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ARTIFICIAL INTELLIGENCE
A CASE FOR UNCONSTRAINED EXPERIMENTATION

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ABSTRACT

Technological advances generating vast improvements in computer processing power, data storage capacity, and digital interconnectivity have raised the specter of an artificial intelligence (AI) arms race. AI has progressed from scientific and popular culture curiosity to direct military application. China and Russia have recently outlined long-term strategies or invested in research with the intent of surpassing the United States in the field within the coming decade. As with past military innovation, maintaining superiority in both the capability and its application is critical to continued U.S. military and strategic dominance. Though the U.S. has lagged behind key competitors in advancing a comprehensive development strategy, recent efforts to do so offer a window of opportunity to maintain the country's lead in applied military use of artificial intelligence. Maintaining that lead in the U.S. Army requires an effort that bridges the boundaries between developers, experimentation, and the practitioners who will employ the technology. Past experience in applying emerging technology, like the Army's General Headquarters Maneuvers in 1941, offer lessons the Army can leverage.

"Artificial intelligence is the future ... for all humankind. It comes with colossal opportunities, but also threats that are difficult to predict. Whoever becomes the leader in this sphere will become the ruler of the world"

–Russian President Vladimir Putin[1]

Artificial intelligence (AI) will change the cognitive dimensions of land warfare to the same degree that mechanization changed its physical dimensions. A recent report by the Center for Strategic and International Studies goes further, suggesting the technology "has profound potential to affect the balance of power in…military competition."[2] Bolstering this assertion are the establishment of AI centers by the Department of Defense (DoD) and U.S. Army,[3] limited application of advanced AI in a combat environment,[4] and China's redoubled efforts to surpass the U.S. in AI development to achieve military overmatch.[5] Ominously, some leading scholars in the field, including Professor Michael Horowitz, suggest that based on current efforts, the U.S. military could lose both its military superiority and technological dominance based on other countries' advances in the field of AI.[6] Within the U.S. military branches, the risk of ceding military dominance is highest for the Army, with its focus on people rather than technology.[7]

AI is not just another potential weapons system. The U.S. Army's ability to effectively integrate the technology pursuant to maintaining its status as the dominant global land force demands a broader approach than traditional experimentation and acquisition processes afford. Four factors will drive success: understanding what AI is and is not from a military standpoint, understanding where global competitors' strengths and weaknesses are in their pursuit of military AI, accurately mitigating barriers to incorporating AI into military systems, and selecting an effective method of military innovation in integrating AI into Army systems and processes. This paper will examine what AI is and why it is militarily relevant now, potential competitors' efforts to incorporate AI in their own armies, barriers to effective integration of AI into military systems, and refinements the U.S. Army must make to its AI strategy to maintain its competitive advantage.

1 Military Relevance: Applications, Timing, and the Competition

Two very important extrinsic factors governing the potential impact of technology on military innovation are whether the technology is developed enough to provide military benefit and how competitors are using the technology. Understanding the potential of applied artificial intelligence for the U.S. Army requires understanding what artificial intelligence is and what it is not. Equally important is establishing why the U.S. Army should care about AI now rather than a decade from now. Finally, any military is only weak or strong relative to potential competitors - how armies employ equivalent technologies to offset one another's strengths and weaknesses has proven determinant on past battlefields.

1.1 Military Applications of AI

The U.S. government codified a basic definition of AI in 2019 legislation as any artificial system that acts or exercises human-like cognitive ability.[8] Most scholars who address AI divide the technology into two general categories - narrow and general. Narrow AI aptly executes narrow tasks, and cannot broaden the capability to execute other tasks, while general AI could theoretically apply lessons from one task to another much as humans do.[9] This paper will exclusively address the former as general AI won't be developed anytime in the near future, if at all.[10]

For military purposes, narrow AI further subdivides into two additional categories: lethal and enabling. Lethal systems, formally labeled "Lethal Autonomous Weapons Systems" (LAWS) by the DoD are systems "that, once activated, can select and engage targets without further intervention by a human operator."[11] The DoD currently prohibits development or employment of LAWS.[12] Though not addressed in most literature on AI, autonomous enabling systems are those with military application not designed to engage targets or apply force.

The distinction between lethal and enabling is useful in two respects. Though policy will inhibit experimentation with LAWS, it should not impact experimentation with enabling systems simply because they share the descriptor 'autonomous.' Second, though precluded from employing LAWS, the U.S. Army must replicate adversaries with such systems during experimentation and training to determine their impact on U.S. doctrine and actions. Examples of the two categories afford perspective on the distinctions between them, as well as the wide range of application of AI for the Army.

Lethal AI-based systems have existed in arms inventories for decades, usually for use in defensive circumstances. Naval and land-based automated mortar and missile defense systems are one example. These weapons are autonomous insofar as they are programmed to react to threats that occur faster than a human could react, but are overseen by an operator, who can override the system's use of kinetic force against an incoming threat.[13] The requirement for human oversight is a policy constraint, not a technology constraint.

Enabling systems are simply AI applications designed for or usable by the military that lack the capability to apply lethal force. An example of an enabling system is an autonomous logistics transport vehicle which would follow manned vehicles, such as those the U.S. Army intends to field in 2019.[14] Another example is Project Maven, a Department of Defense AI program currently active in combat theaters of operation. This system performs analysis of extremely large amounts of video footage to facilitate lethal targeting of adversaries.[15] Most current AI developments applied by the military are enabling, designed to improve logistics, intelligence, command and control, and other management functions.

1.2 Timing Matters: The Current State of Applied AI

Shortly after the turn of the 19th century, developments stemming from the industrial revolution including mechanization allowed humans to move more and larger things faster.[16] Military research yielded weapons that could similarly complete physical tasks better, faster, or more efficiently than humans or animals. AI presents the same opportunities in the cognitive domain. Any military task that a human must think to accomplish has the potential for augmentation by AI.[17] Furthermore, while mechanized vehicles replaced their animal forerunners, AI has the potential to augment both people and the machines they use.

Though AI research and application for military purposes is not new, recent events have reinvigorated private and public efforts to advance the science. Two complementary developments, increases in computing power and availability of vast quantities of data fueled breakthroughs in the study of AI.[18] Beginning around 2010, the current 'season' of AI research is yielding advancess exceeding the expectations of even the most optimistic forecasters.[19] Coinciding with the recent resurgence of AI research are the U.S. Army's efforts to reform its acquisition and technology incorporation processes.[20] Just as the confluence of advances in machines fueled the military developments that wrought such destruction in the World Wars of the 20th century, advances in AI could enable the military revolutions of the early 21st century.

In the mid-1990's, Williamson Murray and Allan R. Millett produced an influential work on military innovation between World Wars I and II. They analogize the strategic environment of the immediate post-Cold War period to the timeframe following World War I, specifically highlighting that "military institutions had to come to grips with enormous technological and tactical innovation during a period of minimal funding and low resource support."[21] Mass employment of the military byproducts of the industrial revolution began in World War I, evolved during the Interwar period, and matured in World War II. The roots of those technologies stemmed back as far as the mid-19th century. Likewise, AI research begun in the mid-20th century was first employed at scale by militaries, specifically the U.S. military during the Gulf War in 1991, in the waning days of the Cold War.

1.3 State of the Competition

The parallels between the present day and the period between World Wars I and II also include a race between potential competitors to achieve breakthroughs employing that technology to gain a competitive advantage. China and Russia are presently of interest to the United States because both have made public statements and taken actions at the highest levels of government pursuant to achieving superiority in the field of AI. Both were also identified as seeking to challenge U.S. influence more broadly in the 2017 National Security

Strategy.[22] Understanding how these and other countries are pursuing military advances in AI will allow the U.S. Army to seek asymmetric advances of its own.

China

China published its "A Next Generation AI Development Plan" in 2017 with the stated goal of leading the world in the field by 2030.[23] Members of the U.S. House of Representatives see this as a globally disruptive threat and warned that loss of U.S. leadership in the field will have broad implications, including military ones.[24] China clearly sees research and development in the field as competitive, stating up front in the Development Plan that it seeks "first-mover advantage in the development of AI."[25] Pursuant to this goal, the Chinese government committed to developing a $150 billion AI industry by 2030.[26]

While the majority of the Chinese AI Development Plan discusses civilian use of AI to improve the lives of its citizens, it also explicitly references military uses. Emphasizing civilian-military research burden sharing, the document highlights specific military development goals including "...strong support to command and decision-making, military deduction, defense equipment, and other applications."[27] More importantly, China maintains an advantage in one of the areas that underpins recent advances in AI - big data.

Unlike most Western democracies that have established laws protecting the privacy of their citizens, China is not limited in its ability to collect data on its extremely large population. Chinese police maintain a cloud-based repository of information tied to AI-based facial recognition software and public safety monitoring devices like traffic cameras to apprehend criminals among other applications.[28] Similar systems could easily be put to military use in much the same way Project Maven is employed. China's ability to leverage data collected on its 1.3 billion citizens to train narrow AI systems provides a distinct advantage.[29]

Large data sets are critical for contemporary AI advances because recent progress has been in machine learning. Defined simply, machine learning entails providing an AI system with data to practice and identify trends that it can then apply to any future data.[30] Western societies are largely constrained by privacy legislation, smaller populations, and less government control of what data is available. China's lack of those constraints provides an advantage in dual-use AI research and development.

China's commitment to advances in AI are not paper deep, and its focus extends beyond internal control of its population. Recent examples of developments with clear military application include a Chinese start-up besting its competitors in a U.S. intelligence community run competition in facial recognition software in 2017.[31] Other explicitly military developments include the demonstration of AI-enabled unmanned aerial vehicle swarms and AI war gaming.[32] Though the Chinese government is opaque about its spending, the AI push has presumably spurred recent increases in provincial and local government AI research or research incentives, as well.[33]

One significant characteristic of the Chinese military that may allow more freedom to innovate with AI is its lack of recent combat experience.[34] Stephen Rosen notes that, "the lack of precedent makes wartime innovation risky, and with the risk often comes a justified aversion."[35] In other words, combat experience can make a military reluctant to innovate because the cost of failure can be perceived as extremely high. Though unburdened by risk-aversion inherent to participation in active or recent conflict, the Chinese military has been able to observe both U.S. and Russian experimentation in conflict over the past twenty to twenty-five years. Holistically, the combination of a national AI plan with emphasis on civil-military collaboration, significant funding, and limited risk aversion benefit the Chinese military.

Russia

Russia is also seeking to produce a national plan for AI development, and will presumably benefit from advantages similar to China's given Russia's propensity for civil-military cooperation and national level direction of key military research and development programs.[36] In 2017, Russian President Vladimir Putin boldly stated that, "the future belongs to artificial intelligence"[37] providing clear indication of direction from the top. Though Russia does not possess the same level of capital or human resources that China does to pursue emerging technology, it nonetheless remains an aspirant in the field.

Russia's planned investments in AI research and development are in the hundreds of millions, rather than billions, of dollars, but still driven by a focused government plan.[38] In November 2018, the Russian Ministry of Defense held a robotics competition for students as part of a broader effort to nurture a base of expertise in emerging technologies.[39] Government run efforts also include establishment of a defense research agency focused on autonomy, investments in foreign AI markets, and recurrent conferences on increasing the quantity of automated systems in the Russian armed forces.[40]

In contrast to China's focus on dual-use technologies, most reports of Russia's AI research and development detail military uses. Given recent adventurism by Russia in the realm of political warfare, and the potential utility of AI in creating credible propaganda for foreign consumption or facilitating cyber-attacks, Russia's focused use of AI could prove more effective than China's broader efforts.[41] Russian interference in the 2016 U.S. presidential elections leveraging social media platforms could be amplified in the future using realistically forged video footage of election candidates.[42] More ominously, forged video footage combined with cyber-intrusions of an adversary's network could fool military analysts. Beyond non-kinetic uses of AI, Russia is deliberately investing in all manner of unmanned vehicles which can easily be armed to operate as LAWS.[43]

Other Significant State Actors

The most significant competitors in this burgeoning field are China and Russia, but they are not the only countries investing in AI. The prevalence of AI in the commercial sector and low cost of replication once developed favor smaller nations not normally grouped with larger military powers.[44] The technology has the potential to supplant more traditional measures of military power - size, population, industrial productivity - with innovation. Three U.S. allies, serving as proxies for potential future 'small-nation' competitors, exemplify the potential for AI to upend standard measures of power.

Israel and Singapore stand out as unlikely innovators who could nonetheless have a strategic impact with breakthroughs in AI research.[45] Both have unique incentive to innovate - Israel due to its precarious position in its region, Singapore both due to the presence of an expanding China and the economic benefits of exporting AI developments. South Korea's investment in AI also deserves mention. The country committed to investing just short of $1 billion in AI research in 2016, a figure that would equal U.S. investment the previous year.[46] Though these nations are not currently U.S. military competitors, the example they set or replication of their AI advances could spur less well-intentioned actors to compete with Western counterparts.

2 Barriers to Successful Adoption

Understanding the technology and competitors' efforts to achieve distinct military advantage using AI should lead any military leader or policymaker to conclude that emphasis on U.S. programs is desirable. Unfortunately, there are significant obstacles to U.S. efforts to maintain its current lead in the field. Innovation is inhibited by: 1) technical constraints inherent to AI in its current state, 2) civil-military cooperation barriers unique to the U.S., 3) and the risk of accepting the status quo borne by any organization in the position of 'industry leader.'

2.1 Technical Challenges Inherent to AI

Unlike past military technological innovations, the behavior of an AI system is not easy to forecast. A tank or a submarine will either function or not - the degree to which it represents disruptive innovation is determined by how a human employs it. Like the human cognitive functions it is designed to augment or replace, AI may behave in unforeseen ways. The three primary drivers of uncertainty inherent to AI in its current state of development are 'brittleness,' 'predictability,' and 'explainability.'

Brittleness is the lack of understanding of the environment outside of the narrow parameters a system was programmed for.[47] In a military context, characterized by Clausewitz's fog of war, inability to adapt to changes in the environment is a critical vulnerability. Citing the challenges militaries inherently have with simulating war, Michael Horowitz notes that AI systems could "be biased, and potentially in a way that militaries do not discover until combat. The fog and friction of real war mean that there are a number of situations in any battle that it would be difficult to train an AI to anticipate. Thus, in an actual battle, there could be significant risk of an error."[48] The AI system is only as good as the data it is provided. War, historically characterized by fragmented data or none at all, would present a poor environment to 'test' training data.

Predictability, or lack thereof, derives from the nature of most narrow AI systems which operate based on past experiential learning. Once programmed, their future behavior may be unpredictable even to the designer.[49] Paul Scharre cites stock market crashes in 2010 and 2012 resulting from AI-driven automated trading, and a friendly fire incident in Iraq in 2003 attributed to an automated air defense system as exemplary of systems behaving in ways not accounted for in their initial design.[50] The systems 'learn' differently than humans making it more difficult to predict outcomes because an AI system's frame of reference is inhuman. Biased training data could also impact a system's predictability, skewing future behavior in ways unanticipated during the learning phases.

Finally, explainability is the characteristic of AI that makes it difficult to understand or audit how a system came to the conclusion it did.[51] Amusing examples include misidentification of curtains or cats in images that a programmer cannot explain,[52] but it is a short leap of logic to imagine how a system could misidentify a noncombatant. Furthermore, people generally trust one another because they believe others' actions are explainable in a manner they can relate to. Not being able to explain why an AI system takes certain actions may yield reluctance to use the system.[53] Finally, most legal regimes, including International Humanitarian Law, rely on understanding how a person arrived at a conclusion in determining culpability, creating further problems beyond humorous misidentification.

2.2 Societal Obstacles

In addition to the technical challenges inherent to AI, the U.S. Army faces a relatively novel obstacle that distinguishes AI from past military-technical advances. Varying from historic trends, most AI research and development in the U.S. is conducted in the civilian sector.[54] While many AI applications may be dual-use, the Army will inevitably require systems without civilian parallels. Exacerbating this potential problem is ongoing discord between the U.S. civilian digital technology sector and government national security enterprise.[55] Aside from not having a robust, dedicated research capability, the military might find itself in the position of paying significantly higher costs to convert civilian technology to military use than if the systems were developed for military use from the outset.

2.3 The Danger of the Status Quo

For all of the benefits military dominance affords the U.S., it generates a significant liability - leaders in any field have little incentive to seek means to disrupt the status quo.[56] Furthermore, British experience during the decades between the two World Wars suggest that being a technology leader, or first-mover, doesn't confer significant advantage.[57] Like cellular phone manufacturers prior to the advent of Apple's iPhone, there is limited drive to innovate when the organization is not facing a significant challenge. In contemporary military parlance, the U.S. Army has few reasons to seek asymmetric means of besting potential opponents it already surpasses with existing capabilities.

This preference for the status quo yields two distinct problems. The first, and more obvious, is that a leader in a field is less likely than a competitor to seek radically new ways to employ emerging technology. The second, and perhaps more dangerous implication, is that a leader in a field is less likely to realize ways they might be disrupted.[58] Prior to World War II, the US Army found itself on the opposite side of this problem and had to pursue disruptive innovation in the face of its eventual opponents' perceived superiority, offering a historic window into possible solutions.

3 Models of Innovation

Disruptive innovation - gaining an unanticipated and unfair advantage over one's opponent - is a goal for every Army. Stephen Rosen, in *Winning the Next War: Innovation and the Modern Military*, asserts that "peacetime military innovation occurs when respected senior military officers formulate a strategy for innovation, which has both intellectual and organizational components."[59] Producing a broad strategy and adjusting the organization incrementally as means of employing the technology evolve is the general approach the Army takes to innovation, informed by historic U.S. military experience.

Rosen provides the example of U.S. development of aircraft carrier task forces and doctrine as exemplary of this model, highlighting elevation of a supportive officer without aviation experience and his role in changing the way the Navy managed its officer leadership.[60] A contemporary example of adopting organizational change to drive military technological advances would be adjustments to U.S. officer management policy made in 2019 legislation allowing the services greater latitude to laterally assess senior personnel with cyber expertise.[61] This model hinges on a specific new system, rather than more general technology like AI. Unlike a tank, cannon, or ship, AI is not a single piece of hardware and will continue to challenge theorists and practitioners imagining applications for revolutionizing military operations.[62]

3.1 The Challenge of Omni-Use Technologies[63]

With individual piece of military hardware, applying existing innovation strategies is relatively simple. If elevating the importance of pilots to advance experimentation with naval aircraft drove doctrinal innovation for the U.S. Navy in the past, another service could assume that adopting a similar strategy with new hardware would work in the future. Past strategies have limited relevance when the new technology could augment almost any existing military hardware, as well as hardware not yet imagined. Michael Horowitz describes AI as operating on several dimensions: directing existing or emerging military systems without human oversight, to help analyze information and predict outcomes, and to augment or supplant existing battle management systems.[64] Developing a means to understand the interaction of AI-enabled systems across these dimensions with each other and existing human-operated platforms will inform the ultimate strategy the Army pursues to innovate with AI. The ultimate path to innovation will be more cyclic than linear. Determining how to inform recurrent reevaluation of the Army's AI innovation strategy presents a novel and significant challenge.

4 Informed by History: A Case for Less Constrained Experimentation

None of the challenges are lost on the U.S. Army. Both the establishment of the Artificial Intelligence Task Force at Carnegie Mellon University and activation of Army Futures Command are recognition that the pace of technological development demands new methods of both innovation and integration of systems into the force. The service has published a Robotic and Autonomous Systems Strategy, and has also shown willingness to rapidly field autonomous systems and query soldiers on what problems future systems could address.[65] Complementing the published strategy is a more recent white paper which outlines the Army's plan to operationalize its strategy.[66] These steps are positive, but not sufficient.

The combination of rapid technological development oriented primarily on civilian applications, and the inherent fallibility of AI systems and reliance on data, demand that the Army look beyond the application of systems in benign or controlled environments and attempt to replicate the chaos of war in early testing and evaluation of emerging AI techniques and technology. Even relatively mundane applications of AI, such as enabling predictive maintenance on vehicles based on built-in sensors, could fail when introduced to a combat environment - what would a system developed for civilian application conclude based on penetration of an engine compartment by projectile fragments?

The problem of unintended consequences or failure to account for the exigencies of actual combat when acquiring new equipment is not unique to AI, but is more consequential given the potential ubiquity of AI. Recent analysis of failures in Army acquisition programs highlight that gathering expert opinions to drive requirements for future systems skips a crucial step to successfully innovating - testing, refining, and validating the initial hypotheses.[67] The recommendations that follow would enable experimentation, feedback from end users, and hypothesis testing.

A comprehensive service approach to innovating with AI should include: 1) better use of large-scale wargames to determine potential disruptive uses of AI both by and to the U.S. Army; 2) the involvement of officers from non-technical specialties earlier in the process; and 3) a means, rather than just intent or cooperation, for collaboration with civilian research organizations that specialize in AI, including colleges and universities. These steps would reveal previously unimagined uses of AI in a military setting; illuminate disruptive uses of AI-enabled systems that competitors might employ; and overcome the technical, societal, and organizational barriers to successful innovation.

4.1 Experimenting in Unconstrained Environments

The first recommendation Greg Allen and Taniel Chan provide in *Artificial Intelligence and National Security* is that the "Department of Defense should fund war-gaming and red-team creative thinking exercises designed to identify how advances in AI might lead to disruptive military innovations that will threat U.S. military advantages."[68] The Department of Defense and U.S. Army are certainly doing so in a variety of ways, largely in simulations, but the recommendation does not go far enough. The U.S. Army should implement periodic large scale, non-virtual war-games and exercises utilizing current AI enabled technologies or replicating emergent ones to determine how bottom-up employment of the technology changes any top-down approach to the innovation strategy. Diverging from current practice, the Army should make these large, live exercises as unconstrained by context - replication of specific regions, enemy tactics, and so on - as possible.

An oft-repeated lesson the great powers learned during World War I was that 100 years of rapid technological advances combined with lack of peer-nation conflict yielded few tactical lessons to inform the development of military plans.[69] The failures of World War I led the future combatants of World War II to experiment with emerging technologies in the subsequent decades. One of the defining characteristics of those experiments was that they were unconstrained in a manner that would seem foreign to contemporary Army soldiers whose wargames have rule books and scenarios as lengthy as the doctrinal manuals they're meant to be following. The latter are extremely beneficial in providing a framework within which to exercise existing hardware and tactics, but stifle some of the free-thinking required to develop new methods with new technologies.

In preparing for entry into World War II, the U.S. Army engaged in multiple large-scale training exercises that informed how the branch organized itself and employed mechanized technologies. These wargames, known as the 'Louisiana Maneuvers,' were the culminating events of a phased training regimen meant to validate mobilized units. A former Army Chief of Military History noted that these maneuvers "exercised an incalculable influence on the development of American force structure in World War II…[serving] to test emerging assumptions about doctrine, organization, and equipment."[70]

The Louisiana Maneuvers offer a useful paradigm for contemporary experimentation with AI not for their original intended outcomes, but for the incidental outcomes they yielded. First, the unconstrained experimentation had significant impacts on broad doctrinal thinking at senior levels in the Army. One salient example was the debate on the relative efficacy of offensive armored vehicles - tanks - and platforms designed to defeat enemy armored operations - antitank guns.[71] A second relevant example was the lack of agreement on whether or not an air force would be better utilized in direct support of ground elements or as a separate military capability employed against targets ground forces could not effect.[72] A contemporary analogy might be disagreement over whether to dedicate resources to AI designed to augment offensive capabilities or AI designed to protect against enemy intrusion into U.S. networks. Similarly, were AI to enable ground forces to overcome the historic resource constraint of enough pilots and aircraft to support both ground targeting and strategic air operations, it could stimulate renewed thinking on the relative value of dividing Air Force resources accordingly.

The Louisiana Maneuvers also resulted in Army leaders establishing new occupational fields and organizations based on innovative techniques used by subordinate leaders during the maneuvers. Prior to 1941, there was little consensus among Army officers on the organizational impact of mechanization.[73] Following the maneuvers, the Army created a new occupational specialty that would effectively own mechanized doctrine, ensuring that the platforms based on the evolving technology would have bureaucratic proponents.[74] Addressing organizational deficiencies identified during the exercise, the Army reorganized its armored formations both during and after the maneuvers.[75] As AI evolves, particularly human-machine teaming, large unconstrained exercises could highlight similar challenges and enable analogous organizational adjustments to compensate. These two outcomes represent the intellectual and organizational pillars of peacetime military innovation that Stephen Rosen argues are necessary for success on future battlefields.

More broadly, the Louisiana Maneuvers demonstrated that senior leader expectations do not necessarily match potential employment of the new technology by end users, which in turn effects how those senior leaders plan and organize for combat operations. Prior to World War II, this realization certainly influenced whether the U.S. Army would privilege tanks or tank-destroyers. Both the pre-World War II German Army and U.S. Navy, in advancing mechanized and carrier warfare respectively, were also notable for the open-ended nature of the exercises conducted prior to the war and impact that experimentation had on wartime outcomes.[76]

Periodic large scale exercises would enable determination of the second and third order impacts AI will have on the modern battlefield. The authors of a Center for New American Security monograph on *Strategic*

Competition in an Era of Artificial Intelligence stipulate that "figuring out how to use a technology" will be more important than developing the technology first.[77] The benefit of live experimentation over simulations is the ability to see how leaders and soldiers down to the lowest level react to and incorporate the new capabilities, both laterally and vertically.[78] These wargames would not supplant existing training architecture or exercises, but complement them.

Replicating AI technology that does not yet exist would enable validation of assumptions about the potential for human-machine collaboration. While replicating a capability may not allow the Army to understand how that AI would actually perform, it would allow the organization to determine whether pursuing particular categories was tactically beneficial or not. The exercise could also demonstrate where the technical shortcomings of AI - brittleness, explainability, and predictability - would generate significant risks. To date, the Army is speculating based on past experience.

In addition to offering a means to experiment with AI employment, large exercises would simulate the confusion and chaos of real battles. Given the technical challenges of brittleness, predictability, and explainability, it is imperative to test AI-enabled systems in environments that approach the level of chaos actual battles entail. Combat involves more than just two competitors. It is an ecosystem of systems where changing one variable has unforeseen impact on other variables. Finally, large-scale live testing would signal to internal and external audiences areas where the Army intends to focus AI development. Live wargames offer a vehicle to subtly incentivize both young leaders and civilian entities to generate new ideas for incorporating AI into Army systems and operations.

4.2 Incorporating the Stakeholders into the Process

Young Army leaders provide perspective neither technical experts nor more senior officers can. Familiar with the complexities of battle and comfortable with basic AI systems present in the civilian sector, they serve as a bridge. Former Deputy Secretary of Defense Bob Work said in a 2015 speech that, "...in this case, in this offset, the young officers who have grown up in this "iCombat" world, they're going to have ideas that our senior officers simply will not be able to make, to connect."[79] Where past technologies have migrated from government laboratories to the civilian world, AI moves in the opposite direction.

Additionally, unlike investment choices the military faced between the World Wars, choices in the field of AI are not binary - contemporary leaders cannot chose between the tank or tank-destroyer, or the battleship or aircraft carrier. While past senior leaders may have been able to overcome cultural bias to adopt new technology, they could see and touch the new technology being considered. Even as AI evolves and becomes a part of physical systems, potential employment options will vary far more than previous technological advances which simply augmented human physical capabilities. Informing Army investments in specific applications demands ideas unconstrained by years of service and ingrained bias.

Outside of immediate benefits of involving personnel in the innovation process that are more familiar with emerging technologies, advancing those same young leaders ensures that new ways of prosecuting war endure over time.[80] The young Army Air Corps and Navy pilots of the early 1940s became the leaders of the U.S. Air Force and commanders of Aircraft Carrier Battlegroups in subsequent decades. Their formative experiences as participants in the innovation process guaranteed that the techniques they developed would be enshrined in service doctrine.

4.3 Facilitating Greater Civil-Military Cooperation

With most AI research in the U.S. occurring in the civilian sector, private technology companies represent the other major stakeholder impacting innovation in the field. Unfortunately, U.S. technology companies have a strained relationship, at best, with the DoD. An open letter that thousands of Google employees endorsed encouraging their CEO to cease contributions in Project Maven in early 2018 is the most high-profile example of this discord, though ethical opposition isn't the only barrier to cooperation.[81] Regardless of the source of the divide, the Army must bridge it in order to sustain their advantage over near peer competitors.

Though non-defense industry civilian corporations involved in AI research are wooed by the Army and other services, they are unlikely to have much other contact with members of the military based on their location, the technical nature of their research, and reduced prevalence of service in civilian society overall. DoD strategic focus on partnering with the private sector notwithstanding,[82] there are few forums for civilian developers to observe unidentified needs their AI systems could fulfill. The Army should endeavor to increase efforts to educate civilians in this sector on its mission and people through mechanisms such as fellowships offered to senior officers.

Another mechanism to improve collaboration could be similar to DARPA's efforts to incentivize civilian research with its series of prize challenges.[83] A collateral benefit researchers gained from the DARPA competitions was publicity and pairwise comparison of their system against potential competitors. The Army could similarly leverage large-scale exercises as platforms for researchers to demonstrate capabilities. Exercises may also offer AI researchers reluctant to interact with DoD an opportunity to observe how advances may be used and how committed to ethical employment of technology DoD is. Though the Army's experience with the Louisiana Maneuvers are less applicable here, the maneuvers did offer civilians a previously unavailable window into how the Army operated and positive opinion of the service increased as a result.[84]

5 Conclusion

The present state of military technological advances bears remarkable similarity to the period between the World Wars. Both then and now, scientific advances were altering both societies and the armies charged with their security. During World War II, armies that successfully integrated mechanized and motorized capabilities triumphed over their competitors. Their successes were fueled by innovative young leaders that harnessed the technologies, civil-military cooperation in research and development, and unconstrained experimentation to develop innovative new ways of employing the technologies. The U.S. Army has recognized that AI presents the same opportunities and challenges that mechanization did in the early 20th century, and should look to the lessons learned by leaders then to maintain a competitive advantage over its contemporary competitors. Failing to adapt appropriate experimentation and strategy refinement processes may yield not only failed acquisition programs, but loss of dominance in the realm of ground combat.

Endnotes

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