How Can the U.S. Army Effectively Leverage Leading-Edge Technologies? Are There Rewards *and* Risks?

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Executive Summary

At the highest levels of U.S. intelligence and military policy documents, there is universal agreement that the United States remains at war, even as the conflicts in Iraq and Afghanistan wind down. As the cost of capital platforms—especially ships and aircraft—continues to rise, the Department of Defense is increasingly looking to procure comparatively inexpensive systems as important assets to supplement the Joint Force.

As the United States builds a force structure to contend with high-end threats, it has introduced a "Third Offset Strategy" to find ways to gain an asymmetric advantage over potential adversaries. One of the key technologies embraced by this strategy is that of unmanned systems. Both the DoD and the DoN envision a future force with large numbers of relatively inexpensive unmanned systems complementing manned platforms.

The U.S. military's use of these systems—especially armed unmanned systems—is not only changing the face of modern warfare, but is also altering the process of decision-making in combat operations. These systems are evolving rapidly to deliver enhanced capability to the warfighter and seemed poised to deliver the next "revolution in military affairs."

Big data, artificial intelligence and machine learning represent some of the most cutting-edge technologies today, and will likely be the dominant technologies for the next several decades and beyond. Generally branded under artificial intelligence or simply AI, most experts agree that advances in AI will change our lives more than any technology since the invention of electricity in 1879.

Sadly, there is vastly more heat than light on the subject of teaming AI and unmanned systems (or "robots" to use the older vernacular), most of it fueled by popular media. The American public, fed a steady diet of books and movies about "bad" robots (for example, *War of the Worlds*, *Terminator*) and even about "good" robots gone rogue (for example, *2001: A Space Odyssey* and *Ex Machina*), are generally fearful that today's robots—unmanned machines enabled with AI—will come to dominate our lives in ways that we can only dimly perceive in 2021.

These concerns go into overdrive when it comes to military applications of AI. Many have expressed apprehension that the U.S. military might lose control of its unmanned systems, and *especially* its armed, unmanned systems. These fears have manifested themselves in many ways, most notably in Google discontinuing work on DoD's Algorithmic Warfare Cross-Functional

Team, otherwise known as Project Maven. This is especially concerning, as Project Maven has nothing to do with armed unmanned systems.

In the United States, the dialogue regarding military uses of AI has become shrill and is impeding the effective insertion of AI into U.S. military weapons systems. These concerns are magnified when AI, autonomy, unmanned and armed are used in the same sentence. Concurrently, our peer competitors, China and Russia, recognize the value of AI in controlling their own societies—as well as others—and are investing hundreds of billions in AI, much of it to provide their militaries with an asymmetric advantage over the U.S. military.

Additionally—and perhaps more importantly—since the speed of warfare today often exceeds the ability of the human brain to make the right decision, the U.S. military needs big data, artificial intelligence and machine learning to give its warfighters the edge in combat, *especially* in the area of decision making. The U.S. military – as well as the militaries of other nations – has had a number of instances where decision-makers did not have the right information at the right time to support time-critical operational decisions and tragedy ensued.

It is important to note that the military people who made these suboptimal decisions were doing the best job they could with the tools at hand. What occurred was that the speed of warfare often exceeded the ability of the human brain to make the right decision. Indeed, as Dr. Alexander Kott, Chief Scientist at the U.S. Army Research Laboratory, put it at a command and control conference, “The human cognitive bandwidth will emerge as the most severe constraint on the battlefield.”

Until recently, the technology to take enhanced decision-making to the next level simply did not exist. Today it does, and leveraging what big data, artificial intelligence, and machine learning can provide to warfighters may well lead to the next breakthrough in naval warfare, especially in the area of decision-making. Naval Information Warfare Systems Center Pacific, along with partners through the Navy R&D community, industry and academia, is leading efforts to ensure that U.S. warfighters are equipped to make better decisions, faster, with fewer people and fewer mistakes.

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Strategic Perspective

The 21st Century has ushered in dramatic changes in world order, geopolitics and the way warfare is conducted. As the National Intelligence Council's capstone publication, *Global Trends: Paradox of Progress* puts it:

> The progress of the past decades is historic—connecting people, empowering individuals, groups, and states, and lifting a billion people out of poverty in the process. But this same progress also spawned shocks like the Arab Spring, the 2008 Global Financial Crisis, and the global rise of populist, anti-establishment politics. These shocks reveal how fragile the achievements have been, underscoring deep shifts in the global landscape that portend a dark and difficult near future.[1]

Global Trends: Paradox of Progress goes on to note that the next five years will see rising tensions within and between countries. Global growth will slow, just as increasingly complex global challenges impend. An ever-widening range of states, organizations, and empowered individuals will shape geopolitics. For better and worse, the emerging global landscape is drawing to a close an era of American dominance following the Cold War. It will be much harder to cooperate internationally and govern in ways publics expect. The Covid-19 crisis has magnified these fault lines and exposed the limits of international cooperation. Veto players threaten to block collaboration at every turn, while information echo chambers will reinforce countless competing realities, undermining shared understandings of world events. **As a result, the chances of conflict will be higher in the years ahead than at any time in recent memory**.

This assessment was reconfirmed in the Director of National Intelligence's *World Wide Threat Assessment*, which noted, in part: "Competition among countries will increase in the coming years as major powers and regional aggressors exploit complex global trends while adjusting to new priorities in U.S. foreign policy. **The risk of interstate conflict, including among great powers, is higher than at any time since the end of the Cold War**."[2] While it is too early to assess the full impact of the Covid-19 pandemic, the initial indications are that this crisis has increased tensions between the United States and its peer competitors.

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[1] *Global Trends: Paradox of Progress* (Washington, D.C.: National Intelligence Council, 2017), accessed at: https://www.dni.gov/index.php/global-trends-home

[2] *World Wide Threat Assessment of the U.S. Intelligence Community* (Washington, D.C., Director of National Intelligence, February 13, 2018).

In 2021 the United States remains engaged worldwide. The *National Security Strategy* addresses the wide range of threats to the security and prosperity of United States.[3] These threats range from high-end peer competitors such as China and Russia, to rogue regimes such as North Korea and Iran, to the ongoing threat of terrorism represented by groups such as ISIL. In a preview of the *National Security Strategy* at the Reagan National Defense Forum, then-National Security Advisor General H.R. McMaster highlighted these threats and reconfirmed the previous administration's "4+1 strategy," naming the four countries, Russia, China, Iran and North Korea, and the "+1"—terrorists, particularly ISIL—as urgent threats that the United States must deal with *today*.[4]

It is difficult to overstate the magnitude of this dramatic change in the international security paradigm. There is little mystery as to what has generated this new focus—it is great power competition with China and Russia. Indeed, The *National Security Strategy* lays out a strategic vision for protecting the American people and preserving their way of life, promoting prosperity, preserving peace through strength, and advancing American influence in the world.[5] It is worth noting that this this new, muscular strategy represents a dramatic shift from the previous version which focused on the three pillars of security, prosperity and international order, all aspirational ideals with little specificity. This new *National Security Strategy* has hardened the U.S. position vis-à-vis China and Russia, discarding the words "friend" and "partner" and substituting "revisionist powers" and "rivals."

Further developing the themes presented in the *National Security Strategy*, the *National Defense Strategy* more-directly addresses the threats to the security and prosperity of the United States. This document notes that the central challenge to the United States' is the reemergence of long-term, strategic competition by what the *National Security Strategy* classifies as revisionist powers. It notes that it is increasingly clear that China and Russia want to shape a world consistent with their authoritarian model—gaining veto authority over other nations' economic, diplomatic, and security decisions. Soon after the publication of the *National Defense Strategy*, senior defense excised the "4+1 strategy," term from the lexicon and now talk in terms of a "2+3 strategy" in recognition of the existential threat posed by Russia and China. Defense leaders have stated openly that "China is #1, Russia is #2." Additionally, they have said that Russia remains our greatest near-term security challenge, and China our greatest long-term challenge.[6]

This *National Defense Strategy* goes on to say, "Long-term strategic competitions with China and Russia are the principal priorities for the Department, and requires both increased and

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[3] *National Security Strategy of the United States of America* (Washington, D.C.: The White House, December 2017) accessed at: https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905-2.pdf.
[4] There are many summaries of this important national security event. For one of the most comprehensive, see Jerry Hendrix, "Little Peace, and Our Strength is Ebbing: A Report from the Reagan National Defense Forum," *National Review*, December 4, 2017, accessed at: http://www.nationalreview.com/article/454308/us-national-security-reagan-national-defense-forum-offered-little-hope.
[5] *National Security Strategy of the United States of America*.
[6] Remarks by Secretary Esper at the Air Force Association's 2019 Air, Space & Cyber Conference, National Harbor, Maryland, accessed at:
https://www.defense.gov/Newsroom/Transcripts/Transcript/Article/1964448/remarks-by-secretary-esper-at-the-air-force-associations-2019-air-space-cyber-c/.

sustained investment, because of the magnitude of the threats they pose to U.S. security and prosperity today, and the potential for those threats to increase in the future."[7]

This dramatically changed strategic landscape has been described in a Congressional Research Service document, *Report to Congress on Great Power Competition and National Defense*. Here is how this report describes today's strategic environment:

> The post-Cold War era of international relations—which began in the early 1990s and is sometimes referred to as the unipolar moment (with the United States as the unipolar power)—showed initial signs of fading in 2006-2008, and by 2014 had given way to a fundamentally different situation of renewed great power competition with China and Russia and challenges by these two countries and others to elements of the U.S.-led international order that has operated since World War II.
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> The renewal of great power competition was acknowledged alongside other considerations in the Obama Administration's June 2015 National Military Strategy, and was placed at the center of the Trump Administration's December 2017 National Security Strategy (NSS) and January 2018 National Defense Strategy (NDS). The December 2017 NSS and January 2018 NDS formally reoriented U.S. national security strategy and U.S. defense strategy toward an explicit primary focus on great power competition with China and Russia. Department of Defense (DOD) officials have subsequently identified countering China's military capabilities as DOD's top priority.[8]

A subsequent Congressional Research Service report, *Defense Primer: Geography, Strategy and Force Design*, emphasized the importance of redirecting the U.S. strategic focus to the two large Eurasian powers, noting:

> Preventing the emergence of regional hegemons in Eurasia is sometimes also referred to as preserving a division of power in Eurasia, or as preventing key regions in Eurasia from coming under the domination of a single power, or as preventing the emergence of a spheres-of-influence world, which could be a consequence of the emergence of one or more regional hegemons in Eurasia.[9]

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[7] *Summary of the 2018 National Defense Strategy of the United States of America* (Washington, D.C.: Department of Defense, January 2018), accessed at: https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf.
[8] *Report to Congress on Great Power Competition and National Defense* (Washington, D.C.: Congressional Research Service, September 30, 2020), accessed via *USNI News* at: https://news.usni.org/2020/10/01/report-to-congress-on-great-power-competition-and-national-defense-2.
[9] *Defense Primer: Geography, Strategy and Force Design* (Washington, D.C.: Congressional Research Service, November 5, 2020), accessed via *USNI News* at: https://news.usni.org/2020/11/06/report-on-world-geography-and-u-s-strategy?utm_source=USNI+News&utm_campaign=8eaef0f0ee-USNI_NEWS_DAILY&utm_medium=email&utm_term=0_0dd4a1450b-8eaef0f0ee-230420609&mc_cid=8eaef0f0ee&mc_eid=157ead4942.

Here is how an editorial in *The New York Times* put the issue of the long term challenges to the United States: "The coronavirus may have changed almost everything, but it did not change this: Global challenges to the United States spin ahead, with America's adversaries testing the limits and seeing what gains they can make with minimal pushback."[10]

While typically left to higher-echelon documents, the U.S. Navy's *Design for Maintaining Maritime Superiority 2.0* also highlights the overarching importance of this peer (and significantly no longer "near-peer") competition in stating, "China and Russia are deploying all elements of their national power to achieve their global ambitions...China and Russia seek to redefine the norms of the entire international system on terms more favorable to themselves."[11]

In his direction upon assuming the duties of the U.S. Chief of Naval Operations, Admiral Michael Gilday highlighted this need for high-end warfighting as well as the importance of integrating with the U.S. Marine Corps in his *FRAGO 01/2019*, noting, "We will ensure the wholeness of combat capable and lethal forces maximizing the benefits of Distributed Maritime Operations, Expeditionary Advanced Base Operations, and Littoral Operations in a Contested Environment."[12]

While it is the Joint Force that will collectively fight the nation's wars, the importance of naval forces in dealing with great power competition was highlighted in a report, *Maritime Security and Great Power Competition: Maintaining the US-led International Order*, which noted, in part:

> Great power competition (GPC) directs a lot of attention to the high-end capabilities needed to deter or defeat the United States' most powerful competitors. Yet competition is broader than just high-intensity conflict, which invites deeper questioning of the relationship between less intense forms of conflict and GPC. Although analysts are increasingly asking what GPC means for day-to-day competition, few have asked about the relationship between GPC and the Navy's maritime security mission. This focus is important because the surface Navy's perpetual deployments are typically dominated by maritime security operations—theater security engagements, freedom of navigation operations, humanitarian assistance, and so on.[13]

This is not to suggest that the Navy is more important than the other U.S. military services or, as some navalists have suggested, that the Navy should receive a bigger share of the finite defense budget.[14] What is does suggest is that front lines of great power competition are, and are likely to

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[10] "As Toll Preoccupies U.S., Rivals Test the Limits of American Power," *The New York Times*, June 2, 2020.
[11] *Design for Maintaining Maritime Superiority 2.0* (Washington, D.C.: Department of the Navy, December 2018) accessed at: https://www.navy.mil/navydata/people/cno/Richardson/Resource/Design_2.0.pdf.
[12] *FRAGO 01/2019: A Design for Maintaining Maritime Superiority* (Washington, D.C.: Department of the Navy, 2019) accessed at: https://www.navy.mil/cno/docs/CNO%20FRAGO%20012019.pdf.
[13] Joshua Tallis, *Maritime Security and Great Power Competition: Maintaining the US-led International Order* (Washington, D.C.: Center for Naval Analyzes, May 2020).
[14] See, for example, Bryan McGrath et al, "To Infinity and Beyond: Battle Force 2045, *War on the Rocks*, October 29, 2020, accessed at: https://warontherocks.com/2020/10/to-infinity-and-beyond-battle-force-2045/. The arguments for a larger U.S. Navy fleet being made today have been made in one form or another for decades. In spite of major

continue to be, the littoral areas of the vast Eurasian landmass. The ongoing friction in the South China Sea is but one point of contention in great power competition, and there are many others.

America's new maritime strategy, *Advantage at Sea*, issued in December 2020, is unambiguous in placing the Sea Services at the forefront of this great power competition, noting, in part:

> The security environment has dramatically changed since we last published *A Cooperative Strategy for 21st Century Seapower* in 2015. Several nations are contesting the balance of power in key regions and seeking to undermine the existing world order. Significant technological developments and aggressive military modernization by our rivals are eroding our military advantages. The proliferation of long-range precision missiles means the United States can no longer presume unfettered access to the world's oceans in times of conflict.
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> Since the beginning of the 21st century, our three Sea Services have watched with alarm the growing naval power of the People's Republic of China and the increasingly aggressive behavior of the Russian Federation. Our globally deployed naval forces interact with Chinese and Russian warships and aircraft daily. We witness firsthand their increasing sophistication and growing aggressiveness. Optimism that China and Russia might become responsible leaders contributing to global security has given way to recognition that they are determined rivals. The People's Republic of China represents the most pressing, long-term strategic threat.[15]

The *National Defense Strategy* has an intense focus on technology and notes that the United States will not achieve the security and prosperity it seeks without harnessing advancing technologies to support our warfighters, noting:

> The security environment is also affected by *rapid technological advancements and the changing character of war*. The drive to develop new technologies is relentless, expanding to more actors with lower barriers of entry, and moving at accelerating speed. New technologies include advanced computing, big data analytics, artificial intelligence, autonomy, robotics, directed energy, hypersonics, and biotechnology—the very technologies that ensure we will be able to fight and win the wars of the future.
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> New commercial technology will change society and, ultimately, the character of war. The fact that many technological developments will come from the commercial sector means that state competitors and non-state actors will also have access to them, a fact that risks eroding the conventional overmatch to which

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shifts in the U.S. strategic paradigm and passionate, often shrill, arguments by senior U.S. naval officers and civilians, the DoD budget has been apportioned at roughly one-third, one-third, one-third for the Army, Air Force and Navy-Marines respectively for over a generation.

[15] *Advantage at Sea: Prevailing With All-Domain Integrated Naval Power* (Washington, D.C.: Department of the Navy, December 2020), accessed at: https://media.defense.gov/2020/Dec/16/2002553074/-1/-1/0/TRISERVICESTRATEGY.PDF.

> our Nation has grown accustomed. Maintaining the Department's technological advantage will require changes to industry culture, investment sources, and protection across the National Security Innovation Base.[16]

The developments highlighted in *Global Trends: Paradox of Progress* as well as the *National Security Strategy* and *National Defense Strategy* are echoed in the U.S. military's future-looking publication, *Joint Operating Environment 2035* otherwise known as the *JOE*.[17] The subtitle of the *JOE*, which looks twenty years out to examine how the future will impact warfighting and the Joint Force is, *The Joint Force in a Contested and Disordered World*. The JOE emphasizes that, even as the conflicts in Iraq and Afghanistan wind down, the U.S. military will be increasingly stressed through the remainder of this decade and beyond.

The *Joint Operating Environment 2035* has a section dedicated to technology. The report's writers explained the reason for addressing technology this way:

> The Joint Force will face a future technological landscape largely defined by accelerating technological change. The U.S. approach to high-technology warfare over the past two decades has encouraged the development of asymmetric, unconventional, irregular, and hybrid approaches by adversaries. Adversaries will continue to innovate by applying varying mixes of high and low technologies to frustrate U.S. interests and military forces.
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> By 2035, the United States will confront a range of competitors seeking to achieve technological parity in a number of key areas. The cumulative result will be a situation in which, in the words of former Deputy Secretary of Defense Robert Work, "Our forces face the very real possibility of arriving in a future combat theater and finding themselves facing an arsenal of advanced, disruptive technologies that could turn our previous technological advantage on its head—where our armed forces no longer have uncontested theater access or unfettered operational freedom of maneuver."[18]

It is clear that the U.S. intelligence community, as well as the U.S. military, recognize that the pace of change in world order is mirrored by the rapid changes in the technology ecosystem. Further, at the highest levels of the U.S. government, there is an acknowledgement that the technological advantage that the United States once enjoyed has eroded, and that the U.S. military can no longer dominate its adversaries with sheer technological superiority. Indeed, this recognition was foreshadowed by several experts who write about the military and technology.

In his best-selling book, *War Made New*, military historian Max Boot notes, "My view is that technology sets the parameters of the possible; it creates the potential for a military

[16] *Summary of the 2018 National Defense Strategy of the United States of America*.
[17] *Joint Operating Environment 2035 The Joint Force in a Contested and Disordered World* (Washington, D.C.: Joint Chiefs of Staff, 2016), accessed at: http://www.dtic.mil/doctrine/concepts/joe/joe_2035_july16.pdf.
[18] Deputy Secretary of Defense Robert Work, Remarks to the National Defense University Convocation, August 5, 2014.

revolution."[19] He supports his thesis with historical examples to show how technological-driven "revolutions in military affairs" have transformed warfare and altered the course of history. Importantly, Boot points out the importance of technology in giving the nation that innovates and fields new military technology quickly a war-winning advantage.

The U.S. military *has* embraced a wave of technological change that has constituted a true revolution in the way that war is waged. As the pace of global technological change has accelerated, the United States has been especially adept at inserting new technology to pace the threat. As Bruce Berkowitz points out in *The New Face of War*:

> Wartime experience suggests that the right technology, used intelligently, makes sheer numbers irrelevant. The tipping point was the Gulf War in 1991. When the war was over, the United States and its coalition partners had lost just 240 people. Iraq suffered about 10,000 battle deaths, although no one will ever really be sure. The difference was that the Americans could see at night, drive through the featureless desert without getting lost, and put a single smart bomb on target with a 90 percent probability.[20]

While both books cited are over a decade old, what they say about technology remains on point regarding the ways that the U.S. military has embraced new tools. But as pointed out in the *Joint Operating Environment 2035*, as well as other high-level government, intelligence community and military publications, while the U.S. military has been adept at adopting new technologies for military use, this process has been under stress. There are a number of factors that have impeded the insertion of new technologies into the U.S. military, including the high operating tempo these forces have faced during the past twenty years, budget pressures and the ongoing specter of sequestration, and the often-clunky military acquisition system. In spite of these pressures, the military services have found ways to embrace new technologies that promise to tilt the balance back toward United States advantage.

Today one of the most rapidly growing areas of innovative technology adoption by the U.S. military involves unmanned systems. In the past several decades, the U.S. military's use of unmanned aerial vehicles (UAVs) has increased from only a handful to more than 10,000, while the use of unmanned ground vehicles (UGVs) has exploded from zero to more than 12,000. The use of unmanned surface vehicles (USVs) and unmanned underwater vehicles (UUVs) is also growing, as USVs and UUVs are proving to be increasingly useful for a wide array of military

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[19] Max Boot, *War Made New: Technology, Warfare, and the Course of History 1500 to Today* (New York: Gotham Books, 2006). Boot does not present technology as the only element determining victory or defeat, giving full acknowledgement to a host of other factors, from geography, to demography, to economics, to culture, to leadership. However, he is firm in his contention of technology's huge impact, noting: "Some analysts may discount the importance of technology in determining the outcome of battles, but there is no denying the central importance of advanced weaponry in the rise of the West…The way to gain military advantage, therefore, is not necessarily to be the first to produce a new tool or weapon. Often it is to figure out better than anyone else how to utilize a widely available tool or weapon."

[20] Bruce Berkowitz, *The New Face of War: How War Will Be Fought in the 21st Century* (New York: The Free Press, 2003). Berkowitz does not restrict his examples to just one conflict, noting further: "The same thing happened when the United States fought Yugoslavia in 1999 and the Taliban regime in Afghanistan in 2001. Each time experts feared the worst; each time U.S. forces won a lopsided victory."

applications. The expanding use of military unmanned systems (UxS) is already creating strategic, operational, and tactical possibilities that did not exist a decade ago.[21]

The expanding use of armed, unmanned systems is not only changing the face of modern warfare, but is also altering the process of decision-making in combat operations. Indeed, it has been argued that the rise in drone warfare is changing the way we conceive of and define "warfare" itself.[22] These systems have been used extensively in the conflicts in Iraq and Afghanistan, and will continue to be equally relevant—if not more so—as the United States' strategic focus shifts toward the Indo-Asia-Pacific region and the high-end warfare this strategy requires.[23] Unmanned system—and especially their utility, not as stand-alone entities, but as warfighters partners in what has been dubbed "man-machine-teaming"—is a foundational tenet of the United States "Third Offset Strategy."

The Need for "Offset" Strategies

The Department of Defense has initiated a "Third Offset Strategy," to ensure that the United States retains the military edge against potential adversaries. An "offset" strategy is an approach to military competition that seeks to asymmetrically compensate for a disadvantaged position. Rather than competing head-to-head in an area where a potential adversary may also possess significant strength, an offset strategy seeks to shift the axis of competition, through the introduction of new operational concepts and technologies, toward one in which the United States has a significant and sustainable advantage.

The United States was successful in pursuing two distinct offset strategies during the Cold War. These strategies enabled the U.S. to "offset" the Soviet Union's numerical advantage in conventional forces without pursuing the enormous investments in forward-deployed forces that would have been required to provide overmatch soldier-for-soldier and tank-for-tank. These offset strategies relied on fundamental innovation in technology, operational approaches, and organizational structure to compensate for Soviet advantage in time, space, and force size.

The first of these offset strategies occurred in the 1950's when President Eisenhower sought to overcome Warsaw Pact's numerical advantage by leveraging US nuclear superiority to introduce battlefield nuclear weapons—thus shifting the axis of competition from conventional force

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[21] There has been extensive reporting regarding the emphasis on unmanned surface vehicles—including the substantial funding for these craft in the Navy's FY2020 budget submission—in the defense media. See, for example, Justin Katz and Mallory Shelboure, "Navy Seeks Accelerated Move into Unmanned Systems," *Inside the Navy*, July 1, 2019.

[22] See, for example, Mitchell Binding, "Have Autonomous and Unmanned Systems Changed War Fundamentally?" *Canadian Military Journal*, Winter 2018, accessed at: http://www.journal.forces.gc.ca/Vol19/No1/page40-eng.asp.

[23] For some of the best work regarding unmanned systems, See, for example, P.W. Singer, *Wired for War* (New York: Penguin Press, 2009), Bradley Jay Strawser, Ed. *Killing by Remote Control: The Ethics of an Unmanned Military* (Oxford, UK: Oxford University Press, 2013), William Arkin, *Unmanned: Drones, Data, and the Illusion of Perfect Warfare* (New York: Little, Brown and Company, 2015), Larry Lewis and Dianne Vavrichek, *Rethinking the Drone War* (Quantico, VA: Marine Corps University Press, 2016), Paul Scharre, *Army of None: Autonomous Weapons and the Future of War* (New York: W.W. Norton and Company, 2018) and John Jackson Ed., *One Nation Under Drones* (Annapolis, MD: U.S. Naval Institute Press, 2018).

numbers to an arena where the United States possessed an asymmetrical advantage. This approach provided stability and offered the foundation for deterrence.

The second of these offset strategies arose in the late 1970's and early 1980's with the recognition that the Soviet Union had achieved nuclear parity. The Second Offset Strategy sought to create an enduring advantage by pursuing a new approach to joint operations by leveraging the combined effects of conventional precision weapons, real-time, long-range ISR (intelligence, surveillance, reconnaissance) sensor capabilities that supported real-time precision targeting, and the joint battle networks that permitted these capabilities to be synchronized and executed over the full breadth of the battlespace.

Fortunately, the military technologies that comprised the Second Offset Strategy were never tested against the Soviet Union in head-to-head battle. However, they were deployed against a Soviet-trained and Soviet-equipped army during Operation Desert Storm. As noted earlier, and as described *The New Face of War*, the Iraq defeat was total and represented one of the most-lopsided campaigns in modern warfare. Clearly, America's potential foes noticed the crucial part technology played in this victory.

At the time of the introduction of the Second Offset Strategy in the early 1980's, the United States was the only nation with the knowledge and capacity to develop, deploy, and successfully execute the intelligence, surveillance and reconnaissance capabilities, the space-based systems, and the precision weapons that supported this approach. Today, competitors such as Russia and China (and countries to which these nations proliferate advanced capabilities) are pursuing and deploying advanced weapons and capabilities that demonstrate many of the same technological strengths that have traditionally provided the high-tech basis for U.S. advantage, such as precision-guided munitions. This growing symmetry between U.S. technical capabilities and potential competitors was seen during Russian power-projection operations in Syria.[24]

The emergence of increasing parity in the international security environment has made it imperative that the United States begin to consider a mix of technologies, system concepts, military organizations, and operational concepts that might shift the nature of the competition and give the United States an edge over potential adversaries. This set of capabilities provides the basis for a Third Offset Strategy. As was true of previous offset strategies, a Third Offset Strategy seeks, in a budget constrained environment, to maintain and extend the United States' competitive technological and operational advantage by identifying asymmetric advantages that are enabled by unique U.S. strengths and capabilities. A Third Offset Strategy ensures that United States conventional deterrence posture remains as strong in the future as it is today and establishes the conditions to extend that advantage into the future.

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[24] The widely reported Russian operations in Syria included an increased use of unmanned systems. See, for example, John Grady, "Experts: Syrian War Prompting Russians to Expand Unmanned Systems," *USNI News*, October 9, 2017, accessed at: https://news.usni.org/2017/10/09/experts-syrian-war-prompting-russians-expand-unmanned-systems?utm_source=USNI+News&utm_campaign=91248db1ff-USNI_NEWS_DAILY&utm_medium=email&utm_term=0_0dd4a1450b-91248db1ff-231544033&mc_cid=91248db1ff&mc_eid=93a1fd6ad6.

In explaining the technological elements of the Third Offset Strategy, then-Deputy Secretary of Defense Robert Work emphasized the importance of emerging capabilities in unmanned systems, artificial intelligence, machine learning and autonomy. He pointed out that these technologies offer significant advantage to the Joint Force, enabling the future force to develop and operate advanced joint, collaborative human-machine battle networks that synchronize simultaneous operations in space, air, sea, undersea, ground, and cyber domains. Artificial intelligence will allow new levels of autonomy—the limited delegation of decision-making authority—within joint battle networks, leading to entirely new opportunities for human-machine collaboration and combat teaming.[25]

It is difficult to overstate the prominence of technologies such as unmanned systems, artificial intelligence and machine learning in the Third Offset Strategy and especially in the Strategy's Long Range Research and Development Plan (LRRDP).[26] That said, there is strong component of this strategy that emphasizes keeping humans in the loop when using unmanned systems with increasingly sophisticated artificial intelligence and machine learning capabilities.

Indeed, human-machine collaboration is an imperative that is emphasized in extant Third Offset Strategy documentation as well as in speeches and interviews with senior DoD officials.[27] While a deep-dive into the full details of the technology thrusts of the Third Offset Strategy is beyond the scope of this paper, it is important to note that the Strategy's primary technical line of effort is focused on the concept of Human-Machine Collaboration and Combat Teaming.[28] The five basic building blocks of this concept are:[29]

- **Autonomous deep learning systems**, which will leverage machine learning to operate "at the speed of light" in areas where human reaction time is too slow, such as cyber-attacks, electronic warfare attacks, or large missile raid attacks.

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[25] Deputy Secretary Work's interview with David Ignatius at "Securing Tomorrow" forum at the *Washington Post* Conference Center in Washington, D.C., March 30, 2016.

[26] The importance of artificial intelligence and autonomy to all aspects of society, and especially to military operations, has been well-documented at the international and national level. See, for example, Executive Office of the President, National Science and Technology Council, Committee on Technology, *Preparing for the Future of Artificial Intelligence*, October 2016, and Office of the Secretary of Defense for Acquisition, Technology and Logistics, *Report of the Defense Science Board Summer Study on Autonomy*, June 2016, and most recently, the March 2021 *Final Report National Security Commission on Artificial Intelligence*.

[27] See, for example: Statement by Mr. Stephen Welby, Assistant Secretary of Defense for Research and Engineering on the Third Offset Strategy, Statement by Dr. Arati Prabhakar, Director, Defense Research Projects Agency (DARPA), on Strategy and Implementation of the Department of Defense's Technology Offset Initiative, and Statement by Dr. William B. Roper Jr. Director, Strategic Capabilities Office, Strategy and Implementation of the Department of Defense's Technology Offsets Initiative in Review of the Defense Authorization Request for Fiscal Year 2017, all before the Subcommittee on Emerging Threats and Capabilities, Armed Services Committee, United States Senate, April 12, 2016.

[28] Some of the most cutting-edge work being done with man-unmanned teaming is being conducted by the U.S. Army. See, for example, Kris Osborn, "How AI and Networked Drones Will Help America Wage Future Wars," *The National Interest*, June 11, 2020, accessed at: https://nationalinterest.org/blog/buzz/how-ai-and-networked-drones-will-help-america-wage-future-wars-162614. See also, for example, *2018 U.S. Marine Corps S&T Strategic Plan* (Quantico, VA: U.S. Marine Corps Warfighting Lab, 2018). This document has a strong emphasis on man-unmanned teaming.

[29] Remarks by Deputy Secretary of Defense Robert Work at the Center for New American Security Defense Forum, December 14, 2015.

- **Human-machine collaboration**, which will allow machines to help humans make better decisions faster. Secretary Work cited the F-35 Joint Strike Fighter and the Naval Integrated Fire Control Counter-Air (NIFC-CA) as examples of these concepts.

- **Assisted human operations**, which will focus on the ways in which man and machines can operate together, through tools such as wearable electronics, exoskeletons, and combat applications to assist warfighters in every possible contingency.

- **Advanced human-machine combat teaming**, which will focus on humans working with unmanned systems in cooperative operations; one example is the operation of the Navy's P-8 Poseidon with an MQ-4C Triton. Going forward, the next level of teaming will examine swarming tactics and cooperative autonomy.

- **Network-enabled, cyber-hardened autonomous weapons**, which will be resilient to operate in an electronic warfare and cyber environment. A current example includes the tactical Tomahawk Block IX, whose targets can be updated in-flight.

Knowledgeable outside observers have referenced the Third Offset Strategy and have highlighted the importance of unmanned systems in achieving U.S. strategic goals. In his article in *Foreign Policy*, "The New Triad," Admiral James Stavridis, former Supreme Allied Commander Europe, identified unmanned systems as one of the three pillars of this new triad, noting, "The second capability in the New Triad is unmanned vehicles and sensors. This branch of the triad includes not only the airborne attack drones but unmanned surveillance vehicles in the air, on the ground, and on the ocean's surface…Such systems have the obvious advantage of not requiring the most costly component of all: people."[30]

A U.S. Army report described how the Third Offset Strategy, first articulated in 2014, and well before the United States began calling China and Russia peer competitors, must morph and change in the third decade of the twenty-first century:

> The numerical superiority of the Soviet Union military precipitated the first two offset strategies. As U.S. military technological advancements applications have proliferated to near-peer adversaries it has effectively re-balanced the battlefield. Ensuring successful implementation of the Third Offset, the DoD in concert with the U.S. Government, must agree on what we are trying to offset and how to balance these priorities against adversaries in vastly different regions and capabilities.
>
> The employment of the Third Offset Strategy would restore U.S. power projection capability and capacity, bolstering conventional deterrence through a credible threat of denial and punishment, and imposing costs upon prospective adversaries as part of a long-term competition. The ability to balance or defeat an adversary's

[30] James Stavridis, "The New Triad," *Foreign Policy*, June 20, 2013. Admiral Stavridis argues that the "New Triad" consists of special operations forces, unmanned vehicles, and cyber-capabilities.

> capability requires resources, to ensure effective employment of the strategy we must address what we are attempting to offset.[31]

Given the strong technical focus of the Third Offset Strategy, as the United States seeks to implement this Strategy this decade and beyond, the manifestation of this strategy will be represented by the military platforms, systems, sensors and weapons that the Joint Forces places in the field. And just as clearly, and the U.S. military services—and especially the U.S. Navy—have indicated a desire to field unmanned systems as an increasingly important part of their force structure.

Leveraging Big Data, Artificial Intelligence and Machine Learning in Military Weapons Systems

During his Congressional testimony is response to a question: "What is the number one priority for DoD technology modernization?" former Secretary of the Army and Secretary of Defense Michael Esper noted, "For me it's artificial intelligence. I think artificial intelligence will likely change the character of warfare, and I believe whoever masters it first will dominate on the battlefield for many, many, many years. It's a fundamental game changer. We have to get there first."[32]

There are any number of reasons for the U.S. military to proactively leverage big data, artificial intelligence and machine learning to make its weapons systems better. Perhaps the most compelling reason is that our potential adversaries—especially our peer competitors—are aggressively doing so. An old saw is the military term, "The enemy gets a vote." In this case, Russia is voting with rubles and China is voting with yuan.

These nations are making enormous investments in these technologies. While both nations are making these investments for domestic reasons—especially to control their own citizens—they are deliberately and methodically inserting them into their military systems as rapidly as possible in order to create an asymmetric advantage over the U.S. military. And in moves that may seem counterintuitive given Russia and China's penchant for secrecy, neither nation has tried to keep these goals secret.

In a widely publicized address, Russian President Vladimir Putin said this: "Artificial intelligence is the future, not only for Russia, but 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."[33]

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[31] Eric Hillner, "The Third Offset Strategy and the Army Modernization Priorities," *Center for Army Lessons Learned*, (Fort Leavenworth, Kansas: United States Army, May 2019).
[32] Congressional testimony before the Senate Armed Services Committee, July 16, 2019.
[33] "'Whoever leads in AI will rule the world': Putin to Russian children on Knowledge Day," *RT* [*Russia Today*] (web), 1 September 2017, https://www.rt.com/news/401731-ai-rule-world-putin/, accessed 29 July 2019.

China's leadership was even more straightforward in signaling the intent to leverage AI, already in use to control its citizens, to gain a military advantage. A Notice of the PRC State Council Issuing the Next Generation of Artificial Intelligence Development Plan stated:

> The first step…is to keep up the overall technology and application of artificial intelligence with the advanced level of the world…Artificial intelligence technology can accurately perceive, forecast, and early warn of infrastructure and social security operation…it is indispensable for the effective maintenance of social stability.…[Goals are to] Promote the formation of multi-element, multi-field, highly efficient AI integration of military and civilian pattern.…Promote AI technology in military-civilian two-way transformation. Strengthen a new generation of AI technology in command-and-decision, military deduction, defense equipment, strong support, and guide AI in the field of defense technology to civilian applications."[34]

Whether expressed in the inflated rhetoric of a Russian President Putin perpetually defying the perceived perfidiousness of the West, or in the cautious, but telling phrases of the State Council of the People's Republic of China (PRC), it is obvious that the other "great powers" view the development of artificial intelligence as a race, and one from which competitive military applications will be harnessed.

From the American perspective—and that of a number of U.S. allies—this race is largely, though not exclusively, an aspect of military competition. There is American and allied concern about the possibility of one or more potential opponents leaping ahead in the development of AI. The Third Offset Strategy was conceived as a method of staying ahead of the military competition for new technologies such as AI.

The history of military great power competition indicates that an AI competition, essentially an arms race, is a natural development. However, an even greater concern than technology leapfrog may be that the military rivals of the United States., all authoritarian regimes of some stripe, may not be as committed to maintaining a "human-in-the-loop" approach to integrating AI into military affairs. This appears to be especially true in current Russian military AI developments.[35]

All three of the major military powers, Russia, China and the U.S. recognize that big data, artificial intelligence and machine learning hold the prospect for application to military capabilities.[36] Yet all three have a different approach to the development and, more importantly,

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[34] People's Republic of China, *Notice of the State Council Issuing the Next Generation of Artificial Intelligence Development Plan, State Council Document [2017] No. 35*, trans. by The Foundation for Law and International Affairs, https://flia.org/wp-content/uploads/2017/07/A-New-Generation-of-Artificial-Intelligence-Development-Plan-1.pdf, accessed 27 July 2019.

[35] Noel Sharkey, "Killer Robots From Russia Without Love," *Forbes*, November 28, 2018, https://www.forbes.com/sites/noelsharkey/2018/11/28/killer-robots-from-russia-without-love/#3640d4dbcf01. See also, Samuel Bendett, "120. Autonomous Robotic System in the Russian Ground Forces," *Mad Scientist Laboratory*, U.S. Army (weblog), February 11, 2019, https://madsciblog.tradoc.army.mil/120-autonomous-robotic-systems-in-the-russian-ground-forces/.

[36] The most comprehensive work on AI programs of potential opponents is U.S. Department of Defense/Joint Chiefs of Staff (J39) [edited by Nicholas D. Wright], *AI, China, Russia, and the Global Order: Technological, Political,*

the prioritized goals for the militarization of AI. The immediate objectives of all three differ as to government involvement in AI research, the risks they are willing to take in its development, the degree to which they will concede autonomy to AI systems, and the immediate applications that they seek.

Given the extent to which potential adversaries are inserting big data, artificial intelligence and machine learning into their military weapons systems, there is a strong imperative to the U.S. military to do likewise to ensure that these nations to not gain an asymmetric advantage. That said, the U.S. military's focus must be on demonstrating that AI-enabled weapons systems will "First do no harm." Therefore, inserting AI into military systems is not an "either-or" question, but rather one of "how much?" Said another way, the U.S. military must focus on applying the right amount of AI, at the right place, at the right time.

As we indicated earlier, DoD has embraced a Third Offset Strategy to attempt to provide the United States with an asymmetric advantage over peer and other adversaries.[37] While there are many aspects to this strategy, one pillar deals with technology, and this pillar is critically dependent on big data, artificial intelligence and machine learning to gain this advantage. As a subset of this technological focus, man-machine teaming is offered as a way to harness AI-enabled unmanned systems to gain a military advantage.[38] But this begs the question, what does man-machine teaming look like?

The capabilities required to find this just right balance of autonomy in military systems must leverage many technologies that are still emerging. The military knows what it *wants* to achieve, but often not what technologies or even capabilities it *needs* in order to field systems with the right balance of autonomy and human interaction. A key element of this quest is to worry less about what attributes—speed, endurance, and others—the machine itself possesses and instead focus on what is *inside* the machine. The Defense Science Board report, *The Role of Autonomy in DoD Systems*, put it this way:

> Instead of viewing autonomy as an intrinsic property of unmanned systems in isolation, the design and operation of unmanned systems needs to be considered in terms of human-systems collaboration…A key challenge for operators is maintaining the human-machine collaboration needed to execute their mission, which is frequently handicapped by poor design…A key challenge facing unmanned systems developers is the move from a hardware-oriented, vehicle-

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Global, and Creative Perspectives, A Strategic Multilayer Assessment (SMA) Periodic Publication December 2018, https://nsiteam.com/social/wp-content/uploads/2018/12/AI-China-Russia-Global-WP_FINAL.pdf.

[37] One of the best references for understanding the United States' offset strategies is Robert Work and Greg Grant, *Beating the Americans at Their Own Game: An Offset Strategy with Chinese Characteristics* (Washington, D.C.: Center for New American Security, 2019) https://www.cnas.org/publications/reports/beating-the-americans-at-their-own-game.

[38] It is important to note that the concept of man-machine teaming is not as new as some of its proponents often allege. See, for example, the 1960 paper by J.C.R. Licklinder, entitled, "Man-Computer Symbiosis," *IRE Transactions on Human Factors in Electronics*, vol. HFE-1 (March 1960), pp. 4-11, http://groups.csail.mit.edu/medg/people/psz/Licklider.html.

> centric development and acquisition process to one that emphasizes the primacy of software in creating autonomy.[39]

Some of the controversy regarding inserting AI into military systems stems from a lack of precision in terminology. One way to help clarify this ambiguity is to ensure that when the word autonomy is used, it refers to the relationship between the person and the machine. Machines that perform a function for some period of time, then stop and wait for human input before continuing, are often referred to as semiautonomous or as having a *human-in-the-loop*. Machines that can perform a function entirely on their own but have a human in a monitoring role, with the ability to intervene if the machine fails or malfunctions, are often referred to as human-supervised autonomous or *human-on-the-loop*. Machines that can perform a function entirely on their own with humans unable to intervene are often referred to as fully autonomous or *human-out-of-the-loop*.

This suggests that we need to recalibrate some of the debate on autonomous weapons to more accurately distinguish between increased autonomy *in* weapons and *autonomous* weapons. In this sense, autonomy is not about the intelligence of the machine, but rather its relationship to a human controller.[40] For the relatively small numbers of unmanned systems that will engage an enemy with a weapon, this balance is crucial. Prior to firing a weapon, the unmanned platform needs to provide the operator—and there must be an operator in the loop—with a pros-and-cons decision matrix regarding what that firing decision might entail.

It is fair to say that even some who are working in the U.S. military AI space can be somewhat conflicted regarding inserting AI into U.S. military weapons systems. Perhaps the best way to address this is to consider one of the most recognized photographs from World War II. Taken by First Lieutenant John Moore of the U.S. Signal Corps, the photo depicts General Dwight Eisenhower talking with men of the 101st Airborne division on June 5, 1944, the day before the invasion of Normandy. Previously, Eisenhower had been briefed by Air Marshal Leigh-Mallory that the 101st was one of two units that would suffer 80% casualties during the invasion.

Those who study the impact of unmanned systems on military operations—especially those who are strong advocates of unmanned systems—can look at this photo and can envision General Eisenhower speaking not with American airborne soldiers, but with robots that he will send into battle. Those who fear unmanned systems might picture the American airborne soldiers as the photo depicts them, but instead of General Eisenhower, they would envision a robot commanding the soldiers—clearly an untenable situation. But those who thoughtfully consider the impact of AI-enabled unmanned systems on military operations would envision General Eisenhower addressing a team of American airborne soldiers standing with their robot partners.

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[39] Defense Science Board, *Task Force Report: The Role of Autonomy in DoD Systems*, July 2012, http://sites.nationalacademies.org/cs/groups/pgasite/documents/webpage/pga_082152.pdf (slides), https://fas.org/irp/agency/dod/dsb/autonomy.pdf (text).

[40] Paul Scharre, "Centaur Warfighting: The False Choice of Humans vs. Automation," *Temple International and Comparative Law Journal* vol. 30, no. 1 (Spring 2016), pp. 151-165, https://sites.temple.edu/ticlj/files/2017/02/30.1.Scharre-TICLJ.pdf.

Clearly, more work needs to be done to fully address what man-machine teaming means to today's military.[41]

But this general aspiration for leveraging big data, artificial intelligence and machine learning fails to address the critical question as to what *specific* tasks we want these technologies to help warfighters perform. At the root of the issue may be the U.S. military's lack of ability to translate the needs of warfighters in a way that suggests technical solutions enabled by big data, artificial intelligence and machine learning. Unless or until this is done, it is unlikely that these technologies will be fully leveraged to support U.S. warfighters.

What Will the American Public Accept? The Dark Side of Military Weapons Systems Autonomy

One of the most iconic films of the last century, Stanley Kubrick's *2001: A Space Odyssey* had as its central theme, the issue of autonomy of robots (the unmanned vehicles of the time). Few who saw the movie can forget the scene where astronauts David Bowman and Frank Poole consider disconnecting HAL's (**H**euristically programmed **AL**gorithmic computer) cognitive circuits when he appears to be mistaken in reporting the presence of a fault in the spacecraft's communications antenna. They attempt to conceal what they are saying, but are unaware that HAL can read their lips. Faced with the prospect of disconnection, HAL decides to kill the astronauts in order to protect and continue its programmed directives.

While few today worry that a 21st century HAL will turn on its masters, the issues involved with fielding increasingly-autonomous unmanned systems are complex, challenging and contentious. Kubrick's 1968 movie was prescient. More than half-century later, while we accept advances in other aspects of unmanned systems improvements such as propulsion, payload, stealth, speed, endurance and other attributes, we are still coming to grips with how much autonomy is enough and how much may be too much. This is arguably th*e* most important issue we need to address with respect to military unmanned systems over the next decade.

These ongoing debates have spawned a cottage industry of books that attempt to address the issue of AI, autonomy, and unmanned systems, especially armed military unmanned systems. Books such as *Wired for War*; *Killing by Remote Control: The Ethics of an Unmanned Military; Unmanned: Drones, Data and the Illusion of Perfect Warfare*; *Rethinking the Drone War*; *Army of None: Autonomous Weapons and the Future of War* and *One Nation Under Drones* represent just a sample of the books that seek to address this complex issue in a thoughtful manner.[42]

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[41] See, for example, Ensign Brendan O 'Donoghue, USN, "The Manned-Unmanned Team is the Future," U.S. Naval Institute *Proceedings*, vol. 144, no. 6 (June 2018), pp. 68-69, for a thoughtful analysis of how this teaming would work in an operational context. The concept of man-machine teaming isn't limited to military applications. See, for example, Tom Friedman, "A.I. Still Needs H.I. (Human Intelligence), *The New York Times*, February 27, 2019, https://www.nytimes.com/2019/02/26/opinion/artificial-intelligence.html.

[42] See, for example, Peter Singer, *Wired for War*: *The Robotics Revolution and Conflict in the 21st Century* (New York: Penguin Press, 2009), Bradley Strawser and Jeff McMahan, *Killing By Remote Control: The Ethics of an Unmanned Military* (Oxford, U.K.: Oxford University Press, 2013), William Arkin, *Data and the Illusion of Perfect Warfare* (New York: Little Brown and Company, 2015), Larry Lewis and Diane Vavrichek, *Rethinking the Drone War* (Washington, D.C.: Center for Naval Analysis, 2016), Paul Scharre, *Army of None: Autonomous Weapons and*

Unmanned systems will become more autonomous in direct proportion to their ability to sense the environment and adapt to it. This capability enables unmanned systems to achieve enhanced speed in decision-making and allows friendly forces to act within an adversary's OODA (Observe, Orient, Decide, and Act) loop.[43] As the environment or mission changes, the ability to sense and adapt will allow unmanned systems to find the optimal solution for achieving their mission, without the need to rely on constant human operator oversight, input and decision-making. Nevertheless, while we need unmanned systems to operate inside the enemy's OODA loop, are we ready for them to operate without our decision-making—to operate inside *our* OODA loops?

An article in *The Economist* entitled, "Morals and the Machine," addressed the issue of autonomy and humans-in-the-loop this way:

> As they become smarter and more widespread, autonomous machines are bound to end up making life-or-death decisions in unpredictable situations, thus assuming—or at least appearing to assume—moral agency. Weapons systems currently have human operators "in-the-loop," but as they grow more sophisticated, it will be possible to shift to "on-the-loop" operation, with machines carrying out orders autonomously.
>
> As that happens, they will be presented with ethical dilemmas. Should a drone fire on a house where a target is known to be hiding, which may also be sheltering civilians? Should a driverless car swerve to avoid pedestrians if that means hitting other vehicles or endangering its occupants? Should a robot involved in disaster recovery tell people the truth about what is happening if that risks causing a panic?
>
> Such questions have led to the emergence of the field of "machine ethics," which aims to give machines the ability to make such choices appropriately—in other words—to tell right from wrong. More collaboration is required between engineers, ethicists, lawyers and policymakers, all of whom would draw up very different types of rules if they were left to their own devices.[44]

In an op-ed in *The New York Times* entitled, "Smart Drones," Bill Keller put the issue of autonomy for unmanned systems this way:

> If you find the use of remotely piloted warrior drones troubling, imagine that the decision to kill a suspected enemy is not made by an operator in a distant control room, but by the machine itself. Imagine that an aerial robot studies the landscape

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the Future of War (New York: W.W. Norton and Company, 2018) and John Jackson Ed., *One Nation Under Drones* (Annapolis, MD: U.S. Naval Institute Press, 2018).

[43] One of the best references on the OODA Loop is, John Boyd, *Destruction and Creation* (Fort Leavenworth, Kansas: U.S. Army Command and General Staff College, 1976).

[44] "Flight of the Drones: Why the Future of Air Power Belongs to Unmanned Systems," *The Economist*, October 8, 2011.

> below, recognizes hostile activity, calculates that there is minimal risk of collateral damage, and then, with no human in the loop, pulls the trigger.
>
> Welcome to the future of warfare. While Americans are debating the president's power to order assassination by drone, powerful momentum—scientific, military and commercial—is propelling us toward the day when we cede the same lethal authority to software.[45]

More recently, while it may seem counterintuitive, concerns about autonomous machines and artificial intelligence are also coming from the very industry that is most prominent in developing these technological capabilities. An article in *The New York Times* entitled, "Robot Overlords? Maybe Not," quoted Alex Garland, director of the movie *Ex Machina*, who talked about artificial intelligence and quoted several tech industry leaders.

> The theoretical physicist Stephen Hawking told us that "the development of full artificial intelligence could spell the end of the human race." Elon Musk, the chief executive of Tesla, told us that A.I. was "potentially more dangerous than nukes." Steve Wozniak, a co-founder of Apple, told us that "computers are going to take over from humans" and that "the future is scary and very bad for people."[46]

The Department of Defense is addressing the issue of human control of unmanned systems as a first-order priority and has issued policy direction to ensure that humans *do* remain in the OODA loop. A directive by then-Deputy Secretary of Defense Ashton Carter issued the following guidance:

> Human input and ongoing verification are required for autonomous and semi-autonomous weapons systems to help prevent unintended engagements. These systems shall be designed to allow commanders and operators to exercise appropriate levels of human judgment over the use of force. Humans who authorize the use of, or operate these systems, must do so with appropriate care and in accordance with the law of war, applicable treaties, weapon system safety rules and applicable rules of engagement. An autonomous system is defined as a weapon system that, once activated, can select and engage targets without further intervention by a human operator.[47]

These are the kinds of directives *and* discussions that are—and should be—part of the dialogue between and among policy makers, military leaders, industry, academia and the science and technology community as the design and operation of tomorrow's autonomous systems are thoughtfully considered. As then-Deputy Secretary of Defense Robert Work noted during his

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[45] Bill Keller, "Smart Drones," *The New York Times*, March 10, 2013.

[46] Alex Garland, "Alex Garland of 'Ex Machina' Talks About Artificial Intelligence," *The New York Times*, April 22, 2015. This heated dialogue continues among other tech titans. See, for example, Cade Metz, "Mark Zuckerberg, Elon Musk and the Feud Over Killer Robots," *The New York Times*, June 9, 2018.

[47] Deputy Secretary of Defense Ashton Carter Memorandum, "Autonomy in Weapon Systems," dated November 21, 2012, updated on May 8, 2017 accessed at: http://www.defense.gov/. See also, "Carter: Human Input Required for Autonomous Weapon Systems," *Inside the Pentagon*, November 29, 2012 for a detailed analysis of the import of this memo.

remarks at the Center for New American Security Defense Forum, "We believe, strongly, that humans should be the only ones to decide when to use lethal force. But when you're under attack, especially at machine speeds, we want to have a machine that can protect us."[48]

It is one thing to issue policy statements, but quite another to actually *design* autonomous systems to carry out the desired plan. This is a critical point from a policy perspective, because although one can choose to abdicate various levels of decision-making to an autonomous machine, one cannot escape responsibility for the resulting actions. In highly autonomous systems, the system becomes opaque to the operator and these operators frequently ask questions such as: What is it doing? Why is it doing that? What is it going to do next?[49] It is difficult to see how an operator can fulfill his or her responsibility for the autonomous system's actions if these questions are being asked.

For these reasons, the bar is extraordinarily high for the U.S. government and especially the U.S. military to prove to the American public that it will not lose control of its robots. Many have expressed apprehension that the U.S. military might lose control of its unmanned systems, and *especially* its armed, unmanned systems. These fears have manifested themselves in many ways, most notably in Google discontinuing work on DoD's Algorithmic Warfare Cross-Functional Team, otherwise known as Project Maven.[50] This is especially concerning, as Project Maven had nothing to do with armed unmanned systems.

The Plan for Military Autonomous Systems

At the highest levels of U.S. policy and strategy documents, unmanned systems are featured as an important part of the way the Joint Force will fight in the future. The most recent *Quadrennial Defense Review* (*QDR*) notes, "Continuing a trend that began in the late 1990s, U.S. forces will increase the use and integration of unmanned systems." Elsewhere in the *QDR*, unmanned systems are identified as: "Maintaining our ability to project power." Importantly, the *QDR* highlights unmanned systems as a key part of the DoD's commitment to innovation and adaptation.[51]

The U.S. Department of Defense's vision for unmanned systems is to integrate these systems into the Joint Force. Because unmanned systems are used by all the military services, the Department of Defense publishes a roadmap to provide an overarching vision for the military's use of unmanned systems. An article published in *Inside the Navy* soon after the new roadmap's

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48 Remarks by Deputy Secretary of Defense Robert Work at the Center for New American Security Defense Forum, December 14, 2015.

49 The issue of "explainability" of autonomous systems has been addressed in both the professional and popular literature. See Matt Turek, "Explainable Artificial Intelligence (XAI)," *DARPA Website*, accessed at: https://www.darpa.mil/program/explainable-artificial-intelligence, and Cliff Kuang, "Can A.I. Be Taught to Explain Itself?" *The New York Times*, November 21, 2017, accessed at https://www.nytimes.com/2017/11/21/magazine/can-ai-be-taught-to-explain-itself.html.

50 See, for example, Daisuke Wakabayashi and Scott Shane, "Google Will Not Renew Pentagon Contract That Upset Employees," *The New York Times*, June 1, 2018, accessed at: https://www.nytimes.com/2018/06/01/technology/google-pentagon-project-maven.html.

51 *Quadrennial Defense Review* (Washington, D.C.: Department of Defense, 2014).

release noted, "The Defense Department's new 30-year unmanned systems plan—the first update of the roadmap in four years—aims to chart a three-decade guide for the rapidly developing field of unmanned systems technology."[52] The most recent roadmap, the *FY 2017-2042 Unmanned Systems Integrated Roadmap*, singled out the need for enhanced UxS autonomy, noting:

> DoD maintains a vision for the continued expansion of unmanned systems into the Joint Force structure, and identifies areas of interest and investment that will further expand the potential integration of unmanned systems. The intent of this document is to provide overarching strategic guidance that will align the Services' unmanned systems goals and efforts with the DoD strategic vision. This strategic guidance will focus on reducing duplicative efforts, enabling collaboration, identifying challenges, and outlining major areas where DoD and industry may collaborate to further expand the potential of unmanned systems. As DoD has embraced the use of unmanned systems across nearly every operating environment, this strategy will allow DoD to capitalize on the technology advancements and paradigm shift that unmanned systems provide.[53]

The *FY 2017-2042 Unmanned Systems Integrated Roadmap* goes on to list four foundational areas of interest that will accelerate the integration of unmanned systems. These include:

- **Interoperability**: Interoperability has historically been, and continues to be, a major thrust in the integration and operation of unmanned systems. Manned and unmanned systems have increasingly synergized their capabilities, focusing on the critical need to use open and common architectures. A robust interoperable foundation provides the very structure that will allow for future advances in warfighting.

- **Autonomy**: Advances in autonomy and robotics have the potential to revolutionize warfighting concepts as a significant force multiplier. Autonomy will greatly increase the efficiency and effectiveness of both manned and unmanned systems, providing a strategic advantage for DoD.

- **Network Security**: Unmanned systems operations ordinarily rely on networked connections and efficient spectrum access. Network vulnerabilities must be addressed to prevent disruption or manipulation.

- **Human-Machine Collaboration**: If interoperability lays the foundation, then human-machine collaboration is the ultimate objective. Teaming between human forces and machines will enable revolutionary collaboration where machines will be valued as critical teammates.[54]

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52 Jason Sherman, "DoD's New Unmanned Systems Roadmap Charts Course for AI, Weaponization," *Inside the Navy*, September 3, 2018.
53 *FY 2017-2042 Unmanned Systems Integrated Roadmap* (Washington, D.C.: Department of Defense, 2018), accessed at: https://news.usni.org/2018/08/30/pentagon-unmanned-systems-integrated-roadmap-2017-2042. The link is via an August 30, 2018 *USNI News* article entitled, "Pentagon Unmanned Systems Integrated Roadmap 2017-2042." The article provides a brief summary of the fifty-plus page report.
54 *FY 2017-2042 Unmanned Systems Integrated Roadmap*.

The report goes on to discuss the *Joint Concept for Robotics and Unmanned Systems* (JCRAS) which provides a vision for the employment of these systems in future warfighting scenarios out through 2035. Aligned directly with the previously discussed in *Joint Operating Environment 2035*, the JCRAS notes eight key attributes that robotic and autonomous systems (RAS) bring to the Joint Force:

- **Ability to learn:** Future RAS will learn through interaction with the environment, humans, and by accessing networked resources.

- **Greater situational awareness:** Future RAS will enhance awareness by collecting, processing, and prioritizing information from advanced sensor networks, which will transform data into knowledge for the warfighter. This will enable more effective operations in a complex, congested battlespace.

- **Enable higher performance:** Unlike manned and optionally manned systems, RAS have no human physiological limitations (e.g., fatigue). This allows for extended ranges and loiter times, persistent surveillance, and novel combinations of sensors and payloads on single platforms.

- **Improve efficiency and effectiveness:** More capable RAS will be able to perform additional joint tasks across the range of military operations, such as intra-theater airlift, mine operations, countering weapons of mass destruction, supply, and sustainment, while improving the efficiency and effectiveness of the force.

- **Provide greater flexibility:** Future RAS systems will be rapidly reconfigurable by exchanging modular hardware and/or by downloading new software that confers new capabilities. Future RAS multi-mission functionality will enable the Joint Forces to quickly adapt to meet varied or changing mission requirements.

- **Increase tempo by operating at machine speed:** RAS "think" at ever-increasing machine speeds. RAS can fuse data from networked ISR sensors, maneuver to an advantageous location, and act more quickly than adversary humans and RAS. Advanced data analytics, real-time processing, and alternate decision-making frameworks will enable commanders to decide and act faster than adversaries.

- **Provide potential to generate mass:** The current Joint Force manned inventory is based on relatively small numbers of highly capable, sophisticated, and expensive weaponry that cannot quickly be regenerated. RAS offers the opportunity to employ large quantities of inexpensive systems to generate mass.

- **Enable distributed and dispersed operations:** Adversary technologies will target U.S. forces with greater precision and range, placing legacy forces at increased risk. Using RAS for distributed and/or dispersed operations will enhance capability in the future operating environment.

As the *QDR* and *Unmanned Systems Integrated Roadmap* both note, unmanned systems are especially important assets in those areas where the U.S. military faces a peer competitor with robust defenses. The *Joint Operational Access Concept* identifies, "Unmanned systems, which could loiter to provide intelligence collection or fires in the objective area," as a key capability that is especially valuable in areas where an adversary has substantial defenses that can limit access of U.S. and coalition forces.[55] Additionally, unmanned systems are a key component in executing the United States AirSea Battle Concept (now re-branded as the *Joint Concept for Access and Maneuver in the Global Commons*, or JAM-GC) in high threat areas such as the Western Pacific, where adversary defensive systems pose an unacceptably high risk to manned aircraft and surface platforms.[56]

Designing in the Right Degree of Autonomy for Military Unmanned Systems

Most are familiar with the children's fable, *Goldilocks and the Three Bears*. As Goldilocks tastes three bowls of porridge, she finds one too hot, one too cold, and one just right. As the DoD and the military services look to achieve the optimal balance of autonomy and human interaction—to balance these two often-opposing forces and get them "just right"—designing this capability into tomorrow's unmanned systems at the outset, rather than trying to bolt it on after the fact, may be the only sustainable road ahead. If we fail to do this, it is almost inevitable that concerns that our armed unmanned systems will take on "HAL-like" powers and be beyond our control will derail the promise of these important warfighting partners.[57]

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[55] Department of Defense, *Joint Operational Access Concept*, (Washington, D.C.: Department of Defense, January 2012).
[56] *Joint Concept for Access and Maneuver in the Global Commons* (Washington, D.C.: Department of Defense, 2017), accessed via a January 27, 2017 *Joint Forces Quarterly* article: https://ndupress.ndu.edu/Media/News/Article/1038867/joint-concept-for-access-and-maneuver-in-the-global-commons-a-new-joint-operati/.
[57] One of the most iconic films of the last century, Stanley Kubrick's *2001: A Space Odyssey* had as its central theme, the issue of autonomy of robots (the unmanned vehicles of the time). Few who saw the movie can forget the scene where astronauts David Bowman and Frank Poole consider disconnecting HAL's (**H**euristically programmed **AL**gorithmic computer) cognitive circuits when he appears to be mistaken in reporting the presence of a fault in the spacecraft's communications antenna. They attempt to conceal what they are saying, but are unaware that HAL can read their lips. Faced with the prospect of disconnection, HAL decides to kill the astronauts in order to protect and continue its programmed directives. While few today worry that a 21st century HAL will turn on its masters, the issues involved with fielding increasingly-autonomous unmanned systems are complex, challenging and contentious. Kubrick's 1968 movie was prescient. Over half-a-century later, while we accept advances in other aspects of unmanned systems improvements such as propulsion, payload, stealth, speed, endurance and other attributes, we are still coming to grips with how much autonomy is enough and how much may be too much. This is arguably *the* most important issue we need to address with respect to military unmanned systems over the next decade. We have addressed this issue in a number of professional journals. See, for example, George Galdorisi and Rachel Volner, "Keeping Humans in the Loop," *U.S. Naval Institute Proceedings*, February 2015, and George Galdorisi, "Designing Autonomous Systems for Warfighters," *Small Wars Journal*, August 2016. "Bridging Multiple Autonomous Systems Disciplines," *Proceedings of the 2016 IEEE/MTS Oceans Conference*, Monterey, California, September 19-23, 2016, "The Rise of Autonomous Vehicles: The Impact on Maritime Operations," *Proceedings of the Maritime Security Challenges 2016: Pacific Seapower Conference*, Victoria, BC, October 3-6, 2016, "Designing Unmanned Systems for Military Use: Harnessing Artificial Intelligence to Provide Augmented Intelligence," *Small Wars Journal*, August 2017, "Designing Unmanned Systems for Military Use: Harnessing Artificial Intelligence to Provide Augmented Intelligence," *Small Wars Journal*, August 2017, "Unmanned Systems and the Re-emergence of Naval Expeditionary Capabilities," *RUSI Defence Systems*, December 2017, "Designing

A key to building the right degree of autonomy in unmanned systems intended for military use is to be mindful of the old saying, "where you stand depends on where you sit." Users and those who design unmanned systems often approach what they are trying to accomplish from different—often demonstrably different—points of view. A Naval Research Advisory Committee report identified four distinct points of view that must be reconciled in designing unmanned systems with the right degree of autonomy.

- **User View:** Can I give this platform a task, and trust it to accomplish it without constant attention? Can it recognize and deal with unexpected events or ambiguous tasking?
- **Robotics View:** Can I build a practical robot that does the right thing at the right time? Can I dynamically control, navigate, actuate, and instrument my robot? Can it manage and fuse data?
- **Machine Learning View:** Can my machine interpret complex sensors? Can it understand spoken language, interpret gestures, or recognize people or objects?
- **Cognitive View:** Can I make a machine that replicates elements of human intelligence like cognition, inference, and reasoning?[58]

As the U.S. military increases its reliance on unmanned systems for a plethora of reasons, it would be well-served to, at some point, decide that the platform is good enough, that is, it has the speed, endurance and other physical attributes necessary to perform its missions. Once that is set, then as suggested by the Defense Science Board report, the hard work of software development must become the driving priority.

Unmanned Systems: One U.S. DoD Use Case

The general aspiration to leverage big data, artificial intelligence and machine learning fails to address the critical question as to what *specific* tasks we want these technologies to help warfighters perform. At the root of the issue may be the U.S. military's lack of ability to translate

Unmanned Systems for the Multi-Domain Battle: Accelerating the Adoption of Augmented Intelligence," *Proceedings of the U.S. Army Training and Doctrine Command "Mad Scientist" Speaker Series*, January 10, 2018, "Time for a Strategic Shift in U.S. Military Unmanned Systems, *Small Wars Journal*, February 2018, "Producing Unmanned Systems Even Lawyers Can Love," *U.S. Naval Institute Proceedings*, June 2018, "Fielding Unmanned Systems Warfighters Can Employ: Leveraging Artificial Intelligence to Provide Augmented Intelligence*," Proceedings of the TechNet Asia-Pacific Symposium*, Honolulu, HI, November 12-16, 2018, "The Navy Knows It Needs AI, It Just Isn't Certain Why," *U.S. Naval Institute Proceedings*, May 2019, "Creating a Convergence of Technologies to Defeat the Deadly Fast Inshore Attack Craft Threat Before 2050," *U.S. Army TRADOC Mad Scientist Blog*, June 22, 2020, "Warfighting Demands Better Decisions. Who Will Make Them: A Man or a Machine?" *U.S. Naval Institute Proceedings*, June 2020, and "Defense Innovation Secrets: Providing AI Solutions the U.S. Military Needs," *Proceedings of the Defense TechConnect Virtual Innovation Summit and Expo*, November 17-19, 2020.

[58] Naval Research Advisory Committee, *How Autonomy Can Transform Naval Operations* (Washington, D.C.: Department of the Navy, October 2012), accessed at: http://www.nrac.navy.mil/docs/NRAC_Final_Report-Autonomy_NOV2012.pdf.

the needs of warfighters in a way that suggests technical solutions enabled by big data, artificial intelligence and machine learning. As former U.S. naval officers and ship commanding officers, our way of thinking about this issue takes us naturally to naval examples, but the concept is the same for an Army unit in a combat zone.

One way to begin to address this question is to think about what information a commander at sea needs. Whether it is Captain Isaac Hull seeking to take USS *Constitution* into action against HMS *Guerriere* in August 1812, or a carrier strike group commander today considering taking his ships into a potentially contested area such as the South China Sea, the commander needs three primary things to help him make the optimal decision.

He or she needs to know what is ahead of the force, needs to have that information communicated back to the flagship, and needs to make an informed decision. While today's naval commanders have a wealth of assets to help achieve these goals, there are gaps that big data, artificial intelligence and machine learning can help close *now*.

A strike group commander has many assets that can look ahead of the force to assess the tactical situation. He may use an MQ-4C Triton UAS to perform this scouting mission. Today, a Triton operator receives streaming video of what MQ-4C sees. But this requires him to stare at this video for hours on end (the endurance of the Triton is thirty hours), seeing mainly empty ocean spaces.[59]

Using big data, artificial intelligence and machine learning, the MQ-4C can be trained to send only video of each ship it encounters, thereby greatly compressing human workload. Taken to the next level, the Triton could do onboard analysis of each contact to flag it for possible interest. For example, if a vessel is operating in a shipping lane, has filed a journey plan with maritime authorities, and is providing an AIS (Automatic Identification System) signal, it is likely worthy of only passing attention by the operator, and the Triton will flag it accordingly. If, however, it does not meet these criteria (for example, the vessel makes an abrupt course change that takes it outside shipping channels or has no AIS signal), the operator would be alerted. As this technology continues to evolve, a Triton MQ-4C—or other UAS—could ultimately be equipped with classification algorithms that have the potential to lead to automatic target recognition.

Once the Triton has processed this information, big data, artificial intelligence and machine learning can help determine how to communicate with the flagship. In today's contested electronic warfare environment, different communications paths have varying levels of vulnerability. Prior to Triton's launch, the commander can determine the acceptable level of risk of communications intercept, as well as the risk of giving away the presence of the strike group.

Armed with this commander's intent, and using big data, artificial intelligence and machine learning, the Triton can assess the electronic environment, select from multiple communications paths, and determine which path offers the least vulnerability to intercept.[60] If the Triton

[59] For an excellent analysis of this data overload issue, see Gabe Harris, Cynthia Lamb, and Jerry Lamb, "Surf the Data Tsunami," *U.S. Naval Institute Proceedings*, February 2018.
[60] For more on how ANI can be used to leverage the electronic spectrum, see, Jonathan Vandervelde, "Disrupt the Spectrum with AI," *U.S. Naval Institute Proceedings*, May 2017, and Connor McLemore and Hans Lauzen, "The

determines that this vulnerability is too high, it can fly back toward the flagship and communicate via line-of-sight UHF. Given the size and growth potential of the Triton, it could even carry a smaller UAV and launch it back to the force to deliver this surveillance information.

Aboard the flagship, the commander must make sense of the data his sensors have collected and then make a number of time-critical decisions. Should he continue forward, wait, or retreat? Should he scout ahead, or in a different direction? Should he call on other forces, or are his organic assets sufficient to successfully complete the mission without undue risk to his forces? This is where big data, artificial intelligence and machine learning can make important contributions to help the commander make critical decisions.

Should the commander choose to forge ahead and force an engagement, big data, artificial intelligence and machine learning can do what today's rudimentary tactical decision aids cannot do—offer a range of options and assess the pros and cons of each one. Importantly, these technologies do not—and should not—make the decision, but rather provide the commander with sufficient, well-curated information so he can make the best decision faster than the adversary can react.

For lethal military unmanned systems, the bar is higher for what the operator must know before authorizing the unmanned warfighting partner to fire a weapon—or as is often the case—recommending that higher authority authorize lethal action. For example, consider the case of military operators managing an ongoing series of unmanned aerial systems flights that have been watching a terrorist and waiting for higher authority to give the authorization to take out the threat using an air-to-surface missile fired from that UAS.

Using big data, artificial intelligence and machine learning, the operator can train the unmanned aerial system to anticipate what questions higher authority will ask prior to giving the authorization to fire, and provide, if not a point solution, at least a percentage probability or confidence level to questions such as: What is level of confidence this person is the intended target? What is this confidence based on? Is it facial recognition, voice recognition, a pattern of behavior, association with certain individuals, the proximity of known family members or the proximity of known cohorts? What is the potential for collateral damage to family members, known cohorts or unknown persons? What are the potential impacts of waiting verses striking now?

These considerations represent only a subset of the kind of issues operators must train their unmanned systems armed with lethal weapons to deal with. Far from ceding lethal authority to unmanned systems, augmenting these systems with big data, artificial intelligence and machine learning and leveraging their ability to operate inside the enemy's decision loop, as well as ours, enables these systems to free the human operator from having to make real time—and often on-

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Dawn of Artificial Intelligence in Naval Warfare," *War on the Rocks*, June 12, 2018, accessed at: https://warontherocks.com/. In the latter article, the authors suggest, "The Navy should start to automate dynamic frequency allocation in communications."

the-fly—decisions in the stress of combat. Designing this capability into unmanned systems from to outset will ultimately enable them to be effective partners for their military operators.[61]

This brings us full-circle back to some of the concerns raised by Deputy Secretary of Defense Robert Work. He noted that when the enemy is attacking us at "machine speeds," we need to exploit machines to help protect us. Building unmanned systems with robust levels of big data, artificial intelligence and machine learning that can collaborate with operators in this effort is what will ultimately ensure that the unmanned systems we build reach their full potential to help our warfighters win in combat.

There is compelling evidence that the United States, and especially the U.S. military, must outpace our peer competitors in leveraging big data, artificial intelligence and machine learning. In its 2019 interim report, the National Security Commission on Artificial Intelligence was unequivocal in its analysis of how AI will be a game-changer. "AI will shape the future of power."[62] In 2020, *The Future of Defense Task Force Report* put the imperative to insert big data, artificial intelligence and machine learning into U.S. military weapons systems this way:

> The incorporation of AI into the military and national security realms will fundamentally change the way wars are fought and won. Whichever nation triumphs in the AI race will hold a critical, and perhaps insurmountable, military and economic advantage…The advent of algorithmic warfare, where AI-enabled weaponry driven by speed and precision compete in a complex battlespace, requires the United States to invest significantly in both offensive and defensive AI capabilities.[63]

We discussed the implications of inserting big data, artificial intelligence and machine learning by using the example of unmanned aerial systems, in this case, the MQ-4C Triton, because this is the warfighting area where most think about when the question of inserting these technologies arises. But there is another area where big data, artificial intelligence and machine learning can make an even greater impact in warfighting, and that is in the area of decision making.

A More Universal Use Case: Enhanced Decision Making

Military history is replete with examples where commanders who made the better decisions were victorious, even when their opponent had a geographic or material advantage, and these events need no retelling here. What *is* important to note is that in centuries past, leaders at all levels had

[61] For an analysis of the Navy's efforts to harness big data, artificial intelligence and machine learning, see, George Galdorisi, "The Navy Needs AI: It Just Isn't Certain Why," *U.S. Naval Institute Proceedings*, May 2019 and See Matt Turek, "Explainable Artificial Intelligence (XAI)," *DARPA Website*, accessed at: https://www.darpa.mil/program/explainable-artificial-intelligence.
[62] National Security Commission on Artificial Intelligence, *Interim Report* (Nov. 2019) (online at https://www.epic.org/foia/epic-v-ai-commission/AI-Commission-Interim-Report-Nov-2019.pdf).
[63] House Armed Services Committee, *The Future of Defense Task Force Report* (Washington, D.C., House Armed Services Committee, 2020), accessed at: https://armedservices.house.gov/_cache/files/2/6/26129500-d208-47ba-a9f7-25a8f82828b0/6D5C75605DE8DDF0013712923B4388D7.future-of-defense-task-force-report.pdf.

hours, or even days, to make crucial decisions. But by the middle of the last century, warfare changed in ways that dramatically compressed the decision cycle.

During the Korean War, Russian MiG-15s and American F-86 Sabres fought heated battles for mastery of the air. Seeking to find a way to mitigate U.S. combat losses, Air Force Colonel John Boyd created what we know today as the OODA Loop. OODA stands for: Observe, Orient, Decide and Act. Boyd's concept was that the key to victory was to create situations where one can make appropriate decisions more quickly than one's opponent can.

Boyd's construct was originally a theory of achieving success in air-to-air combat, developed out of his energy-maneuverability theory and his observations on air-to-air combat between MiG-15s and North American F-86 Sabres in Korea. Harry Hillaker—chief designer of the F-16—said of the OODA theory, "Time is the dominant parameter. The pilot who goes through the OODA cycle in the shortest time prevails because his opponent is caught responding to situations that have already changed."[64]

It is clear to even non-military observers that air-to-air combat is arguably one of the most stressful military operations. But increasingly, military leaders became more aware that stress—and especially the inability to process information—caused military operators begin to have their own OODA Loops unravel and make suboptimal decisions.

The challenge of making crucial military decisions under stress found its way into popular culture in the 1965 movie, *The Bedford Incident*. Loosely based on a number of Cold War incidents between U.S. Navy ships and Soviet submarines, the plot line of the movie revolves around the cat-and-mouse game between an American destroyer, USS *Bedford* (DLG 113), and a Soviet submarine.

The *Bedford's* crew becomes increasingly fatigued by the days-long search for the submarine. As the urgency to find the Soviet adversary intensifies, *Bedford's* captain ignores warnings that his crew is wilting under the pressure and ratchets up his demands, even running over the diesel submarine's snorkel. When someone asks the captain if he will take the first shot against his adversary, he replies that he will not, but "If he fires one, I'll fire one." A tired ensign mistakes his captain's remarks as a command to "fire one," and fires an anti-submarine rocket that destroys the submarine, but not before it launches a nuclear-armed torpedo which annihilates the ship.

While fiction, *The Bedford Incident* was eerily prescient of a real-world event fifty-five years later. While a full investigation of the January 2020 Iran Revolutionary Guard shoot-down of a Ukrainian jetliner will take months, or even years, what is known today is that in the stress of combat, where Iran had just fired a barrage of ballistic missiles at U.S. military forces, the country was on high alert for an American counterattack.[65]

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[64] Harry Hillaker, "John Boyd, Father of the F-16," *Code One Magazine*, July 1997.
[65] While there are a plethora of news reports regarding this tragic incident, one of the best it, "Iran plane crash: Ukrainian jet was 'unintentionally' Shot Down, BBC News, January 11, 2020, accessed at: https://www.bbc.com/news/world-middle-east-51073621

Somewhere in the Iranian intelligence or military chain of command, a warning of incoming cruise missiles was issued. The officer in charge of an anti-air missile battery tried to reach his higher-echelon command center for authorization to shoot. Tragically, he could not get through, and armed with incomplete information, he fired two anti-aircraft missiles and 176 people died.

These incidents—one fictional and one all-too-real—had one thing in common: Humans were forced to make crucial decisions with insufficient or erroneous information. In the case of *The Bedford Incident* it was the air gap between humans a few feet apart. In the case of the Ukrainian aircraft shoot down, it was the inability to communicate, as well as the incorrectly perceived threat.

It would be easy to dismiss incidents like those described above as either implausible fiction or decisions made by militaries that are inferior to the U.S. military, but that would be a tragic mistake. All military personnel are challenged to make optimal decisions today. Why? It is because the speed of warfare often exceeds the ability of the human brain to make the right decision.[66] Indeed, as Dr. Alexander Kott, Chief Scientist at the U.S. Army Research Laboratory, put it at a command and control conference, "The human cognitive bandwidth will emerge as the most severe constraint on the battlefield."[67]

A U.S. Air Force *Technology Horizons* report stated the challenge this way, "Although humans today remain more capable than machines for many tasks, natural human capacities are becoming increasingly mismatched to the enormous data volumes, processing capabilities, and decision speeds that technologies offer or demand. Closer human-machine coupling and augmentation of human performance will become possible and essential."[68] For these reasons and others, the Navy needs big data, artificial intelligence and machine learning to give its warfighters the edge in combat.[69]

This challenge should come as no surprise to those of us who use technology today. As anyone with a smart phone learns soon after turning the machine on, having access to sufficient data is rarely an issue. What is sometimes overwhelming is sorting through vast amounts of data and trying to tease out only what is essential at the moment. From a warfighting perspective, this

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[66] Lee Bennett addressed this challenge in his article, "Fight Information Overload," where he noted, "There are human limits to quickly understanding, retaining, and implanting critical information." *U.S. Naval Institute Proceedings*, July 2017.

[67] Keynote Address, 22nd Command and Control Research and Technology Symposium, Los Angeles, CA, November 7, 2017.

[68] *Technology Horizons: A Vision for Air Force Science and Technology 2010-2030*, accessed at: http://www.defenseinnovationmarketplace.mil/resources/AF_TechnologyHorizons2010-2030.pdf.

[69] A significant part of this emphasis on leveraging big data, artificial intelligence and machine learning for U.S. military applications is the fact that potential adversaries are fielding this capability in their weapons systems, often faster than the U.S. military is doing so. See, for example, the Naval Research Advisory Committee report, *Autonomous and Unmanned Systems in the Department of the Navy* (Washington, D.C.: Naval Research Advisory Committee, September 2017).

means having systems that present a decision-maker with only that well-curated information that helps him or her make better decisions, often in the stress of combat.[70]

The Current Strategy Forum, held each spring at the Naval War College, is the U.S. Navy's annual conference to discuss and assess the Navy's contributions to national and international security. While each forum has its highlights, the 2017 event will likely be remembered as one where the Chief of Naval Operations talked with his hands. That's right, Admiral John Richardson, a nuclear submariner—not a fighter pilot—talked with his hands and took the audience back to an aviation tactic invented over seven decades ago.[71]

The CNO turned the clock back to the 1950s to Air Force Colonel John Boyd and the OODA Loop. Admiral Richardson used the OODA Loop as a way of discussing the kinds of new technologies the U.S. Navy is fielding.[72] He noted that the Navy has already invested heavily in the Observe and Act parts of Boyd's taxonomy. He pointed out that until the advent of emerging technologies such as big data, machine learning, and artificial intelligence, we could not do much about the Orient and Decide aspects of the OODA Loop, but that today we can.[73]

This is precisely why the CNO used Boyd's OODA Loop in his remarks. He explained that today's naval warfighters have an enormous—even overwhelming—amount of data to deal with. They need big data, artificial intelligence and machine learning to curate this data to present only that information that helps decision makers and those pulling the trigger make better decisions faster. It is easy to see that this effort to turn data into tactically useful information is important to all aspects of warfighting, not just fighter tactics.

It may be time to build upon the U.S. military's decades-long efforts to help warfighters make better decisions. The Navy has been at the forefront of leveraging technology to help warfighters make better decisions faster with fewer people and fewer mistakes in stressful situations. In the 1980s, the Office of Naval Research initiated a program to study how warfighters could make better decisions in high stress situations. Dubbed TADMUS (Tactical Decision Making Under Stress) this initiative used cognitive science to break new ground in understanding how decision makers make decisions.[74] This led to several prototypes (Multi-Modal Watch Station, Knowledge Wall and others) designed by scientists and engineers at Naval Information Warfare

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[70] A classic case where this did not happen was in July 1988 when USS *Vincennes* shot down Iran Air flight 655. See, Anthony Tingle, "The Human-Machine Team Failed Vincennes," *U.S. Naval Institute Proceedings*, July 2018. The author noted, "Technology must create time for the commander, mitigating compression while presenting the proper information to the warfighter, at the correct time, and in a useful and usable format."

[71] Richard Burgess, "CNO: Precision Era Gives Way to Decision Era," *Seapower Magazine Online*, June 13, 2017, accessed at http://seapowermagazine.org/stories/20170613-CNO.html.

[72] Discussions of the OODA Loop are making resurgence in professional journals. See, for example, Carl Governale, "Brain-Computer Interfaces Are Game-Changers," U.S. *Naval Institute Proceedings*, August 2017, and, John Allen and Amir Husain, "AI Will Change the Balance of Power," *U.S. Naval Institute Proceedings*, August 2018.

[73] Details of the Current Strategy Forum, held June 13-14, 2017 at the U.S. Naval War College, can be found at the following link: https://www.youtube.com/playlist?list=PLam-yp5uUR1ZUIyggfS_xqbQ0wAUrGoSo. This includes a one-hour video of the CNO's remarks.

[74] One of the best works that explains the TADMUS system is Janis Cannon-Bowers and Eduardo Salas, *Making Decisions Under Stress* (Washington, D.C.: American Psychological Association, October 1998).

Center Pacific that were beta-tested and which achieved promising results in helping decision makers achieve improved decisions.[75]

TADMUS—along with similar programs—was good as far as it went. But as Admiral Richardson pointed out in his Current Strategy Forum remarks, until recently, the technology to take enhanced decision making to the next level did not exist. Today it does, and leveraging what big data, artificial intelligence, and machine learning can provide to warfighters may well lead to the next breakthrough in naval warfare, especially in the area of decision making. Naval Information Warfare Center Pacific, along with partners through the Navy R&D community, industry and academia, is leading efforts to ensure that U.S. warfighters are equipped to make better decisions, faster, with fewer people and fewer mistakes.

Moving Forward To Fully Leverage Big Data, Artificial Intelligence, and Machine Learning

At the highest levels of U.S. strategic and military guidance, big data, artificial intelligence and machine learning are identified as vitally important to providing the American military with a warfighting edge. And increasingly, those with stewardship for integrating these technologies into U.S. military platforms, systems, sensors and weapons have identified decision making as an important area where these technologies can add the most value.

In an address at the AFCEA/Naval Institute "West" Conference, the Navy's budget director, Rear Admiral Dietrich Kuhlmann, put the question of how the Navy can best use big data, artificial intelligence and machine learning this way: "How do we leverage AI, not to produce autonomous platforms that kill people, but to give commanders the edge in combat?"[76] Indeed, the essence of what the U.S. Navy—and by extension, the U.S. military—wants to do with big data, machine learning and artificial intelligence is not to launch Terminator-like unmanned systems downrange against our adversaries with no human oversight, but to help operators make faster, more-informed decisions.

Military operators will *always* be in-the-loop, and will be assisted by big data, machine learning and artificial intelligence. What the military wants to achieve with these cutting-edge technologies—whether applied to unmanned systems or to other aspects of warfighting—is to get inside the adversary's OODA loop.

In an address at the Naval War College, the Director of DoD's Joint Artificial Intelligence Center, Lieutenant General Jack Shanahan, put it this way: **"The most valuable contribution of AI to U.S. defense will be how it helps human beings to make better, faster and more precise decisions, especially during high-consequence operations."**[77]

[75] See, for example, Glenn Osga et al, "'Task-Managed' Watchstanding: Providing Decision Support for Multi-Task Naval Operations," *Space and Naval Warfare Systems Center San Diego Biennial Review*, *2001* and Jeffrey Morrison, *Global 2000 Knowledge Wall*, accessed at: http://all.net/journal/deception/www-tadmus.spawar.navy.mil/www-tadmus.spawar.navy.mil/GlobalKW.pdf.
[76] Rear Admiral Dietrich Kuhlmann, AFCEA/Naval Institute "West" Conference, February 6, 2018.
[77] Remarks by General John Shanahan at the U.S. Naval War College Artificial Intelligence Symposium, December 10, 2019.

It is clear that the U.S. Department of Defense has recognized that warfighters drowning in a sea of data cannot make effective decisions, and has sought to harness technologies such as artificial intelligence and machine learning to help curate the data and present only information that is useful in the heat of battle.

In his War College remarks, General Shanahan addressed the opportunities and challenges of leveraging big data, artificial intelligence and machine learning to help warfighters make better decisions when he noted, "There is a chasm between thinking, writing and talking about AI, and doing it. There is no substitute whatsoever for rolling up one's sleeves and diving into an AI project."[78]

More recently, the new Director of DoD's Joint Artificial Intelligence Center, Lieutenant General Michael Groen, put the emphasis on decision-making this way:

> When I think about artificial intelligence applications, I'm thinking beyond just the use case of near-instantaneous fires upon the detection of a target. There is a broad range of decision-making that has to occur across the joint force that can be enabled by AI.[79]

In 20th Century warfare, the unit of measure for military superiority was tanks, ships or aircraft and the ability to "out-gun and out-stick" an opponent. In 21st Century warfare, where military leaders have minutes or even seconds to make crucial decisions, the ability to out-think an adversary will spell the difference between victory and defeat.

As the U.S. military and its defense industry partners shape their R&D investment decisions in the third decade of the 21st Century, it is well-past time to focus on a long-neglected area—the minds of our military decision makers—and ensure that they can make better decisions, faster and with fewer errors than their adversaries.

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[78] Remarks by General John Shanahan at the U.S. Naval War College Artificial Intelligence Symposium, December 10, 2019.

[79] Sydney Freedberg, "Military AI Is Bigger Than Just the Kill Chain: JAIC Chief," *Breaking Defense*, November 4, 2020.