FUTURE OPERATIONAL ENVIRONMENT: FORGING THE FUTURE IN AN UNCERTAIN WORLD

2035-2050

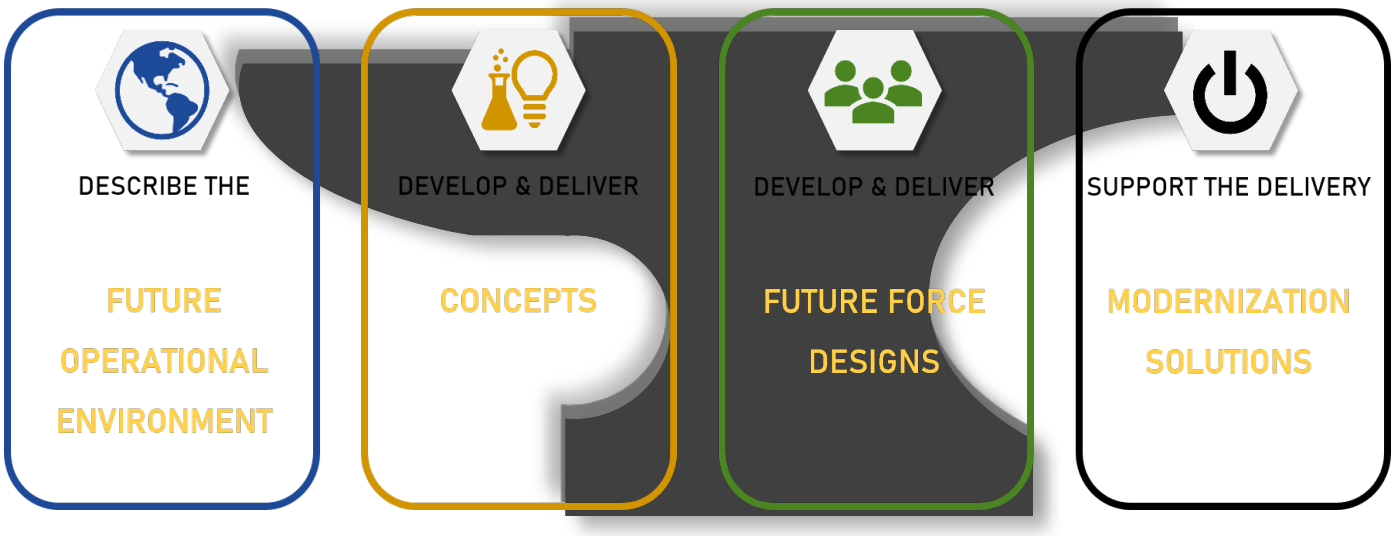
"The Future Operational Environment will force us to think differently and seek opportunities in nontraditional space. If we do not imagine large and reach deep, we will not be successful in future battlefields"

-General John "Mike" Murray

U.S. ARMY FUTURES COMMAND

"We do not want to get to 2035 to find we have fallen behind.
We want to aim ahead of the competition and not behind it."
-General John "Mike" Murray

WHAT WE DO



Foreword

From the Commanding General, Army Futures Command

The greatest validation of Army Futures Command would be that the Army never finds itself in another global conflict against a peer or near-peer adversary. This is, and always has been, about deterrence. It will always be about deterrence. The goal is not to win the future conflict – but to never get into the conflict in the first place. The best way to deter conflict is to demonstrate that you can fight and win if you have to.

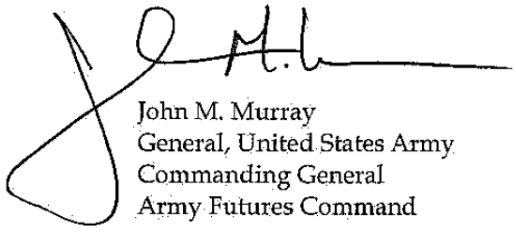
Conflict is not the only kind of future contestation that we need to prepare for – we also have to compete successfully and aggressively. Our adversaries view competition as a constant, not the exception. For them, the competition is not primarily military. They compete across the whole spectrum, including diplomatically, economically, and in the information space. Our adversaries have been remarkably successful so far in achieving their strategic objectives below the threshold of conflict, in ways that are contrary to our own interests.

In the future, we need to deter conflict, and we need to temper aggressive competition by our adversaries that undermines our own national interests.

To do that, we need to be able to see the future as clearly as possible. We're never going to be exactly right – and that's okay – but we need a baseline to guide our thinking and decision-making. What adversaries, with what intentions, are we likely to face? And how are they likely to apply the emerging array of advanced technology?

This document offers a way of thinking both rigorously and creatively about the future…about "what could be". I invite you to explore it, stretch its limits, and help us think harder about the future environment we may face.

Forge the Future!



John M. Murray
General, United States Army
Commanding General
Army Futures Command

Introduction & Scope

This document describes the U.S. Army's Future Operational Environment (FOE). It is not meant to predict "what will be," but rather explores "what could be." It includes several plausible alternative views of the future out to 2050, and therefore is foundational to the development of concepts *beyond* the Multi-Domain Operations (MDO) timeframe. It attempts to explore and focus operational concepts in order to develop capabilities that will deter potential adversaries and, if necessary, fight and win the Nation's wars. It employs the first two steps of the Intelligence Preparation of the Battlefield (IPB) process—defining and describing the effects of the environment—and is intended as a basis for Army deliberation and decision-making about concepts, capabilities, force design, and S&T investments. Judgments expressed in the document are not definitive – there are no 'right answers' about a dynamic, uncertain, and rapidly-changing world. Neither is the document a detailed description of future adversaries. Rather, it reviews two key drivers and explores their potential influence on the FOE through the use of descriptive alternative futures.

The document has two main sections. First, it introduces two key factors critical to deliberations about Army Modernization: (1) concentration of global power, and (2) global technological innovation. Second, it presents four alternative futures to explore how different values of these two factors might interact in the future, as well as implications for adversaries' use of diplomatic, information, military, and economic instruments of power. The document also includes an annex describing several global-level structural trends common to each of the four alternative futures.

This document serves as the starting point for a new running estimate. It is written to aid creative thinking about "the realm of the possible," and to generate topics for follow-on rigorous intelligence analysis based on Army Modernization priorities. Ideally, Senior Leaders will use inferences derived from this iterative process to continually describe and visualize the changing character of competition and conflict, through wargame-based experiments or other means.

Each of the four alternative futures presented in this document possess unique features. Several common themes emerged, as well:

The U.S. Army must be prepared to deter, or fight and win, against a range of highly capable actors and across multiple domains in the Future Operational Environment of 2035-2050.

Adversaries will leverage various technologies to blur the distinction between war and peace, conflict and competition.

Advancements in robotics, artificial intelligence (AI), quantum computing and navigation, nanomaterials, synthetic biology, direct-energy weapons, and hypersonic missiles all complicate this picture, increasing the complexity and speed of battle.

Russia, China, and other states will continue to challenge the United States for strategic and economic resources and influence around the world.

The proliferation of lethal technologies will afford opportunities for a range of other actors – from smaller states to a range of non-state actors – to challenge Army forces in certain contexts.

Key Factors

The two key factors that frame the four alternative futures are: (1) concentration of global power, and (2) global technological innovation. Notably, these factors maintain a natural relationship with one another: technological innovation can contribute to power, and power and resources can lead to greater innovation. This dynamic is referenced in the alternative futures where technological innovations are leveraged by superpowers to maintain power or by ascendant states to compete with hegemons.

Factor 1: Concentration of Global Power

The concentration of global power plays a crucial role in determining the prevalence and character of future conflict and competition. Here, power is defined as a function of a state's resources in relation to that of other states in the world: the relative capacity to leverage economic, natural, population, geographical, and military resources to influence (including coerce) behavior, achieve objectives, or deny others' objectives; diplomatic resources to induce cooperation and forge, monitor, and enforce international institutions; and informational or cultural resources to generate attention, trust and credibility and mobilize constituencies.

There exist at least three broad system-types of concentration of global power, determined by the number of "Great Power states": unipolar, bipolar, and multipolar. While a unipolar system emerged at the end of the Cold War, the 2017 National Security Strategy and 2018 National Defense Strategy recognized that the United States

could no longer presume political, economic, or security dominance. Based on this guidance and future trends, the alternative futures in this document explore only the latter two broad types of concentration of global power.[i]

Bipolar System

The classic case of a bipolar world is the Cold War between the U.S. and the Soviet Union that dominated the second half of the 20th century. In this type of order, power is held relatively equal between two states. Relations between these two "superpowers" might range from intensely competitive to détente and, in limited cases, cooperative. Although military parity and potential economic interdependencies would lower the risk of large-scale conflict between the two states, some forms of protracted zero-sum competition would be very likely. Threats in this future, as well as opportunities for greater security, would also emerge from second-tier states and regional powers. These states may pursue their own security by allying with a superpower or forming coalitions amongst themselves to protect against or challenge superpower power projection. Moreover, regional rivalries among competing states could draw the superpowers into localized disputes, especially if they threaten access to critical resources.

This system, comprising only two Great Powers, is considered to be the least likely to change and therefore most stable. However, stability does not guarantee peace. In a bipolar system, the hegemons (and their allies) will likely engage in constant efforts to balance one another's strengths, but primarily in ways that avoid triggering large-scale conflict. Even as Great Powers prioritize preparing their militaries for large-scale conflict, they would be more liable to engage their militaries in proxy conflicts, civil wars, or other conflicts—events that may be protracted and lethal but that fall short of large-scale conflict with a Great Power competitor.

Multipolar System

Alternatively, concentration of global power may be more widely distributed across three or more actors. The classic case of a multipolar world is that of Europe on the eve of World War I. Historically, the rise and fall of great powers is attributed primarily to shifts in the distribution of material power—for example, as nodes of innovation and productivity move from superpowers to other actors in the international system, resulting in changes in relative economic growth. Additionally, a state can squander its position if the defense costs of maintaining international commitments undermine other domestic investments and economic health. Multipolar systems are inherently less stable than bipolar systems: in these systems, it is harder for states to judge and maintain "balance" among competing poles (each of which often include multiple states). Moreover, interstate allegiances – especially those among weaker and geographically-peripheral states – are more likely to shift than in a bipolar system, potentially resulting in rapid power imbalances and opportunities for conflict.

Multipolar systems are more likely to result in the formation of multiple systems of security alliances: the absence of outsized diplomatic and military "checking" influence of hegemons may raise mutual fears among near-peer competitors, and therefore preemptive coalition-building. Whether this dynamic results in greater stability or instability depends on the potential for incompatibilities and clashes across myriad global interests and the resulting alliance network.

Notably, there is heightened risk associated with *transitioning* among unipolar, bipolar, and multipolar system states. This will occur as rising states, in their search for security, wealth, and/or greater influence, attempt to balance against or change the existing concentrations of global power. This risk also exists when declining powers attempt to regain influence or placate restive domestic constituencies by launching wars of choice. Ascending powers may also become more aggressive in their pursuit of resources or reputation, including once they perceive that they have sufficient capabilities to enforce their will.

Factor 2: Global Technological Innovation

Global technological innovation will shape future competition and conflict, affecting the nature of military applications and influencing strategy. However, the trajectory of innovation remains uncertain and nonlinear. Our alternative futures consider two broad trajectories—"evolutionary" and "revolutionary" technological innovation. Most innovations would be considered *evolutionary*, consisting of gradual, incremental, and continuous improvements to existing concepts and systems. *Revolutionary* innovations, on the other hand, result in rapid, leap-ahead improvements to existing concepts and systems, or even completely new ways of solving problems, potentially transforming markets and economic activity.

To simplify, the alternative futures maintain a key assumption: whether in an evolutionary or revolutionary world, all hegemons and ascendant states will adopt *any accessible* technological innovation and employ it to its fullest military potential. Of course, in reality there are several factors bridging the sometimes yawning gap between initial R&D investment and effective military fielding,[ii] [iii] many of which are discussed below. Any such factors that are overlooked in the alternative futures – for example, variation in technology adoption capacity and employment – represent promising subjects for future alternative analyses.

Public and Private Incentives and Investments

Technological trends largely depend on the interaction of global public and private investments in basic and applied research. We have experienced historical periods in which the preponderance of inventions emerges from outside of the military and are pulled into warfighting (i.e., dual-use application); as well as periods in which the private sector co-opts and commercializes technologies derived from military

investment in basic and applied research. Innovation trends will track public and private incentives to invest in (a) more predictable and incremental improvements to existing technologies to solve current and emerging problems, versus (b) more unpredictable, risky, costly, and time-consuming leap-ahead technologies.

Some breakthrough technologies envisioned for the future, even if successfully demonstrated in the lab or by prototype, may not be cost-effective to scale. For example, full autonomy, general artificial intelligence (i.e., humanlike), and genetic engineering are all possible, but their broad exploitation by the military is unclear due to nonlinear technological development cycles. Moreover, certain novel technologies or applications may prove too fragile for battlefield application until further breakthroughs in production technology emerge.

Excludability and Diffusion

Many investment decisions hinge largely on the "excludability" of innovations—i.e., whether conditions limit knowledge diffusion and confer first-mover advantages. Under such scenarios, developers enjoy monopolies, ideally for periods of time sufficient to cover investment costs. Military research and development programs may be a source of such innovations. These programs may be exceedingly expensive for commercial investment or highly complex relative to commercial applications—especially if necessary components or data are unavailable on commercial markets—and will thereby preclude emulation. Successful exclusion of key military technologies could result in further concentration of military power among existing powers. However, some technologies may be subject to deliberate, strategic diffusion via trade or bilateral or multilateral agreements with states or non-state partners, thereby resulting in greater military parity and interoperability.

If, instead, innovations are non-excludable and rapidly or indiscriminately diffused, then investments in leap-ahead technologies and systems will be discouraged by a second-mover advantage in which competitors can avoid incurring substantial R&D costs. This kind of diffusion can occur due to increasingly sophisticated communications technologies and dense information networks, widespread commitments to open-source development, plausible reverse-engineering and mimicry (including the ability to accommodate production costs), economic and intellectual espionage and theft, or where breakthroughs have significant profit potential and are rapidly commercialized. In some cases, competitors may include even small, non-state actors who would be able to acquire and refine technologies of coercion that had previously been the domain of great powers. If a free-riding, second-mover strategy prevails globally, technological innovators will be less inclined to pursue unproven science and technology, and revolutionary innovations may occur largely in the private sector and even more as a result of fortuitous adaptations and combinations of existing technology. In fact, this resembles current private sector trends: companies tend to

hedge by placing many small bets, often involving new applications of commercially available off-the-shelf (COTS) products, especially regarding software innovations.

Adoption Capacity

The relative influence of technological inventions and innovations is informed by the state's educational system (or access to others' educational systems), the industrial base available to serialize production, and how the military adopts and uses technologies. Key hurdles to widespread adoption include whether innovations are sufficiently understood, usable, predictable, and serviceable. Militaries will be challenged to envision strategic possibilities and must be willing to commit to technology adoption despite potential disruptions to their existing force structure, personnel roles and status, military culture or identity, and bureaucratic norms.

Furthermore, many feasible technological innovations may engender profound ethical dilemmas—e.g., different forms of genome editing, bioweapon production, and human enhancements—and their proliferation will be limited by a degree of societal tolerance as well as international and domestic institutions, including cultural norms and standards-of-use agreements. Still, widespread proliferation of technologies may also result in variable adherence to legal or ethical standards, undermining control-of-use agreements.

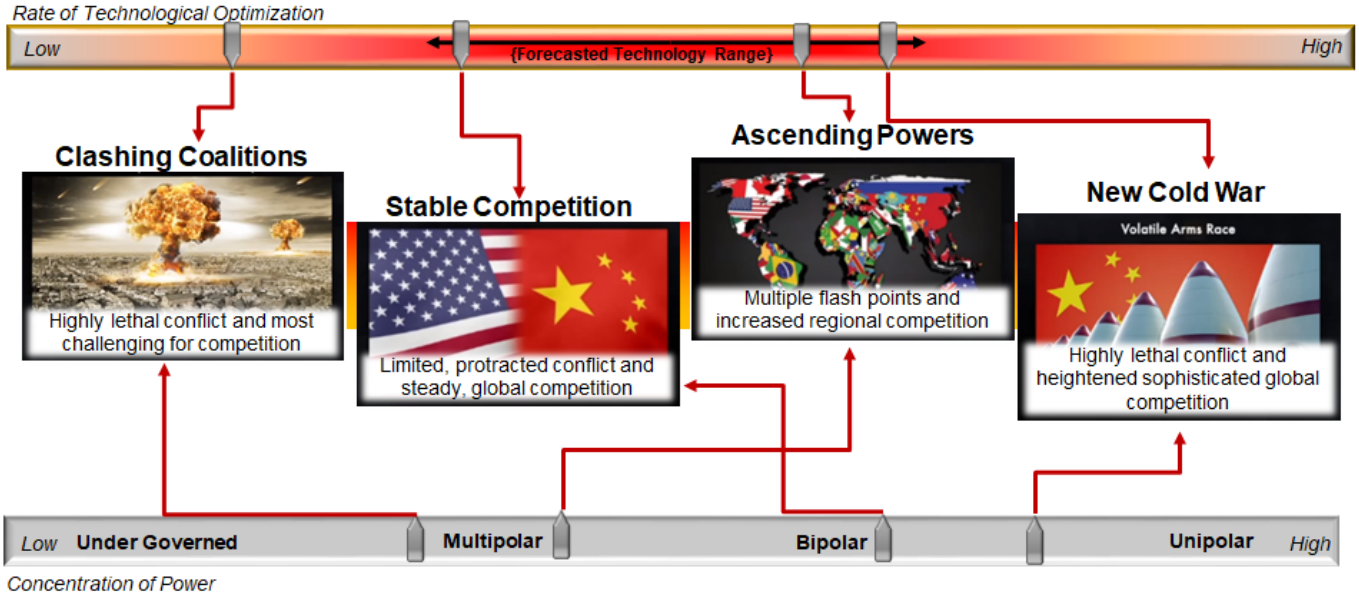
The Alternative Futures

This document generates four distinct alternative futures, presented below: (1) a bipolar system with revolutionary technological innovation, (2) a multipolar system with revolutionary technological innovation, (3) a bipolar system with evolutionary technological innovation, and (4) a multipolar system with evolutionary technological innovation.[iv] More attention is devoted to the first two alternative futures, as they are deemed most consequential to the U.S. Army. There are innumerable pathways leading us to these four alternative futures, and these will be subjects for future alternative analyses. Still, we can point to several likely key change factors.

For example, for China to achieve superpower status, it will likely have to overcome a wide range of current domestic challenges to sustainable economic growth and global power projection: a rapidly aging population and the absence of a social safety net, corruption and potential for social unrest, a polluted environment, low productivity and inefficient state enterprises. It will have dispersed its production activities globally to challenge U.S. multinational corporations, improved its domestic manufacture of infrastructure, and invested sufficiently in human capital to ensure a strong base for the sustainable generation of wealth. Critically, China will have become

a technological powerhouse and developed the capacity to transform its economic and technological growth into military capability.

Likewise, many factors will be key to bringing about a multipolar world, either by contributing to the ascension of lower-tier states or to the decline of superpowers (including the U.S.). These would likely include the relative size and sophistication of one's scientific, industrial, and human capital bases; whether investments correspond with growing productivity; the ability to convert economic growth and wealth into military capacity; the extent of a state's stockpile of sophisticated military systems; the ability to coordinate the production of needed weapons systems with a capacity to employ those weapons in a coordinated manner; the ability to cultivate security and economic alliances; and the ability to avoid unsustainable domestic expenditures including commitments to aging populations or management of social and political unrest.



Alternative Future #1: The New Cold War

In this alternative future—a bipolar system with "revolutionary" technological innovation—the U.S. and China compete to achieve global primacy. Aggressive and active competition, rather than kinetic warfare, dominates the U.S.-China relationship. Advanced weapons and economic interdependencies are deterrents to large-scale conventional warfare, but China pursues its strategic goals partly through a series of proxy conflicts around the world and by demanding acquiescence to its extractive economic policies. Lower-tier powers and non-state actors still remain capable of presenting substantial threats – as well as opportunities for security cooperation – thereby influencing global geopolitics, albeit in more limited ways.

There exists a discernable gap in global economic, diplomatic, military, and cultural influence between the superpowers and all others. Superpower competition is

the primary driver of global trade and diplomacy. It is shaped by U.S. promotion of a liberal-democratic order that values individual freedom and choice, versus China's promotion of authoritarian socialism that endorses safety and predictability via centralized control and intensive social monitoring. China continues to proffer their system as an alternative to that of the West, primarily to guarantee its own security, sovereignty, and economic advantages. There is intense competition over access to and control of markets, commodities, and the global commons. Technology continues to shape Chinese diplomatic efforts such as the Belt and Road Initiative 2080, the next-generation Digital Silk Highway, and the spread of 7G across Europe, the Middle East, Africa, and the Americas. Although the U.S. and China may cooperate on less-contentious issues like counter-piracy, disaster relief, and terrorism, both will seek to exploit crises (e.g. pandemics, natural disasters, social, economic and political crises) to gain advantage.

By 2050, China is the largest economy in the world. The Yuan, or a new digital currency backed by China, competes with the dollar as the global reserve currency. Despite concerns over global supply chains and a trend toward protectionism and nationalism – including China's cultivation of exclusive, regional economic blocs – there remains extensive economic interdependence between the U.S. and China, especially concerning critical, niche resources like rare earth materials. Global economics are heavily influenced not only by traditional factors such as trade agreements and technology transfer, but also by digital trends in cryptocurrency, digital citizenship, and algorithmic trading. In pursuit of ambitious economic goals, China invests heavily in disruptive technologies (e.g., artificial intelligence, autonomy, quantum information sciences, and next-generation communications technology) for commercial and military application to secure advantages over the U.S. across key sectors such as space, biotechnology, and quantum computing. Such applications may include sophisticated AI algorithms to defend against hypersonic and supersonic missiles; swarms of smart sea mines to block commercial shipping; constellations of automated sensors to detect and identify various actors in the Operational Environment; the use of quantum computing to create large-scale simulations of large-scale military deployments; and detailed modeling of complex synthetic biological applications.

China continues its military growth and modernization efforts by developing and fielding advanced technologies. The People's Liberation Army (PLA) continues to exploit the space and cyber domains and is increasingly proficient in semi-independent maneuver, extended expeditionary capabilities, hypersonic and supersonic missiles, advanced long-range precision fires, and directed energy weapons. China possesses advanced capabilities to launch covert attacks on critical U.S. space assets, degrading surveillance and navigation capabilities.

Furthermore, the PLA is structured to win in the competition space. In the cyber domain, China attacks vital U.S. financial assets via AI-enabled malware and ransomware, degrading and disrupting the U.S. economy. China invests in its ability to

target U.S. civilian and military logistics systems, infrastructure, and installations and to impede U.S. naval and expeditionary maneuver—for example, by cyber-directing autonomous merchant traffic into congested SLOC and port facilities. It wields sophisticated instruments of economic warfare to secure favorable security and economic outcomes, threatening American partners with economic isolation and otherwise seeking opportunities to drive wedges in U.S. alliances. China also funds, arms, and trains state and nonstate actors to confront the U.S. in areas of strategic interest. Selective diffusion of revolutionary technologies to proxies kicks off regional arms races—especially involving technologies characterized by speed and lethality—and potentially draws the U.S. Army into outbreaks of regional conflict.

Access to and control of information continues to be a strategic commodity, particularly in a world of advanced artificial intelligence (AI). China seeks to obtain large amounts of information, secure their own information and communications (quantum key encryption), capture adversarial information (quantum sensing), and disrupt adversaries' abilities to communicate effectively (electronic warfare/anti-satellite). This alternative future is characterized by persistent information warfare, with AI-generated deep-fake images, videos, and messaging sowing confusion, misleading planners, exploiting and deepening social divides, and eroding trust. Due to an inherent cognitive bias to "anchor" on any information received first, mass-produced disinformation campaigns favor early-moving, *offensive* actors. Information warfare can be especially damaging to democracies, as citizens' ability to trust the free press and fellow members of their society are bedrocks of this representative type of government.

Total war between the superpowers is not impossible. If the U.S. secures a limited capability that China does not have – temporarily breaking a state of military parity – Beijing may feel compelled to act before the U.S. has a chance to field the system. Alternatively, if China develops a niche capability, it may act preemptively to avoid a disarming strike. Total war could also result from misperceptions or unexpected escalation of hostilities. For example, the PRC could underestimate American responses to Chinese attempts to control disputed territories. Such Chinese attempts might involve violence (or the threat of violence) or non-kinetic tactics like deployment of AI troll armies, cyber infiltration of supervisory control and data acquisition (SCADA) systems and critical financial systems, and virtual hostage-taking of critical resources.

As long as military parity deters large-scale conflict in this alternative future, digital-maneuver capabilities—e.g., cyber-attacks and defense of critical infrastructure and sustainment systems, digital power projection, and digital information operations—gain prominence. Nevertheless, the U.S. Army must prepare for kinetic warfare characterized by heightened speed, lethality, and uncertainty. For example, advanced lethal autonomous weapons systems or nuclear-capable hypersonic or supersonic missiles launched from various platforms truncates response time, and

ambiguity of origin increases the probability of miscalculation. Protection capabilities will require the adoption of system-level defense strategies such as multi-dimensional protection, and account for critical civilian infrastructure.

Alternative Future #2: Ascending Powers

This alternative future—a multipolar system with "revolutionary" technological innovation—is marked by persistent instability and conflict. The transition to a multipolar world has been marked by intense competition among several states, as well as domestic political strife within the U.S. and China that consumes significant resources and acts as an important "leveling" factor. Economic rebalancing has occurred: the U.S. and China experience economic stagnation as a result of long-running political and economic struggles, while emerging powers have leveraged decades of liberal economic order to consolidate wealth critical to military growth.

The competition space in this alternative future is beset by constant, widespread "balancing" actions among competitors. A number of states—e.g. the U.S., China, Russia, India, Turkey, and some European powers—expend valuable resources, to include military power, in a protracted struggle to gain advantage. The absence of global hegemons to check aggression among regional competitors results in coalition-building and arms races, especially involving provocative revolutionary technologies characterized by speed and lethality. During this critical transition period, rising powers are aggressive in their pursuit of critical resources and prestige, while declining states launch preventive wars to maintain access to critical resources or to control domestic populations. Domestic instability among waning superpowers gives way to the rise of organized nonstate groups. Some of these groups are able to access revolutionary weapons systems and therefore able to pose significant challenges to national militaries.

Military advantage in this alternative future is won by those possessing revolutionary technologies to employ across all domains in conflict—for example, hypersonic or supersonic systems, advanced robotics and autonomy, revolutionary energetics, quantum key encryption and sensing, counter-space capabilities and AI-enabled data-processing and decision-making systems. Access to such technologies enable weaker states to make sudden and dramatic improvements to their capabilities—i.e., to join the race—and ultimately challenge military superiority of regional hegemons. The speed and uncertain capabilities of some of these technologies—e.g., lethal autonomous weapons systems—forces actors to closely monitor and quickly match the capabilities of their rivals. The threat posed by these technologies also complicates the task of understanding the network of converging "red lines" among one's many competitors – in other words, deciphering what constitutes acceptable behavior so as to avoid triggering conflict spirals. The highly competitive environment

does not help matters, as states may also miscalculate the extent to which another will go to defend their interests.

Diplomacy in this alternative future is no longer dominated by the interests of two global superpowers, transforming instead into a highly dynamic – and, at times, brittle – system conforming to the interests of many more peer and near-peer states. Moreover, because technological innovations emerge from multiple actors in this alternative future—not from only two superpowers—states will use technology diffusion to serve their interests, leveraging highly valuable, exclusive revolutionary technologies as diplomatic centerpieces.

In this alternative future, threats are geographically unpredictable, occur across multiple domains, and are dispersed widely among numerous adversaries with varying degrees of temporary overmatch and intentions. The U.S. Army is forced to engage in many types of conflict, perhaps simultaneously, in which soldiers face a range of highly capable adversaries—from conventional forces to insurgents, transnational criminal organizations, mercenary armies, and proxy forces. Due to heightened international competition and the primacy of security coalitions, the U.S. Army acts as a secondary player in many conflicts, with allies taking the lead on grounds of national interests or niche technological leadership. Alliances will be critical to shore up U.S. defense and strike capability, deter economic aggression, and mitigate distributed information warfare campaigns.

Alternative Future #3: Stable Competition

This alternative future—a bipolar system with an "evolutionary" rate of technological innovation—in many ways resembles the world of today. In it, enduring economic and political effects of successive global pandemics cause the U.S. to lose its position as sole superpower, while China ascends to superpower status on the back of its thriving economy.

China continues to disperse its economic production activities globally to its spheres of influence, challenging U.S. multinational corporations in many instances. In its cultivation of exclusive economic blocs, China guarantees itself access to critical natural resources that it does not possess at home. It otherwise guarantees manufacture of military, medical, and supplies vital to national security through domestic means or from trusted bilateral partners. China continues to invest heavily in leading-edge technologies—e.g., artificial intelligence, autonomy, quantum information sciences, next-generation communications, biotechnology, hypersonic and supersonic missiles, advanced long-range precision fires, directed energy weapons, and cyber and electronic-warfare tools. It also continues to invest in human capital, domestic

manufacture of infrastructure, and the production of more value-added products – all in order to maintain wealth generation critical to its military power.

The evolutionary pace of technological change results in only marginal changes in the deployment speed and lethality of military systems, moderating fears among competitors and lowering the risk of preemptive strikes in reaction to perceived military gains. Generally, "rebalancing" after temporary shifts in military power is faster than in a world of revolutionary technological innovations. Military parity and continuing economic interdependencies between China and the U.S. are deterrents to large-scale conventional warfare. In the unlikely event of large-scale conflict, however, Chinese and American forces would rely on legacy systems – perhaps employed in novel ways – or marginally disruptive technologies involving artificial intelligence and autonomy, tailoring its forces to win limited high-intensity conflicts using overwhelming speed and firepower.

China avoids direct, conspicuous acts of aggression that would undermine its legitimacy among other global powers. Instead, it attempts to gain economic and financial advantages in licit and illicit ways against the U.S.—to include AI-enabled malware and ransomware attacks against commercial, defense-logistics, public-infrastructure and installation targets—in order to undermine U.S. military capability and achieve marginal economic advantages. However, the evolutionary pace of technological change allows sufficient time for potential targets to develop reliable counter-measures, undermining China's ability to attack in non-attributable ways.

In an emerging bipolar world, lower-tier states pursue bilateral relationships and economic and security blocs increasingly aligned to Chinese economic, diplomatic, and military interests; as well as parochial pacts with whomever best affords security and economic opportunities. In their pursuit of new strategic partners and greater leverage with others, China plays an active role in leading and reshaping the international order, partly through its participation in key international institutions—e.g., the United Nations, World Trade Organization, and World Health Organization. It leads emerging technological standards and agreements (e.g., regarding cyber governance and artificial intelligence), and continues to weaken international norms of human rights and political freedoms, transparency, and accountability. Many of China's international relationships will be transactional and extractive in nature, in contrast to the U.S.'s efforts to strengthen other countries' capacities to make independent choices and counter foreign interference.

In this alternative future, the U.S. military must prepare to confront a familiar array of challenges such as Chinese military modernization and expeditionary operations, increased Russian proxy warfare and fait-accompli land grabs in Europe and Central Asia, Iranian and North Korean nuclear development, and the ever-present threat of insurgency and terrorism. The United States will continue to pursue its

national interests within a system of degraded alliances and fewer partners resulting from China's increased relative global power and influence.

Alternative Future #4: Clashing Coalitions

In this alternative future—a multipolar system with an "evolutionary" rate of technological innovation—rising and declining states compete with one another, regional rivals, and even non-state actors for resources and global influence. A protracted era of globalization—including free trade, investment, and labor-flow regimes—has been a central feature of the leveling dynamic, producing several regional hegemons. Partial defections from the current globalized economic order occur in limited situations where ascending regional powers challenge the standing of their respective regional hegemons, encouraging the latter to extend military threats or cultivate relatively exclusive, bilateral agreements in their own long-term favor. However, because ascending powers are incapable of acquiring truly provocative "leap-ahead" capabilities, this kind of event is uncommon.

In order to maintain wealth generation critical to military power, regional hegemons invest heavily in domestic infrastructure and human capital. Furthermore, these states continue to support the private engines of their economies, facilitating the dispersal of economic production activities globally. Multinational corporations wield significant political-economic influence, straining weaker governments and exacerbating inter- and intrastate wealth disparities. In this environment, first-mover advantages are marginal and fleeting, except where actors are able to maintain periods of excludability (i.e., limiting diffusion) around highly marketable marginal innovations or novel convergences of existing technologies.

The evolutionary pace of technological innovation does not produce large military disparities among competitors, or the corresponding atmospheres of uncertainty and fear. This results in greater adherence to control-of-use agreements, as states feel less compelled to block the rise of regional competitors with threats and use of force. Lower-tier states can band together to force the negotiation of institutions over which regional hegemons attempt to maintain disproportionate sway, including these control-of-use agreements. Still, acute diplomatic disputes and sporadic military conflict—events that risk escalation—may occur over access to critical, ever-dwindling natural resources. Furthermore, there is a heightened risk that states will misinterpret the increasingly complex network of mutual "red lines," or the extent to which a competitor will go to defend their interests.

In a world of evolutionary technological innovation, strategies of discreet, marginal improvements to one's relative economic and military standing – including through impeding competitors' progress – are particularly effective. Many regional

hegemons conduct covert economic and financial warfare against adversaries' commercial, defense-logistics, public-infrastructure and installation targets. Others conduct information operations to foment internal unrest abroad or to undermine traditional alliances.

As in the multipolar alternative future with "revolutionary" technological innovations, threats in this world are geographically unpredictable, occur across multiple domains, and are dispersed widely among numerous adversaries with varying intentions. The U.S. Army is forced to engage in many types of conflict, perhaps simultaneously, in which soldiers face a range of highly capable adversaries. However, any temporary overmatch among competitors in this alternative future is more predictable and more readily balanced.

Conclusion

The alternative futures presented here are neither definitive nor all-inclusive. Rather, these are just a glimpse of what the future may hold. Regardless of whether we find ourselves in a bipolar or multipolar system, the U.S. Army must be prepared to face a range of threats as something other than the sole superpower. Describing the FOE is the first step in driving the concepts and capabilities necessary to fight and win the wars of tomorrow. For the nation and the Army to succeed, we will continue to study the environmental, geopolitical, technological, and military trends that are already changing the nature of warfare.

This document is the start of a conversation about what it will take for the U.S. Army to fight and win on the future battlefield. It strives to generate critical discourse among Army and DOD senior leaders about what the future may hold, implications for the Army, and requisite investments in concepts, technology, material, and training.

As a next step, an FOE running-estimate will explore, through a series of compendia, various key topics in order to challenge and enrich the descriptions presented in this document.

Annex: Structural Trends

Below are highlighted several global trends common to each of the four alternative futures. Each section contains a brief description of the (linear) forecasts for each topic. Future analyses should address at least three aspects of these topics:

1. The possibility of nonlinear and unpredictable change – i.e., discontinuities, or "where trends may break."

2. Variation in how global-level trends are filtered through local physical and social systems, and therefore affect local outcomes in different ways.

3. How each trend could influence Army Modernization.

Global Environmental Change

Human activity is rapidly causing significant disruption to the Earth's geosphere, hydrosphere, biosphere, and atmosphere—including changes to land-systems and energy and biogeochemical flows, freshwater stress, ocean acidification, mass extinction and threats to biosphere integrity, atmospheric aerosol loading, and tropospheric warming and climate change.[v]

According to the most recent reporting from the Intergovernmental Panel on Climate Change (IPCC), human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels. Scientists have high confidence

that warming will reach 1.5°C between 2030 and 2052 if the trend continues at the current rate. About half of the early 21st-century warming is committed in the sense that it would occur even if atmospheric concentrations of CO_2 were held fixed at year-2000 values.[vi] Warming is generally higher over land than over the ocean; and warming greater than the global annual average is being experienced in many land regions and seasons, including a 2-to-3-fold higher in the Arctic.

Projected climatic changes will manifest as more frequent and unpredictable extreme weather events—droughts, floods, heat waves and fires, and violent storms. These will also cause slow-onset changes to weather and climate-dependent phenomena at local, watershed, national, and regional scales—e.g., changes in temperature and precipitation patterns (e.g., dry areas become drier, wet areas become wetter), massive loss of land and sea ice (portending significant changes to Great Power competition in the Arctic), sea-level rise, ocean acidification and changes to ocean circulation, large-scale biodiversity loss, and changes in the distribution of vector-borne diseases.[vii] Such changes, and their indirect effects on human systems, will likely increase the nature and frequency of challenges that the Army will be asked to address.

Shifting Energy Markets

The U.S. Energy Information Administration (EIA) currently projects that global energy consumption will grow by nearly 50% between 2018 and 2050, mostly coming from regions where strong economic growth is driving demand – particularly in Asia. Renewables are projected to be the fastest-growing source of electricity generation through 2050, driven by continued declines in the capital costs for solar and wind technologies. The EIA also projects that worldwide renewable energy consumption will increase by 3.1% per year between 2018 and 2050, compared with 0.6% annual growth in petroleum and other liquids, 0.4% growth in coal, and 1.1% annual growth in natural gas consumption.[viii] [ix] Such changes in energy production and consumption trends will likely impact global strategic competition as well as states' relative wealth.

Infectious Disease

Continued rapid landscape conversion and encroachment into wildlife habitat facilitates zoonotic disease transmission to humans. Furthermore, modern livestock operations, especially those that mix wild and domesticated animals, are particularly prone to interspecies host transfers of disease agents as well as the emergence of dangerous antibiotic-resistant strains of bacteria.[x] [xi] The hyper-connectivity of humans, aided by the increasing ease of regional and global travel, also increases the risk that local and regional epidemics become global pandemics. Outbreak response will continue to be part of the competition domain. Globally, it will likely become more efficient but challenged by an increase in previously unknown (novel) diseases.

Climate change will likely as a threat multiplier of disease transmission by progressively weakening ecosystem resilience, reducing biodiversity, and removing natural buffers between disease hosts and humans. Additionally, global warming and regional climate changes could widen geographical and temporal ranges of certain vector species such as mosquitoes carrying malaria or dengue – especially into places that are currently relatively cold.[xii] [xiii]

The threat of biowarfare and bioterrorism will almost certainly persist. Growing access to emerging and disruptive technologies like synthetic biology and CRISPR, as well as AI, will increase actors' abilities to develop and deploy these threats—in some cases to counter conventional military superiority—as well as skirt detection and attribution.

Demographic Changes

Global population growth is slowing, owing to sustained declines in fertility. Still, according to the United Nations population statistics, by 2050 the global population is expected to near 10 billion people, presenting challenges for sustainable economic development. More than half of the projected increase is expected to concentrate in just nine countries: the Democratic Republic of the Congo, Egypt, Ethiopia, India, Indonesia, Nigeria, Pakistan, Tanzania, and the United States of America. Least-developed countries are among the fastest growing countries, putting pressure on strained resources.[xiv]

Humanity will very likely experience further declines in fertility and increases in average length of life, resulting in continued widespread population ageing. Working-age populations will very likely shrink in higher-income nations, but grow in developing nations, presenting opportunities for economic growth and a reallocation of global economic resources.[xv] This change will force high-income nations to adapt social safety systems that traditionally depend on large working-age populations. These shifts may impact democratic countries and their economies even more dramatically, as populations in these countries wield greater influence in shaping national priorities.

According to UN statistics, more than half of the world's human population currently live in urbanized communities, a figure that is projected to grow toward 70% by 2050.[xvi] The international migrant population could rise significantly by 2050 depending on various factors such as conflict, environmental-related stressors, poverty, temporary labor dynamics, and improved travel options.[xvii] High rates of immigration—especially in urban and peri-urban centers—will raise popular pressure for effective public policy and, in many places, result in social fragmentation, social unrest, and opportunities for violence.

Challenges to Domestic Governance

Supra-national organizations like the United Nations, European Union, World Trade Organization, and regional trade organizations may gain influence under conditions of heightened economic interdependencies, advancements in transportation and communications, and the pressure of global-scale challenges like climate change and migration. More assuredly, states will face more frequent and stronger challenges from sub-state and non-state actors including powerful cities, corporations, non-governmental or virtual organizations, transnational organizations (whether criminal, economic, ethnic, or political), and even super-powered individuals. Some of these actors may be able to field highly capable private armies to pursue resources, contest rivals, and subvert state authority. If central governments weaken, new power centers could emerge that challenge that authority, sometimes resulting in unstable, ungoverned spaces vulnerable to exploitation by non-state actors.

Non-state Actors

In the future, non-state actors will attempt to advance their interests across multiple domains, including in ways that contest U.S. forces.[xviii] Even today, non-state actors employ self-made or commercially manufactured unmanned aerial systems to conduct a wide range of activities – from business to ISR operations and air strikes. Non-state actors could tap into the global network of commercial and government satellites that have long benefitted U.S. ISR and communications, or even launch and operate cheap micro-satellites. The ability to operate across domains will also help non-state actors deal with the challenge of distance—once-secure bases and even distant homelands will become observable, targetable, and reachable, whether by malware or physical systems.[xix] Whether or not non-state actors aim to undermine the United States, they are likely to make the future battlefield more complex – adding de facto sensors that increase information and reporting in near-real time to friendly and opposing forces. While some non-state actors will pose real security challenges to the U.S. and our allies, others will bring about more transparency within states that stifle citizens' communications and access to information.

Some non-state actors will very likely intensify cyber threats to U.S. security. Dark markets proliferate systems and capabilities, and the Internet of Things creates avenues for non-state actors to target command-and-control networks and even use "Stuxnet-style" digital weapons to inflict physical damage. And artificial intelligence will likely enable the creation of "deep fake" videos whereby non-state actors could fabricate or attribute attacks on civilians to U.S. forces.[xx]

Some non-state actors will attempt to adapt benign technologies – primarily intended to promote human health and prosperity – for security purposes and in ways that have implications for the military.[xxi] For example, they could employ swarms of intelligence systems (i.e., maneuverable machines imbrued with artificial intelligence or

a fleet of vehicle IEDs), hijack the Internet of Things to disable vehicles or in-home appliances, commandeer and crash civilian airliners, or shut down national power-grids. Some groups may use sophisticated information technologies to mobilize and recruit supporters and raise funds from around the world. Employing a *combination* of innovative technologies might be especially dangerous—for example, using 3D printing to manufacture an autonomous IED-carrying drone and equipping it with biometrics databases, AI-enabled facial-recognition software, and home-grown precision navigation satellites to locate, identify, and assassinate political elites or target military or commercial installations.

Defense Trends

Various defense-related technologies are likely to proliferate in the future, though to varying degrees depending on research and development achievements (including innovative technological convergences). For example, automation will become more ubiquitous, enhancing digital maneuver capabilities—e.g., offensive and defensive cyber, digital information operations, and dominance of the electromagnetic spectrum—and partially easing pressures associated with aging populations. Advances in artificial intelligence will become critical to processing and sustaining a clear common operating picture in data-rich environments. Additive manufacturing, nanotechnology, and advanced biotechnology tools will become more cost-efficient and accessible to a wider range of actors, enabling widespread advanced materials development and production (assuming accommodative laws and defense-industry agreements). We will experience leaps in (grid-scale to wearable) power management. Multiple unmanned system classes will be employed to sense, stimulate, intimidate, strike and overwhelm indications and warning systems. Several states will possess hypersonic and supersonic missiles capable of being nuclear-armed and launched from conventional missile platforms.

Adversaries will expand threats across multiple domains (land, sea, air, space, and cyberspace). They will adopt hybrid strategies that take advantage of a range of capabilities, attempting to avoid a conventional force-on-force fight. Space will be an increasingly congested, commercialized, democratized, and contested domain, slowing operational tempo and increasing situational ambiguity. Moreover, the definition of national security will expand to increasingly involve protection of critical civilian infrastructure—including cyberspace and financial infrastructure—and public health.

Advancements in nuclear technology and weapons—including the development of a greater range of payloads, as well as wider proliferation of nuclear technologies and material to state and non-state actors—represent a critical threat in the FOE. The prospect of nuclear use—which maintains the ability to disintegrate of the coherency of an armed force and produces cognitive shock—will continue to color deliberations on the importance of conventional superiority among nuclear peers, and requires that

Army Modernization planning continually considers nuclear-escalation strategy.

This document was produced by the Army Futures Command Directorate of Intelligence and Security, Future OE Division, Strategic Futures Branch, in coordination with the Intelligence Community, Joint Service and DoD, Academia, Industry, and Scientific Community partners.

---

[i] A large body of International Relations theory informs this variable. Notable works referenced include:
Robert Gilpin, *War and Change in World Politics* (New York: Cambridge University Press, 1981);
Charles L. Glaser, *Theory of Rational International Politics* (Princeton: Princeton University Press, 2010);
Robert O. Keohane, *After Hegemony: Cooperation and Discord in the World Political Economy* (Princeton: Princeton University Press, 1984); John Mearsheimer, *The Tragedy of Great Power Politics* (New York: W.W. Norton, 2001);
Thomas Schelling, *The Strategy of Conflict* (Cambridge: Harvard University Press, 1960);
Thomas Schelling, *Arms and Influence* (New Haven: Yale University Press, 1966);
Kenneth N. Waltz, *Theory of International Politics* (New York: McGraw-Hill, 1979); R. Harrison Wagner, *War and the State: The Theory of International Politics* (Ann Arbor: Michigan University Press, 2010); Wagner, RH (1994), "Peace, War, and the Balance of Power," American Political Science Review, 88(3): 593-607.

[ii] Horowitz, M (2018), "Artificial Intelligence, International Competition, and the Balance of Power," Texas National Security Review, 1(3).

[iii] Michael C. Horowitz, *The Diffusion of Military Power: Causes and Consequences for International Politics* (Princeton: Princeton University Press, 2010).

[iv] International Relations scholarship informed the construction of the alternative futures in this document, including the following publications: Michael Beckley, *Unrivaled: Why America Will Remain the World's Sole Superpower* (Ithaca: Cornell University Press, 2018); Brooks, S. and Wohlforth, W.C. (2015), "The Rise and Fall of the Great Powers in the Twenty-First Century: China's Rise and the Fate of America's Global Position," Quarterly Journal: International Security, 40(3): 7-53; Garfinkel, B. and Dafoe, A. (2019), "How does the offense-defense balance scale?" Journal of Strategic Studies, 42(6): 736-763; Glaser, CL and Kaufmann, C (1998), "What is the offense-defense balance and can we measure it?" International Security, 22(4): 44; Horowitz, MC (2019), "When Speed Kills: Autonomous Weapon Systems, Deterrence, and Stability," Journal of Strategic Studies, 42(6): 764-788; Ikenberry, GJ (2004), "Liberalism and empire: logics of order in the American unipolar age," Review of International Studies, 30(4): 609-630; Ikenberry, GJ (2005), "Power and liberal order: America's postwar world order in transition," International Relations of the Asia-Pacific, 5(2): 133–152; John J. Mearsheimer, *The Tragedy of Great Power Politics* (New York: Norton, 2001); Sechser, N. et al. (2019), "Emerging technologies and strategic stability in peacetime, crisis, and war," Journal of Strategic Studies, 42(6): 727-735; Kenneth N. Waltz, *Theory of International Politics* (Reading: Addison-Wesley Pub. Co, 1979); van Evera, S (1998), "Offense, defense, and the causes of war," International Security, 22: 5-43.

[v] Rockström, J., et al. (2019). "Planetary boundaries: exploring the safe operating space for humanity." Ecology and Society. 14(2): 32.

[vi] Masson-Delmotte, V. et al. (2018). Summary for Policymakers. In: Global Warming of 1.5°C. Intergovernmental Panel on Climate Change, World Meteorological Organization: Geneva, Switzerland.

[vii] IPCC (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Intergovernmental Panel on Climate Change: Geneva, Switzerland.

[viii] U.S. Energy Information Administration (2019). International Energy Outlook 2019 - with projections to 2050. September 24, 2019.

[ix] van Vuuren, DP et al. (2018). "Alternative pathways to the 1.5°C target reduce the need for negative emission technologies." Nature Climate Change. 8: 391–397.
[x] Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: Synthesis. Ch. 14: Human Health: Ecosystem Regulation of Infectious Diseases. Island Press, Washington, DC.
[xi] Jones, BA et al. (2013). "Zoonosis emergence linked to agricultural intensification and environmental change." PNAS. 110 (21).
[xii] Caminade, C et al. (2014). "Impact of climate change on global malaria distribution." PNAS. 111(9): 3286-3291.
[xiii] Ryan, S et al. (2019). "Global expansion and redistribution of *Aedes*-borne virus transmission risk with climate change." PLoS Neglected Tropical Diseases. 13(3).
[xiv] United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019: Highlights (ST/ESA/SER.A/423).
[xv] United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019: Highlights (ST/ESA/SER.A/423).
[xvi] United Nations, Department of Economic and Social Affairs, Population Division (2018). The World's Cities in 2018—Data Booklet (ST/ESA/ SER.A/417).
[xvii] International Organization for Migration (2020). World Migration Report 2020. Geneva, Switzerland.
[xviii] Jakub J. Grygiel, *Return of the Barbarians: Confronting Non-State Actors from Ancient Rome to the Present* (Cambridge: Cambridge University Press, 2018).
[xix] Peter Warren Singer, *Insurgency in 2030: A Primer on the Future of Technology and COIN*, Accessed April 22, 2019: https://www.newamerica.org/international-security/reports/insurgency-2030/.
[xx] Peter Warren Singer, *Insurgency in 2030: A Primer on the Future of Technology and COIN*, Accessed April 22, 2019: https://www.newamerica.org/international-security/reports/insurgency-2030/.
[xxi] Audrey Kurth Cronin, *Power to the People: How Open Technological Innovation is Arming Tomorrow's Terrorists* (Oxford: Oxford University Press, November 2019).