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Introduction

The world of emerging technologies has changed countries' access and placement to these digital enablement tools of the future, with blockchain, decentralization, and a myriad of other compounding technologies accelerating the pace of development and growth combining the physical and the digital world. Historically, America's Silicon Valley has led the world's development of new technologies, particularly during the latter part of the digital revolution. In contrast, China focused on enhancing its manufacturing capabilities, becoming a world leader by capitalizing on the ever-connected world and leveraging its economic prowess. These roles became reversed in the early-2000s,[1] when China first surpassed the United States in the output of artificial intelligence (AI)-specific scientific papers, demonstrating its commitment to becoming the world's AI superpower.

To solidify its emphasis on changing perceptions as a consumable goods manufacturer to a global leader in emerging technologies, the People's Republic of China (PRC) unveiled its "Made in China 2025" plan in May 2015.[2] Made in China 2025 aims to invest in domestic innovations across 10 industries to reduce reliance on foreign technology and enable Chinese companies to compete globally. In this respect, the PRC's plan to place emphasis on enhancing home-grown AI technologies serves as a cautiously aspirational tale of how critical public private partnerships are in terms of strategic competition. These partnerships are critical to drive innovation in AI and other fields as part of America's shift to regain the competitive advantage.

Understanding the Terminology Behind "Dual-Use Technology"

In the United States, the term "dual-use technology" has achieved significant relevance in recent history, with multiple defense and government technology startups seeking to capitalize on increasing government focus towards understanding and implementing trends in emerging technologies. However, the very notion of this word simply highlights how much the United States is falling behind in terms of innovation.

The use-case of AI presents an excellent example of how American technology innovation is falling behind its Chinese-backed peers. For one, individuals and organizations in China have continued their accelerated pace of research and development (R&D) in the AI space, with a 34.5% increase from 2019 to 2020 in research publications from China alone.[3] Currently, the PRC ranks second globally in AI firms,[4] while also being the epicenter of the most consistently filing of AI

patents in the world.[5]

In contrast, research studies into the top 50 global defense companies (of which most are American) revealed that only 11 out of 50 global defense companies even pursued AI development through company acquisition, with this number being a mere six companies from 2013 to 2020.[6] As a result, it is clear that the focus on AI R&D is a top priority for the PRC and its associated entities, while demand from the U.S. defense ecosystem remains relatively limited by comparison.

Additionally, 5G provides another data point for understanding the critical importance of dual-use technology. The DoD has attempted to try to prioritize the utilization of 5G through its 5G development strategy, most visibly through a series of efforts termed "Tranches" in 2020 and 2021.[7] More recently, the announcement of an Open Stack 5G challenge in 2022 to incentive the development of open-architecture technologies that could possibly be integrated into future military testbeds garnered further attention to the DoD's attempts to prioritize 5G.

Despite these multi-million-dollar efforts by the DoD, the fact remains that the PRC priority on 5G R&D far outspends and outpaces American development of 5G technology. China has emerged as the global leader in 5G patents, with almost 40% of all standard essential patents belonging to China.[8] In fact, over 14% of these 5G patents on a global level specifically belong to Huawei,[9] highlighting the extent that the PRC has invested into 5G R&D in past decades.

Additionally, China has also taken significant roles in leading industry organizations such as the 3rd Generation Partnership Project, a group of standards organizations developing protocols for mobile telecommunications. This type of influence on the standards side highlights the two-sided nature of dual-use technology; not only is the PRC ahead in terms of R&D and military integration, but it is also literally establishing future standards for 5G development.

This notion of how the PRC has been prioritizing R&D far before American public and private peers is something that must be understood when analyzing the role of emerging technologies in strategic competition. Whether it be AI, 5G, or even cybersecurity, the fact remains that the term "dual-use technology" itself highlights the lack of progress the United States has placed into emphasizing the development of such technologies.

AI and "Intelligentization"

In the case of technologies with military applications, the People's Liberation Army (PLA) has established its goal to become a "world-class" military capable of "intelligentization" - the PLA's concept of future warfare based emerging and disruptive technologies, particularly AI.[10] In 2017, Chairman Xi Jinping elevated the

importance of "Military Civilian Fusion" (MCF) as one of the pillars of China's military modernization and upgraded it to a national strategy, calling for a seamless synergy of efforts between the military and civilian sectors.[11]

To support this, the PLA re-organized its longstanding Academy of Military Science (AMS) in 2017 to create a critical military think tank with a focus on defense innovation to integrate disruptive technologies like AI and autonomous systems in PLA military doctrine.[12] Since the AMS' inception, the PLA has funded AI projects focusing on machine learning for strategic and tactical recommendations, as well as AI-enabled wargaming for training, in addition to social media analysis. In mid-2017, China's State Council also issued its New Generation Artificial Intelligence Develop Plan (AIDP),[13] with this highlighting the PRC emphasis on AI R&D by self-comparing Chinese technological development in the space to other governments, to the point where Chinese government AI reports regularly cite American national security think tank publications.[14] Similarly, the PRC's Ministry of Science and Technology identified 22 research tasks to dedicate approximately $85 million dollars of research to in 2020, including brain-inspired software and hardware, human-machine teaming, swarming, and decision-making,[15] further highlighting the PRC's prioritization of AI domination.

Additionally, Chairman Xi continues to widen the gap between China and the U.S.in AI innovation by creating an advantageous regulatory framework, enabling better crosscollaboration between public and private entities. As mentioned previously, in mid-2017, Xi specifically described the need to have China's "policies play a bigger role in civil-military integration."[16] Accordingly, an MCF policy document released in December 2017 called for the declassification of National Defense Patents for the civilian sector's use and to combine military and civilian research centers, to include facilities at the China Academy of Sciences and universities.[17]

To demonstrate further alignment with MCF, the PRC has designated fifteen different companies as official "AI Champions."[18] These companies include global technology firms Hikvision, Huawei, SenseTime, and Tencent, with each of these companies possessing "core technologies" necessary to overtake the U.S. in AI. The "AI Champion" designation results in that company being deemed responsible for a specific AI focus, with some of these projects including autonomous vehicles, smart cities, and cybersecurity. The assured crossover of AI technologies for military applications is also inevitable, given the already deep ties between the PRC and companies like Hikvision and Huawei. Hikvision is a current critical hardware equipment supplier to the People's Liberation Army Air Force (PLAAF),[19] while a recent employment records study showed significant crossover in key mid-level personnel who have worked at both Huawei and Chinese military and intelligence organizations,[20] sometimes on a simultaneous basis. This type of advantageous capacity to leverage innovation in both civil and military domains has and will

continue to benefit the PRC as it develops its concept of intelligentization.

In contrast, former Air Force Chief Software Officer Nicolas Chaillan has commented how America has "no competing fighting chance against China in 15 to 20 years,"[21] indicating a significant lag in current American-based AI development when compared to China's capabilities. While not necessarily a concrete statement indicative of the holistic development of AI and technological R&D in general, the lack of successful partnerships between U.S.-based civil and military authorities can also be seen through the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs. The SBIR/STTR programs are meant to help fund small business conducting R&D, with the DoD being the largest agency participating in these programs. However, shockingly enough, over half of companies that receive SBIR/STTR funding to commercialize the technology that they have proposed for government use do not receive any institutional venture capital (VC) funding. In fact, while the SBIR/STTR programs inserted money into over 7,000 companies in 2020, only 3,400 of these companies received institutional VC funding during the same period.[22] This discrepancy between what the American government believes to be potential useful technologies and what business believe to have actual possibilities for commercialization (and subsequently, profits), reinforces Chaillan's point about how America has lost a "competing fighting chance" against China in terms of technological development and implementation.

The PRC has clearly been able to leverage both military and civilian organizations to further enhance its development of AI technologies. In contrast, American initiatives are struggling to find a balance between innovation, navigating within government bureaucracy, and commercialization, presenting significant obstacles to challenging China's newfound dominance in AI.

AI in Application: Understanding AI Integration into C4ISR Systems

The PRC's lead in front of the United States in terms of AI R&D is important to understand on both a strategic and a tactical basis. At a high level, the PLA's main strategy on the battlefield is to disrupt its enemy's C4ISR systems,[23] with the PLA placing a significant emphasis on controlling information technology (IT) networks, which AI can play a part in supporting, as part of its battlefield strategy. In a potential conflict against the American military, the PLA is focused on developing AI technology that targets the American Department of Defense's (DoD) expanded maneuver concept,[24] specifically the ability for American forces to execute successful command and control. These efforts began as early as in 2015,[25] with the PLA establishing its Strategic Support Force (PLASSF) to centralize "space, cyber, electronic warfare, and psychological warfare missions under a single organization," with the PLASSF reportedly pursuing cognitive electronic warfare,[26] demonstrating a true integration between C4ISR systems and AI.

Ultimately, PLA efforts are doctrinally and strategically aimed at disrupting the U.S. military's ability to communicate and fight effectively. While information advantage is a functional battle area of expanded maneuver, Chinese electronic warfare doctrine from as early as 2011 goes as far as to compare the American military's battlefield information networks to the human nervous system,[27] stating "Once the 'tendons and veins' or 'blood vessels' are cut off, people will be paralyzed or even killed", and that data integrity is the "the Achilles' heel" of joint forces.[28] This emphasis on development of C4ISR tools, to include the integration of AI into said applications, highlights the advanced nature of AI development within the PLA-at-large.

At the tactical level, Chinese state-run news media reported that the PLAAF were using simulators to stage dogfights against AI aircrafts in mid-2021.[29] This integration of AI into this type of C4ISR-based training highlights just how advanced the PRC's AI capabilities have become. In this case, each training iteration, regardless of outcome, gathers valuable data on human decision-making and a pilot's habits. The AI opponent learns from each engagement and applies its lessons learned to the following iterations to introduce new stress to the human pilots. Other information also reveals that the PLAAF uses AI not only in C4ISR-enabled training, but also in direct integration of AI technology into aircrafts to assist pilots in combat by calculating the best tactical options in real time.

In fact, the PLAAF's AI capabilities are sufficiently advanced that reports have highlighted how this AI opponent has been able to down several PLA pilots in several exercises taking place over the past several years.[30] This demonstrated capability is worrisome as a use-case for how the PRC is integrating AI into its C4ISR applications and beyond, with the implication of significant technology transfer between public and private entities being the result of years-long cooperation efforts to enable such Ai development in technologies like these and undoubtedly in others.

The United States has also recognized the importance of AI integration into its C4ISR capabilities but has not achieved the volume and scale of implementation that the PRC has achieved so far. At a strategic level, the Joint Artificial Intelligence Center (JAIC) was established only in 2018,[31] highlighting the later-stage approach and delayed priority that AI has had in the government, with AI only recently being a relative focus for leaders within the DoD. In fact, the JAIC itself ceased to exist in 2022, with the JAIC being subsumed into yet another organization, with this organization being termed the Office of the Chief Digital and Artificial Intelligence Officer.[32] This notion is reinforced by the emphasis on AI in the unclassified version of America's National Defense Strategy in 2018,[33] with previous reports in 2015 making no mention of the development of AI capabilities as part of a holistic strategy to maintain American power.

At the tactical level, the Defense Advanced Research Projects Agency (DARPA) has taken an approach akin to China's overall emphasis on AI, leaning forward in its development of a system known as the Air Combat Evolution (ACE) program, a human-machine collaborative dogfighter system that uses AI to create problems of increasing realism. In August 2020, the Johns Hopkins Applied Physics Laboratory (APL) executed the AE program's AlphaDogfight trials.[34] Broadcasted live, eight teams developed AI 'pilots' to fly F-16 fighter jets in simulated dogfights. The winning team then flew a series of five simulated dogfights against an experienced F-16 fighter pilot in a simulator, beating the human pilot 5-0.

While individual government agencies may have taken an interest in AI early-on, the fact remains that overall American governmental emphasis on AI has only occurred in recent years. This lack of emphasis on development into systems like C4ISR that are so critical to military functionality is particularly alarming from the viewpoint of the American military, particularly considering the advanced stance that China has developed throughout the past decade.

What's Next on the Horizon: AI and 5G

Advances in AI will only become more important given the implementation of Web 3.0 in the immediate future. The inevitable interconnected nature of different emergent technologies is just one way that Web 3.0 will change the world, with ties between AI and 5G becoming increasingly critical to civilian and military organizations alike. A report released by the American National Security Council on AI (NSCAI) in April 2020 specifically stated that "is a national security imperative for the U.S. military to have access to a powerful 5G network to enable future AI capabilities."[35] Ensuring the American lead in 5G R&D will be critical for a myriad of different applications, to include communication, cyberweapons, and cybersecurity.

Development of 5G in the United States requires a multi-disciplinary approach to compete with the PRC, specifically due to the significant investments that the PRC has already made in terms of 5G R&D and implementation through its involvement in supporting companies like Huawei in their bids for different 5G implementation contracts throughout the world.[36] However, America has two unique opportunities that enable it with the chance to regain the technological advantage in this space, to include leveraging 5G to provide clarity in the confusing world of DoD technology, as well as leveraging international relationships in 5G specific R&D.

Specifically, 5G provides the America military with a unique opportunity to integrate its fragmented network into a singular network, as referenced in an April 2019 report developed by the Defense Innovation Board.[37] In December 2021, the DoD began Tranche 2 of its 5G testing and implementation, testing specific 5G use-cases in the manufacturing, logistics, satellite communications, and surveillance

realms.[38] Additionally, the United States has dedicated over $90M in separate funding to support 5G prototyping of different military-specific capabilities,[39] with this highlighting the DoD's seriousness in ensuring competitiveness on the 5G front. This opportunity to utilize 5G to focus American spending, resources, and willpower will be critical for America to leverage in the immediate future. Utilizing 5G as a unifying force on an institutional level and between different everyday applications like IT will enable the DoD to provide increasing focus to developing this technology.

Capitalizing on America's relationships with other countries could also help the U.S. gain the lead in 5G R&D. One example can be seen through Samsung, one of the world's largest developers of both 5G and AI technologies. Samsung announced plans in November 2021 to build a semiconductor plant worth over $17 billion dollars in Texas,[40] highlighting the close relationship between America and its Korean counterparts. Additionally, previously in October 2020, Samsung announced its participation in a 5G test bed for augmented and virtual reality capabilities at Joint Base Lewis-McChord in Washington state.[41] These types of bilateral efforts aimed at cooperation spanning both public and private enterprises are essential for America to identify, and leverage should it wish to regain the advantage in 5G, and subsequently, other technologies. It will be critical for America to continually leverage relationships like its connections with Samsung to ensure competitive American R&D in 5G technologies while enabling America to catch-up with the PRC in terms of AI growth. Bridging the gap between public and private organizations and between American and international entities will help to jumpstart American R&D competitiveness to compete with actors like the PRC.

Conclusion

In short, America may be losing its technological advantage in some aspects of AI R&D due to better PRC coordination of military-civil fusion strategies, harnessing the capabilities of both civilian and military to develop AI technologies. The case of AI R&D is a cautionary tale for the American government in its shift of focus to prioritize emerging technologies. This provides regulators and military personnel alike with a framework to showcase how complacency in technological development can lead to the loss of competitive advantages.

However, 5G offers an interesting option that America can leverage to regain its power in understanding and utilizing technology. While the PRC has already made significant investments in support of 5G development, America's capacity to work internationally with foreign partners, as well as its utilization of 5G as a unifying factor for use-cases such as communications, creates a distinct chance for America to rapidly shift its focus from fighting tactical-level conflicts to truly maintaining relevance in the realm of strategic competition.

America's unique governance structure, in contrast to China and Russia, creates a culture of self-imposed limitations and restrictions when integrating technologies for military applications, as seen with the example of AI and C4ISR systems. However, with increased capabilities to work jointly and with better enablement of public-private partnerships, America can regain the technological competitive advantage to truly make a difference in the next stages of strategic competition.

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It is important to note that at the time of writing this article, ChatGPT was still unknown to the larger public.

Notes

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