military command and control under the background of intelligent warfare [智能化战争背景下人工智能技术在军事指挥控制中的应用]', Military Digest, Aug. 2022, pp.27-30.

14 Wang C., and Hu C., 'Application of Artificial Intelligence in Military Communication Network: Based on "Zero Trust" Method [人工智能在军事通信网络中的应用 :基于 "零信任" 方法]', Industry Observation, Feb. 2021, pp. 46-48.

15 Yang, Y., Feng, L., Zhao, W., and Gao, X., '[量子技术及其在军事领域的应用], Military Digest [军事文摘], no. 6 (2022), p. 15.

16 Chen, J. and Ban, F., 'The role of quantum information technology in the military field main impact' [量子信息技术对军事领域的主要影响], Military Digest [军事文摘], no. 5 (2020), p. 20.

17 Ibid., p. 21.

18 Li B., Zhang F., Li Q., and Zheng M., 'Research on the Application of Artificial Intelligence Technology in Military Field [人工智能技术在军事领域的应用思考]', Journal of CAEIT, Mar. 2022, Vol. 17, No. 3, pp. 238-246.

19 Xu J., Wu H., and Tang C. 'The Application and Progress of Artificial Intelligence in National Defense [人工智能在国防领域的应用与进展]', Aerodynamic Missile Journal, Mar. 2021, No.3, pp.87-92.

20 Wen L. and Long K., 'Opportunities and Challenges Brought by Artificial Intelligence to Military Security [人工智能给军事安全带来的机遇与挑战]', Information Security and Communications Privacy,2021(5):18-26.

21 Feng S., 'International Relations in the Age of AI: Moving Towards Shifting and Unequal World [人工智能时代的国际关系: 走向变革且不平等的世界]', Foreign Affairs Review, Vol. 1, 2018, pp. 128-156.

22 Xu W., 'Military AI and Network Security [军用人工智能与网络安全]', Civil-Military Integration on Cyberspace, 2019, Vol. 10.

23 Yu, P., et al., '5G and Blockchain Military Applications'.

24 Liu, K., Liu, Y., Luo, C., and Meng, B., 'The disruptive impact of quantum technology' [量子科技带来的颠覆性影响], Military Digest [军事文摘],no. 6 (2022), pp. 9-10.

25 Luo, Y. and Li, B., 'First Mover Advantage in Military AI Competition' [军用人工智能竞争中的先行者优势], Quarterly Journal of International Politics [国际政治科学], 7, no. 3 (2022), p. 2.

26 Zhang H. and Du Y., 'The Development Trend and Security Impact of the Militarization of Artificial

Intelligence [人工智能军事化发展态势及其安全影响]', Foregin Affairs Review, 2022, Vol.3, pp.99-130.

27 Liu Y., 'A Comparative Study of Artificial Intelligence Strategies and Policies Between China and Tte United States [中美人工智能战略及政策的比较研究]', The Journal of Yunnan Administration College, 2022, Vol.1, pp. 101-124.

28 Zhang D., '[转向"数字霸权":美国国家人工智能战略及其国际影响]', Contemporary World and Socialism, 2020, Vol.5, pp. 158-168.

29 Zhen, H., 'Exploration of 5G Technology in Military Field by Western Countries', [西方国家对5G技术在军事领域应用的探索],Military Digest [军事文摘],no.3 (2022), p. 33.

30 Liu, K., Liu, Y., Luo, C., and Meng, B., 'The disruptive impact of quantum technology' [量子科技带来的颠覆性影响], Military Digest [军事文摘],no. 6 (2022), p. 8.

31 You, G., Cheng, Y., Yang, Y., and Jin, Y., 'Quantum technology in major powers and regions in the world Policy History and Military-Civil Dual-Use Application' [世界主要大国和地区的量子科技政策沿革及军民两用应用情况], Military Digest [军事文摘],no. 6 (2022), p. 11.

32 Ibid., pp. 11-14.

33 Li Z., 'Sino-US Tech competition from Russian perspectives [俄罗斯视角下的中美科技博弈]', Journal of Eurasian Economy, Vol. 3, 2021.

34 Ibid.

35 Liu, D., Chen, Q., and Xu, J., 'Development Status and Reference of Russian Hypersonic Weapons' [俄罗斯高超声速武器发展现状及借鉴思考], Tactical Missile Technology [战术导弹技术], 2022, DOI: 10.16358/j.issn.1009-1300.20220046; a similar discussion can be found in: Wang, F., Zhu, Q., and Zhang, J., 'A brief analysis of the development of Russian hypersonic weapons' [俄罗斯高超声速武器发展简析], National Defense Technology [国防科技], 42, no. 3 (Jun 2021), pp. 57-64.

36 Liu, D., et al., 'Development Status and Reference of Russian Hypersonic Weapons'.

37 Ibid.

38 Ibid.

39 Luo X., 'Advances in artificial intelligence technology led to new military reform [人工智能技术进步引发新的军事变革]', Shijie Zhishi [世界知识], Vol. 5, 2018, pp.14-16.

40 Li X. and Luo T., 'Military Application of Artificial Intelligence and its International Law Issues [人工智能军事应用及其国际法问题]', Information Security and Communications Privacy, 2021(1):99-108.

41 Zhang D., 'The Militarization of Artificial Intelligence and Global Strategic Stability [人工智能军事化与全球战略稳定]', Guoji zhanwang [国际展望], Vol. 5, 2022, pp. 142-161.

42 Han H., 'An analysis of the Potential Application and Influence of Artificial Intelligence in Nuclear Combat Systems [人工智能在核作战体系中的潜在应用及影响浅析]', National Defense Technology, Aug. 2022, Vol. 43, No. 4, pp.77-81.

43 Li C., 'The Application of Artificial Intelligence in the Military Field and Global Governance [人工智能在军事领域的应用及全球治理]', Frontiers, May 2021, pp. 22-29.

44 Zhang D., 'The Militarization of Artificial Intelligence and Global Strategic Stability [人工智能军事化与全球战略稳定]', Guoji zhanwang [国际展望], Vol. 5, 2022, pp. 142-161.

45 Xu J., Wu H., and Tang C. 'The Application and Progress of Artificial Intelligence in National Defense [人工智能在国防领域的应用与进展]', Aerodynamic Missile Journal, Mar. 2021, No.3, pp.87-92.

46 Niu, Y. and Wang, C., 'Situation analysis of arms control for Lethal Autonomous Weapon Systems [致命性自主武器系统军备控制态势分析]', National Defense Technology [国防科技], 42, no. 4 (Aug. 2021), p. 37.

47 Ibid., p. 39.

48 Zhou, H., 'On Strategic Stability in Cyberspace [网络空间的崛起与战略稳定]', Global Review [国际展望], (2019), p. 27.

49 Ibid., pp. 29-30.

50 Li C., 'The Application of Artificial Intelligence in the Military Field and Global Governance [人工智能在军事领域的应用及全球治理]', Frontiers, May 2021, pp. 22-29.

51 Zhang H. and Du Y., 'The Development Trend and Security Impact of the Militarization of Artificial Intelligence [人工智能军事化发展态势及其安全影响]', Foreign Affairs Review, Vol.3, 2022, pp. 99-130.

52 Lan, S., 'China takes the lead in launching an international initiative to regulate artificial intelligence for military use' [中国率先发起规范军用人工智能国际倡议], World Affairs [世界知识], no. 1 (2022), p. 56.

53 Zhou, H., 'On Strategic Stability in Cyberspace' [网络空间的崛起与战略稳定], Global Review [国际展望], (2019), p. 32.

54 Niu and Wang, 'Situation analysis of arms control for Lethal Autonomous Weapon Systems', p. 41.

55 Zhao T., 'Transcript of Engaging China on Arms Control', Carnegie Endowment for International Peace, 26 Jan. 2021, <https://carnegieendowment.org/files/Tanscript_of%20Engaging%20China%20on%20Nuclear%20Ars%20Control.pdf>

56 Long K. and Xu N., 'AI's Military Applications: Risks and Governance [人工智能军事应用的国际安全风险与治理路径]', Global Review [国际展望], Vol. 5, 2022, pp.123-141.

57 Zhou, 'On Strategic Stability in Cyberspace', p. 32.

58 Zhang D., 'The Militarization of Artificial Intelligence and Global Strategic Stability [人工智能军事化与全球战略稳定]', Global Review [国际展望], Vol. 5, 2022, pp. 142-161.

59 Long K. and Xu N., 'AI's Military Applications: Risks and Governance [人工智能军事应用的国际安全风险与治理路径]', Global Review [国际展望], Vol. 5, 2022, pp.123-141.

60 Niu and Wang, 'Situation analysis of arms control for Lethal Autonomous Weapon Systems', p. 40.

61 State Council of the People's Republic of China, 'Notice of the State Council on Printing and Distributing "Made in China 2025" [国务院关于印发《中国制造2025》的通知]', 8 May 2015, <http://www.gov.cn/zhengce/content/2015-05/19/content_9784.htm>.

62 National Development and Reform Commission (NDRC) of the People's Republic of China [国家发展改革委员会; 国家发改委], 'Internet+' Artificial Intelligence Three-Year Action and Implementation Plan ['互联网+' 人工智能三年行动实施方案]', 18 May 2016, <https://perma.cc/X2M9-N7RQ>.

63 Xinhua, 'Xi Jinping: Strive to build a world power in science and technology [习近平: 为建设世界科技强国而奋斗]', 31 May 2016, <http://www.xinhuanet.com//politics/2016-05/31/c_1118965169.htm>.

64 State Council of the People's Republic of China, '13th Five-Year Plan for the Development of Strategic Emerging Industries [国务院关于印发 '十三五' 国家战略性新兴产业发展规划的通知]', 29 Nov. 2016, <http://www.gov.cn/zhengce/content/2016-12/19/content_5150090.htm>.

65 State Administration for Science, Technology and Industry for National Defense, 'SASTIND Publishes Guide to Publicize Military Industrial Intelligent Manufacturing Special Action Plan for Defense S&T Industry Strong Basic Project [国防科工局公开发布国防科技工业强基工程军工智能制造专项行动计划项目指南]', 28 Apr. 2018, <http://www.gov.cn/xinwen/2018-04/28/content_5286691.htm>.

66 Chinese Ministry of Science and Technology, 'The 13th Five-Year Special Plan for S&T Military-Civil Fusion Development ["十三五" 科技军民融合发展专项规划]', 24 Aug. 2017, <http://www.aisixiang.com/data/106161.html>.

67 State Council of the People's Republic of China, 'Opinions of the General Office of the State Council on Promoting the Deep Development of Military-civilian Integration of National Defense Science and Technology Industry [国务院办公厅关于推动国防科技工业军民融合深度发展的意见]', 4 Dec. 2017, <http://www.gov.cn/zhengce/content/2017-12/04/content_5244373.htm>.

68 Xinhua, 'Xi Jinping: Speech at the Symposium of Scientists' [习近平: 在科学家座谈会上的讲话], 11 Sep. 2020, <http://www.xinhuanet.com/politics/leaders/2020-09/11/c_1126483997.htm>.

69 Chinese Ministry of Foreign Affairs, 'Global Data Security Initiative [全球数据安全倡议]', 29 Oct. 2020, <https://www.fmprc.gov.cn/web/ziliao_674904/tytj_674911/zcwj_674915/202010/t20201029_9869292.shtm>.

70 'Tianjin Biosecurity Guidelines for the Codes of Conduct for Scientists [科学家生物安全行为准则天津指南]', Jul. 2021, <https://www.centerforhealthsecurity.org/our-work/Center-projects/IAPendorsementTianjinCodes/211116-TIANJINBIOSECURITYGUIDELINES-CHI.pdf>.

71 Chinese Ministry of Foreign Affairs, 'China's Positions on International Rules-making in Cyberspace [中国关于网络空间国际规则的立场]', 20 Oct. 2021, <https://www.fmprc.gov.cn/web/wjb_673085/zzjg_673183/jks_674633/zclc_674645/qt_674659/202110/t20211012_9552671.shtml>.

72 Chinese Ministry of Foreign Affairs, 'Position Paper of the People's Republic of China on Regulating Military Applications of Artificial Intelligence [中国关于规范人工智能军事应用的立场文件]', 14 Dec. 2021, <https://www.fmprc.gov.cn/web/wjb_673085/zfxxgk_674865/gknrlb/tywj/zcwj/202112/t20211214_10469511.shtml>.

73 The State Council Information Office of the People's Republic of China, 'China's Space Program: A 2021 Perspective [2021中国的航天白皮书]', 28 Jan. 2022, <http://www.scio.gov.cn/zfbps/32832/Document/1719689/1719689.htm>.

74 Chinese Ministry of Foreign Affairs, 'Remarks by Ambassador Zhang Jun at the UN Security Council Briefing on Technology and Security [常驻联合国代表张军大使在安理会技术与安全公开会上的发言]', 23 May 2022, <https://www.mfa.gov.cn/zwbd_673032/wjzs/202205/t20220523_10691538.shtml>.

75 'Xi Jinping: Improve the new national system for tackling key core technologies', [习近平: 健全关键核心技术攻关新型举国体制], 14 Sep. 2022, <http://www.dangjian.cn/shouye/dangjianyaowen/202209/t20220914_6472955.shtml>.

76 Chinese Ministry of Foreign Affairs, 'Position Paper of the People's Republic of China on Strengthening Ethical Governance of Artificial Intelligence [中国关于加强人工智能伦理治理的立场文件]', 17 Nov. 2022, <https://www.fmprc.gov.cn/web/ziliao_674904/tytj_674911/zcwj_674915/202211/t20221117_10976728.shtml>.

77 Ministry of Industry and Information Technology (MOST) of the People's Republic of China [工业和信息化部; 工信部], ''14th Five-Year' Plan for the Development of the Big Data Industry ['十四五' 大数据产业发展规划]', 30 Nov. 2021, <https://perma.cc/4NF2-FW6D>.

The European Leadership Network (ELN) is an independent, non-partisan, pan-European NGO with a network of nearly 200 past, present and future European leaders working to provide practical real-world solutions to political and security challenges.

About the authors

Fei Su
Researcher with SIPRI's China and Asia Security Programme

Dr Jingdong Yuan
Associate Professor, University of Sydney and Associate Senior Fellow, SIPRI's China and Asia Security Programme

Contact

European Leadership Network (ELN)
8 St James's Square
London, UK, SE1Y 4JU

@theELN | europeanleadershipnetwork.org

EUROPEAN LEADERSHIP NETWORK

European Leadership Network
8 St James's Square
London, SE1Y 4JU
United Kingdom

Email: secretariat@europeanleadershipnetwork.org
Tel: 0203 176 2555

Follow us

europeanleadershipnetwork.org