Winning Future Wars: Modernization and a 21st Century Defense Industrial Base

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Modernization Defined and Theories of Modernization

Former Secretary of Defense Donald Rumsfeld is remembered for (among other statements) his famous comment on military preparedness: "You go to war with the Army you have, not the Army you might want or wish to have at a later time."[1] His insight aptly encompasses the modernization challenge for the U.S. military.

America's military must always be capable of going to war this very day with capabilities on which warfighters can rely, with which they have trained, and for which they have the necessary sustainment. At the same time, the military needs to prepare for future conflicts, to modernize, in anticipation of or in response to changes in threats and technology, seeking capabilities that will be needed in the event of future fights. Finally, the military must ensure that there is sufficient resilience and adaptability in the defense industrial base to respond to unanticipated circumstances and emerging needs, particularly in wartime.

Modernization is one of the four pillars on which U.S. military power rests, along with force structure, readiness, and sustainability. The goals of modernization are to close a capability gap, provide a qualitatively improved capability, and/or reduce costs. Modernization entails the replacement of an existing military technology, generally a platform, weapon, or system, with one that is significantly more capable, even transformational. Modernization is about more than just hardware. To achieve a significant increase in military effectiveness, the new item must be married to an appropriate organization, concept of operations, set of tactics, command and control system, and supporting infrastructure.

One of the best historical examples of military modernization involving the interplay of new platforms, organizations, and operational concepts is the United Kingdom's successful effort in the 1930s to create the integrated air defense system that proved victorious during the Battle of Britain. Over a period of years, the British military married advances in technology, most notably radar that could detect hostile aircraft at significant ranges, with a novel command and control network to relay warnings and dispatch interceptors and a family of fighter aircraft, most famously the Hurricane and Spitfire.[2]

It is important to recognize that this achievement owes as much to nontechnical factors as it does to advances in electronics or aircraft design. As one defense analyst has observed, "[t]he revolutionary innovation of British air defense emerged from the confluence of the Royal Air Force reorganization, a revision of strategic assumptions and national strategy, and a small group of pivotal civil-military advocates who championed the integration of emerging technology."[3]

Modernization is qualitatively different from the U.S. military's ongoing efforts to

make incremental improvements in individual platforms or weapons systems. This process, termed upgrading, can go on for decades and ultimately involve changing virtually all components or systems on a given piece of military equipment. Often, platforms undergo recapitalization, the process by which they are returned to as-new condition at the same time that they receive upgrades.

Many of the most capable systems that the U.S. military operates today have received repeated upgrades. The current fleet of B-52 bombers, last produced in the late 1950s, has undergone continuous upgrades and is slated to remain in service until around 2040. Similarly, the Abrams main battle tank, first deployed in 1980, has benefitted from an extensive series of upgrades including a new gun; better armor; improved sensors, transmission, command and control capabilities; and, most recently, an active protection system. As a result, the Abrams remains the most lethal main battle tank in the world.

Even the newest platforms and weapons systems undergo continuous incremental improvements. The F-35 Joint Strike Fighter (JSF) has just entered service with the Air Force and Marine Corps; the Navy is a few years behind. Yet the program is beginning early software development and integration for a Block 4 upgrade, scheduled for deployment in the early 2020s, that will allow the employment of additional precision weapons as well as an automatic ground collision avoidance system.[4] Continuous product improvement allows the warfighter to have capabilities in hand while exploiting later advances in tactics and technologies.

Historically, changes in military technologies have often occurred in clusters, reflecting major advances in the sciences, manufacturing processes, the organization of economic activities, and even political structures. Many military historians refer to these as Revolutions in Military Affairs.[5] An RMA is based on the marriage of new technologies with organizational reforms and innovative concepts of operations. The result is often characterized as a new way of warfare. RMAs require the assembly of a complex mix of tactical, organizational, doctrinal, and technological innovations in order to implement a new conceptual approach to warfare.

There have been a number of RMAs just in the past century.[6] An example is the mechanization of warfare that began in World War I with the introduction of military airpower, aircraft carriers, submarines, and armored fighting vehicles. Out of these advances in technology came independent air forces, strategic bombardment, and large-scale amphibious operations. Another occurred with the invention of nuclear weapons and long-range ballistic missiles, which led to the creation of new organizations such as the now-defunct Strategic Air Command and new concepts such as deterrence. In the 1970s, the advent of information technologies and high-performance computing led to an ongoing RMA based largely on improved intelligence and precision strike weapons. The 1991 Gulf War and Operation Iraqi Freedom in 2003 are considered to be quintessential examples of this RMA.[7]

A variant of the RMA theory that is specifically applicable to U.S. defense planning, Strategic Offsets, was introduced by the Obama Administration in 2014. Senior defense officials argued that since the end of World War II, the United States had twice exploited investments in advanced technologies to offset the military advantages of its major competitors.[8] These strategically driven modernization efforts radically changed the equipment, organization, and operations of America's armed services.

In the 1950s and 1960s, to counter the Soviet Union's quantitative superiority in conventional forces, the United States built a large and sophisticated arsenal of nuclear weapons and delivery systems. This was the First Offset. Once the Soviet Union acquired parity in nuclear forces, the United States reacquired military superiority in the 1970s and 1980s by exploiting the revolutions in electronics and materials and investing in stealth, information technologies, computers, high-resolution/multispectral sensors, and

precision navigation. This was the Second Offset. The U.S. military has sought to extend the advantages from this Second Offset for the past 25 years.

Now many believe that the U.S. military must pursue a new modernization effort. This Third Offset is made necessary by the rise of great-power competitors, the loss of the military advantages achieved by the Second Offset, and the development of a host of new technologies, many driven by the private sector rather than by government, that promise to change the way military equipment is designed and built and the way military forces will fight. This new Offset is a function, first and foremost, of the proliferation of sensors and so-called smart devices; the creation of increasingly large, complex, and sophisticated information networks; and the growing potential in automated systems and artificial intelligence.[9] Defense leaders seek to reestablish U.S. military-technological superiority by investing in such new areas as undersea systems, hypersonics, electronic warfare, big data analytics, advanced materials, 3-D printing, energy and propulsion, robotics, autonomy, man-machine interfaces, and advanced sensing and computing.[10]

It is noteworthy that the first two Offset strategies were driven primarily by government, principally defense-related, investments in science and technology. The Third Offset is largely based on advances by the private sector in areas such as electronics, artificial intelligence, information technologies, and networking. The innovation cycle times for many of these new technologies are far faster than those for traditional military programs. In addition, because these advances are the product of commercial development, it is difficult to control access to them by competitors, both great and small. As a result, the U.S. defense establishment is increasingly challenged not only to adopt these advances and integrate them into military systems, but also to adapt to the more rapid pace of change in everything from contracting and budgeting to organization, training, and sustainment.

The centerpiece of the Obama Administration's effort to jump-start a Third Offset was a new Long-Range Research and Development Planning Program (LRRDPP) to help identify, develop, and field breakthroughs in the most cutting-edge technologies and systems, especially in the fields of robotics, autonomous systems, miniaturization, big data, and advanced manufacturing, including 3-D printing.[11] The LRRDPP was a capabilities-based exercise that reflected the generic nature of the Administration's threat assessments.[12] In the absence of a threat-driven research and development (R&D) plan, the best the Pentagon could do was try to speed up the overall introduction of new technologies.

In order to accelerate the acquisition of leading-edge innovations from the commercial sector, then-Secretary of Defense Ashton Carter stood up the Defense Innovation Unit Experimental (DIUx). Located in Silicon Valley and modeled after the CIA's In-Q-Tel, a venture capital firm that provides seed money for innovative commercial companies working in areas of interest to the Intelligence Community,[13] the DIUx provides capital to small and start-up companies that are working on applications of advanced technology that are relevant to long-range Department of Defense (DOD) R&D goals.

The Trump Administration has been even more forceful than its predecessor in stressing the need for a broad-based, strategically driven modernization effort. Great-power competition has returned as a driving force in international relations. While this country spent 20 years in the modernization wilderness, investing in capabilities to defeat low-tech insurgencies and building capacity over capability, competitors targeted modernization efforts intended to undermine U.S. military-technological advantages. According to the Administration's 2017 *National Security Strategy*:

> Deterrence today is significantly more complex to achieve than during the Cold War. Adversaries studied the American way of war and began investing in

> capabilities that targeted our strengths and sought to exploit perceived weaknesses. The spread of accurate and inexpensive weapons and the use of cyber tools have allowed state and non-state competitors to harm the United States across various domains. Such capabilities contest what was until recently U.S. dominance across the land, air, maritime, space, and cyberspace domains. They also enable adversaries to attempt strategic attacks against the United States—without resorting to nuclear weapons—in ways that could cripple our economy and our ability to deploy our military forces.[14]

In addition to the intensification of competition between nations, technological change is also driving the need to modernize the U.S. military. The 2018 *National Defense Strategy* states that the key to future U.S. security lies in the exploitation of these new technologies:

> 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.[15]

However, investments in technology are only part of what is required for the United States to engage successfully in the new great-power competition and deter major conflicts. The *National Defense Strategy* takes a broad view of what must be done to modernize U.S. national security capabilities and institutions. In particular, it proposes expanding the competitive space in ways that position areas of U.S. comparative advantage against those where our adversaries are relatively weak:

> A long-term strategic competition requires the seamless integration of multiple elements of national power—diplomacy, information, economics, finance, intelligence, law enforcement, and military. More than any other nation, America can expand the competitive space, seizing the initiative to challenge our competitors where we possess advantages and they lack strength. A more lethal force, strong alliances and partnerships, American technological innovation, and a culture of performance will generate decisive and sustained U.S. military advantages.[16]

It is difficult to question the fundamental assumption in current U.S. national security planning: that this nation must pursue comprehensive, rapid modernization of its military capabilities. The rapid evolution of the international security environment, the growing military-technological sophistication of both state and non-state adversaries, and the intensifying rate of global technological change, much of it driven by the private sector, necessitate such an effort. While inevitably costly, the alternative—the loss of U.S. military superiority—would entail far greater costs to this country.

Challenges to U.S. Military Modernization in the 21st Century

Today, U.S. national security may be under greater stress than at any time since the early days of the Cold War. The number of geostrategic threats to U.S. global interests and allies has increased, and the ways and means of modern warfare are evolving with remarkable speed. Competitors are engaged in an intensive and broad-based arms race intended, first, to deny the United States its hard-won military advantages and, second, to establish their own military superiority. Advanced military and dual-use technologies are proliferating widely. The defense industrial base has shrunk to the point that there are numerous instances of single suppliers of critical items. The national security innovation base is under stress from within and attack from without.

Senior defense officials and military leaders have identified five evolving strategic challenges to U.S. security: Russia, China, North Korea, Iran, and terrorism. The first two are engaged in major military modernization programs, investing in capabilities designed to counter long-held U.S. military-technological advantages. According to Army Major General Eric Wesley, "some analysts have said of 10 major capabilities that we use for warfighting that by the year 2030, Russia will have exceeded our capability in six, will have parity in three, and the United States will dominate in one."[17]

In a number of ways, Russia has made the greatest strides in the shortest period of time. Compare Russia's problematic campaign against Georgia in 2008 with the much better-planned and better-executed operations in Crimea and Ukraine a short six years later. Moscow's operations in Ukraine allowed the world to observe the gains Russian ground forces have made in both technologies and combat techniques. Russian forces have demonstrated advances in armored combat vehicles; electronic warfare (EW); long-range massed fires coupled with drone-provided intelligence, surveillance, and reconnaissance (ISR); mobile, high-performance air defenses; and air assault.[18] A respected expert on this new generation of Russian military capabilities has described one engagement:

> In a 3-minute period…a Russian fire strike wiped out two mechanized battalions [with] a combination of top-attack munitions and thermobaric warheads…. If you have not experienced or seen the effects of thermobaric warheads, start taking a hard look. They might soon be coming to a theater near you.[19]

The impact of Russian investments in a new generation of ground combat capabilities has been amply demonstrated by operations over the past several years in Ukraine and Syria. The combination of drone-based ISR, communications jamming, and the application of long-range firepower with advanced warheads has proved to be especially lethal.

Russian advances in EW have been particularly noteworthy and have resulted in the deployment of systems that can challenge one of the central features of modern U.S. military capabilities: the ability to link sensors to shooters in a manner that provides a near real-time ability to conduct long-range and multidomain fires. Ukrainian separatist forces equipped with Russian EW systems have demonstrated a highly sophisticated ability to jam communications systems, deny access to GPS, and interfere with the operation of sensor platforms. Recently, it has been reported that U.S.-made tactical drones operated by Ukrainian security forces were being jammed and hacked by the Ukrainian rebels.[20] Russian forces in Syria were reported to have jammed U.S. intelligence/psychological operations aircraft operating in the western portion of that country.[21]

"Given [the Russian military's] modernization, the pace that it's on," Army General Curtis M. Scaparrotti, Supreme Allied Commander, Europe, has warned, "we have to maintain our modernization…so that we can remain dominant in the areas that we are dominant today." Otherwise, "I think that their pace would put us certainly challenged in a military domain in almost every perspective by, say, 2025."[22]

China is equally intent on developing military capabilities that pose a direct challenge to the United States and its allies. According to Defense Department's 2017 *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China*:

> China's leaders remain focused on developing the capabilities to deter or defeat adversary power projection and counter third-party intervention—including by the United States—during a crisis or conflict….
>
> China's military modernization is targeting capabilities with the potential to degrade core U.S. military-technological advantages. To support this modernization, China uses a variety of methods to acquire foreign military and dual-use

> technologies, including cyber theft, targeted foreign direct investment, and exploitation of the access of private Chinese nationals to such technologies....[23]

In its 2017 report to Congress, the U.S.–China Economic and Security Review Commission identified a number of specific capabilities that the People's Liberation Army is developing for the purposes of targeting U.S. military forces and countering advanced U.S. capabilities:

> The weapons and systems under development and those that are being fielded by China's military—such as intermediate-range ballistic missiles, bombers with long-range precision strike capabilities, and guided missile nuclear attack submarines—are intended to provide China the capability to strike targets further from shore, such as Guam, and potentially complicate U.S. responses to crises involving China in the Indo-Pacific....
>
> China's increasingly accurate and advanced missile forces are intended to erode the ability of the United States to operate freely in the region in the event of a conflict and are capable of holding U.S. forces in the region at risk.
>
> China's continued focus on developing counter space capabilities indicates Beijing seeks to hold U.S. intelligence, surveillance, and reconnaissance satellites at risk in the event of conflict.[24]

More and more, the strategic competition with Russia and China will be in the exploitation of advanced technologies with military applications. In her statement before the Senate Armed Services Committee, Lisa J. Porter, nominee to be Deputy Under Secretary of Defense for Research and Engineering, observed that:

> [N]ot only do we face a diversity of threats, we also face a diversity of technological approaches being employed against us, which range from innovative uses of existing technologies in ways we have not always anticipated, to the employment of cutting edge capabilities ranging from space systems to cyber attacks to machine learning to hypersonics to biotechnology.[25]

Outgoing Commander of U.S. Pacific Command (PACOM) Admiral Harry Harris has warned explicitly that the United States is in danger of losing the next arms race with China:

> I am also deeply concerned about China's heavy investments into the next wave of military technologies, including hypersonic missiles, advanced space and cyber capabilities, and artificial intelligence—if the U.S. does not keep pace, USPACOM will struggle to compete with the People's Liberation Army (PLA) on future battlefields. China's ongoing military modernization is a core element of China's stated strategy to supplant the U.S. as the security partner of choice for countries in the Indo-Pacific.[26]

In addition, Russia and China are providing advanced conventional military hardware to a growing number of states. According to a senior U.S. Army source, "If the Army goes into ground combat in the Middle East, we will face equipment from Russia, Iran and in some cases China."[27] Russia is a major defense exporter. It sells advanced aircraft, air defense systems, radar, and ships to China and India; recently began to deliver the S-300 air defense system to Iran; and has reentered the Egyptian market, selling Egypt 50 Kamov Ka-52 Alligator combat helicopters.

Regional challengers like North Korea and Iran are investing in such asymmetric military capabilities as ballistic missiles, advanced air defense systems, and even nuclear weapons. Both nation-states and non-state terrorist groups are able to access advanced military equipment provided not only by Russia and

China, but by Western countries as well. Iran has received advanced air defense systems from Russia and land-based anti-ship cruise missiles from China. Capabilities once viewed as restricted to peer competitors are increasingly within the arsenals of local adversaries and terrorist groups.

The Army's latest operating concept describes the challenge in stark terms:

> As new military technologies are more easily transferred, potential threats emulate U.S. military capabilities to counter U.S. power projection and limit U.S. freedom of action. These capabilities include precision-guided rockets, artillery, mortars and missiles that target traditional U.S. strengths in the air and maritime domains. Hostile nation-states may attempt to overwhelm defense systems and impose a high cost on the U.S. to intervene in a contingency or crisis. State and non-state actors apply technology to disrupt U.S. advantages in communications, long-range precision fires and surveillance.[28]

Even terrorist groups are deploying advanced weaponry. A recent YouTube video that went viral shows the destruction of an Iraqi M-1 Abrams, basically the same kind operated by the U.S. military, by an Islamic State (ISIS)-fired, Russian-made Kornet anti-tank guided missile.[29] Since 2003, the U.S. military and its coalition allies have lost vehicles of all kinds to rocket-propelled grenades. U.S. Navy ships operating in the Gulf of Aden have been attacked repeatedly by Yemeni Islamist rebels armed with Chinese-made anti-ship cruise missiles.[30] It has been discovered that ISIS set up industrial-scale facilities to produce improvised explosive devices (IEDs) and other military equipment.[31]

A new global arms race is heating up. It does not involve nuclear weapons, advanced fighter aircraft, robotic tanks, or long-range missiles. It is a race between terrorists weaponizing commercially available drones and efforts by the world's most technologically advanced militaries to deploy effective, low-cost countermeasures.

In the hands of groups like ISIS, Hezbollah, and Hamas, drones constitute the ultimate hybrid threat. For the first time in history, non-state terrorists and insurgencies have an air force. ISIS, for example, now routinely employs commercially available drones to perform many of the missions that the U.S. military performs with large, sophisticated, and expensive aircraft: ISR, targeting for indirect fire systems, weapons delivery, and information operations. ISIS is reported to use drones to help direct vehicle-borne IED attacks.[32]

It is evident that both nation-states and terrorist groups are making enormous efforts to negate the U.S. military's long-held technological advantages. Some challengers are developing a comprehensive suite of countervailing capabilities; others are deploying available technologies, sometimes based on commercial systems adapted for military purposes. All, however, are creating forces that are intended to counter or even defeat U.S. ground forces.

The consequence of investments by adversaries in systems to counter and even exceed the capabilities deployed by the U.S. military is the progressive loss of tactical overmatch. Challengers generally—but the Russian military in particular—have invested in asymmetric capabilities such as EW, air defenses, anti-armor weapons, improved combat vehicles, and advanced artillery and missiles precisely for the purpose of denying tactical overmatch to U.S. and allied ground forces.

The Department of Defense has created the dangerous illusion of undiminished U.S. military prowess by ensuring the readiness of deploying forces at the expense of force size, modernization, infrastructure recapitalization, and training. In fairness to those in uniform and their civilian counterparts, they had no other choice. It made no sense to prepare for the next war while losing the ones you were currently fighting. In addition, for most of the past century, the risk of major conflict with a

regional power or near-peer was judged to be extremely low. But that is no longer the case.

Decades of declining U.S. defense budgets and a 20-year focus on low-intensity conflicts has resulted in a U.S. military that is simultaneously unready for today's conflicts; unfit to conduct the high-end, high intensity wars of the future; and worn out after nearly two decades of continuous combat. According to Secretary of Defense James Mattis:

> Our military remains capable, but our competitive edge has eroded in every domain of warfare—air, land, sea, space, and cyber. The combination of rapidly changing technology, the negative impact on military readiness resulting from the longest continuous period of combat in our Nation's history, and a prolonged period of unpredictable and insufficient funding, created an overstretched and under-resourced military.[33]

Senior members of the military made the obligatory pilgrimage to Capitol Hill last year to testify as to the state of the armed forces. In virtually every case, the message was the same: As a consequence of years of underfunding, the U.S. military is at the breaking point—and this is in the absence of a major conflict.

- According to the Army representatives, in order to maintain enough ready forces, the service has "accepted considerable risk by reducing end-strength and deferring modernization programs and infrastructure investments" in "trade-offs [that] reflect constrained resources, not strategic insight.... [O]ur restored strength must be coupled with sufficient and sustained funding to avoid creating a hollow force."[34]

- The Navy representatives acknowledged that the effort to ensure that deployed forces are ready has come at the expense of the rest of the service: "[W]hile our first team on deployment is ready, our bench—the depth of our forces at home—is thin. It has become clear to us that the Navy's overall readiness has reached its lowest level in many years."[35]

- Air Force leaders joined this somber chorus, pointing out that "[s]ustained global commitments combined with continuous fiscal turmoil continue to have a lasting impact on readiness, capacity, and capability for a full-spectrum fight against a near-peer adversary."[36]

All of the services have credible plans to repair the damage done over the past decades, but funding limitations are forcing them to modernize at a pace that is both uneconomical and irrelevant to the growing threat. For example, at current production rates, the Air Force, Navy, and Marine Corps will not receive their full complements of F-35 fighters until approximately 2037. The Army's plan is to modernize its fleets of tanks, armored fighting vehicles, artillery, and rocket launchers over a period of decades. Even with additional funding, the Navy will not achieve its goal of 355 ships until the 2030s.

The U.S. military is at an inflection point. It must address readiness shortfalls for a force that could be called on to fight at any time. However, decades of deferred modernization have resulted in a force that is obsolescing. Maintaining fleets of aging planes, ships, and tanks is becoming prohibitively expensive. In addition, new threats and a quickening pace of technological progress make modernization an imperative. The challenge confronting DOD is the need to lay out a long-term investment strategy that replaces aging systems with new ones that incorporate advanced technologies to provide greater lethality, improved maintainability, and lower operating costs.

The same underfunding that hollowed out the U.S. military over the past several decades also affected the industrial base that is necessary for a credible national defense. In the future, that industrial base may not have sufficient capacity and capability to meet the needs

of a nation engaged in a long-term strategic competition with multiple adversaries.

The United States fought and won the Cold War on the basis of a unique set of political, economic, industrial, and technological advantages. By the end of World War II, this country had learned how to harness its industrial might and scientific talent to produce more and, in many cases, better military equipment than any other country was capable of producing.[37] In the decades that followed, the United States continued to depend on its superiority in science and technology and the capabilities of its aerospace and defense industries to turn the products of government-sponsored research and development into advanced military systems.

The end of the Cold War marked the beginning of the end for the system of technological and industrial investment that had sustained U.S. military preeminence for more than four decades. Protracted periods of declining defense budgets caused a sharp contraction in the aerospace and defense sector.[38] A period of rapid vertical and horizontal integration in this sector led to the concentration of critical manufacturing and R&D capabilities in a handful of major defense companies, the so-called primes, and a hollowing out of the supplier base on which these large companies relied for parts, components, and even major systems.

As a result, the once vaunted Arsenal of Democracy withered. The demand of national security no longer would drive investments in science and technology or in productive capacity. The number of companies specializing in aerospace and defense goods shrank precipitously through mergers and exiting of the sector. "We will have American industry providing for national defense," opined Norman Augustine, then chairman of one of the new defense primes, Lockheed Martin, itself a product of the merger of Lockheed and Martin Marietta. "But we will not have a national defense industry. This is not the best of all worlds. We'll have to draw on our industrial base rather than having the defense capability of the past."[39]

The decline of the defense industrial base as a driver of the overall economy is reflected in the *Fortune* 500 listings. In 1961, 15 defense companies were among the top 100 companies listed. In 2017, only four aerospace and defense companies were ranked above 100. Of these, only two—Lockheed Martin and General Dynamics—were primarily defense companies. The other two—Boeing, the highest ranking of the four at 24, and United Technologies—are major providers of defense products but receive a large percentage of their total revenues from commercial sales.[40]

The change in the ranking of defense and aerospace companies in the *Fortune* 500 reflects two critical factors. The first is the long-term decline in U.S. defense spending. Even as the overall revenues and earnings of the top 100 companies increased about sevenfold over the past five decades, those of the aerospace and defense companies only doubled.[41] This decline translated into a reduced demand for unique defense items, which in turn resulted in a collapse in the resources available to aerospace and defense companies to sustain, much less upgrade or modernize, their productive capacities.

The impact of declining defense spending on the output of defense-related goods and products has been exacerbated by the overall deindustrialization of the U.S. economy. From basic commodities such as steel and aluminum to the major subsectors such as shipbuilding and even textiles, the United States has seen the decline of domestic production and increased reliance on offshore suppliers, including such competitors as China.[42] Survival of the commercial U.S. shipbuilding, ship repair, and maritime workforce now depends almost entirely on the requirements imposed by the Jones Act.[43]

The globalization and offshoring of critical industries challenge the U.S. industrial base to produce sufficient quantities of major end items even in peacetime. In the event of war, the U.S. military could rapidly run out of munitions, spare parts, and even critical consumables. Even in major industrial sectors such as automobiles, there is no longer the domestic capacity to support a major, protracted

high-end conflict. "In not just World War II, but Korea and Vietnam and the Cold War, you were able to draw from this manufacturing industrial base that was dual use. You had a vibrant automotive industry for instance," an Administration official has said. "Today, the manufacturing capacity is just not there on the civilian side."[44]

Consequently, the U.S. military faces a problem both of capability, the product of modernization, and capacity, the result of insufficient productive means. According to Marine Corps General Joseph Dunford, Chairman of the Joint Chiefs of Staff, the combination of disinvestment and deindustrialization has limited the ability of the U.S. industrial base to meet the demands of a high-end conflict: "Aging logistics infrastructure (i.e. roads, rails, ports, bases), along with an increasingly brittle defense industrial base have long-term consequences that limit our ability to sustain a protracted or simultaneous conflict."[45]

The second factor behind the defense and aerospace companies' changed *Fortune* 500 rankings is the change in the composition of defense goods and services. Increasingly, advances in defense capabilities, whether they result from upgrades or from modernization, are due to the introduction of technologies developed by private companies for the commercial market. Many of these companies provide goods and services to the military, but for the majority, the Department of Defense is but one of many customers. This is particularly the case with respect to IT products, logistics services, and activities critical to the sustainment of military forces and operations. For example, in order to save money and improve functionality, the Pentagon is shuttering its own data centers and increasingly buying cloud services from commercial suppliers. In Operations Iraqi Freedom and Enduring Freedom, much of the flow of supplies into the theater, as well as the sustainment of military forces, was conducted by such private companies as UPS, FedEx, KBR, and Agility.

Defense leaders are increasingly aware that the impetus for innovation for much of the next generation of military equipment, both hardware and software, will come from the commercial sector and that this sector is increasingly globalized. This is particularly true with respect to information technologies, software development, artificial intelligence, robotics, and the biological sciences.

This has created a host of challenges for U.S. defense modernization. The primary challenge is the defense acquisition system, which has a set of standards, practices, timelines, and incentives that are orthogonal to those that operate in the commercial world. The increasingly globalized nature of advanced R&D and production requires a different approach to exploiting cutting-edge commercial advances ahead of potential adversaries. According to Under Secretary of Defense for Research and Engineering Michael Griffin, the key is rapid innovation:

> The technology playing field is changing. Important technology breakthroughs in many fields are now driven by commercial and international concerns. Our strategy acknowledges the imperative of a global, networked and full-spectrum joint force. It responds to the new fiscal environment and emphasizes new ways of operating and partnering. In a world where all have nearly equal access to open technology, innovation is a critical discriminator in assuring technology superiority.[46]

Defense R&D and acquisition officials are struggling to reconcile two very different approaches to the development, production, and support of goods and services. It often takes 15 or 20 years for major defense programs to go from initial concept to full-rate production. In the commercial world, it can take only two years. It is recognized by DOD's leadership that the current acquisition system is too slow at fielding new capabilities. In the words of Under Secretary Griffin:

> We need to think again, as we have really not since the 1980s, about our approach to acquisition. Government acquisition

> across the board—not restricted to space—is a mess. We take far longer to buy things that we need on behalf of the taxpayers, and we spend more money trying to prevent a mistake than the cost of the mistake. We're far out of balance on checks and balances in terms of government acquisition.[47]

When it comes to software, the contrast between defense and commercial practices is even starker. It can take the Pentagon two years to write a request for proposal for a new software system and another two years to award a contract. In the commercial world, six months can be a long time for the delivery of software. Will Roper, former head of DOD's Strategic Capabilities Office and now Assistant Secretary of the Air Force for Acquisition, Technology and Logistics (AT&L), has reportedly warned that "[t]he Defense Department's decades-old acquisition system, which was created to build things like aircraft and submarines, simply doesn't work for software, because by the time the service actually takes ownership of the software it's no longer relevant."[48]

More broadly, the argument made by critics of the current defense acquisition system is that it lacks the characteristics that enable agile and innovative organizations like those in Silicon Valley. According to one account, Lisa Porter has aptly described the difference between the two cultures: "'We have to reset the culture at the Pentagon' to allow for failure, learn from it and move on.... To Silicon Valley entrepreneurs, 'risk aversion is anathema,' but that is the practice in the Defense Department."[49]

The Trump Administration is the first to identify the American ability to innovate as critical to the nation's security and economic well-being. The 2017 *National Security Strategy* specifically calls for the protection of the National Security Innovation Base:

> We must defend our National Security Innovation Base (NSIB) against competitors. The NSIB is the American network of knowledge, capabilities, and people—including academia, National Laboratories, and the private sector—that turns ideas into innovations, transforms discoveries into successful commercial products and companies, and protects and enhances the American way of life. The genius of creative Americans, and the free system that enables them, is critical to American security and prosperity.[50]

Congress has recognized the need to make the Pentagon's acquisition system more agile and innovative. To that end, the 2017 National Defense Authorization Act (NDAA) mandated that the office of Under Secretary for AT&L, the organization that oversees the entire Pentagon acquisition system from basic science and technology to sustainment of existing capabilities and demilitarization of retiring platforms and systems, be split into two smaller offices: Under Secretary of Defense for Research and Engineering and Under Secretary for Acquisition and Sustainment.[51] The primary objectives of this reorganization are to achieve greater innovation in the pursuit of advanced military technologies, more rapid transition of new technologies into acquisition programs, and more expeditious fielding of new capabilities.

Beyond achieving the goal of greater innovation, defense modernization also depends on the ability to produce advanced military capabilities and related software rapidly and in volume. The ability to respond to changing demands from the field and to increase the production of defense end items is limited by the state of the defense industrial base and by cumbersome acquisition processes.

Perhaps the clearest acknowledgement of the current acquisition system's inadequacies was the creation by DOD and the services of special offices with unique authorities expressly for the purpose of leveraging technology development efforts across DOD and expanding or repurposing existing operational capabilities. In 2012, the Pentagon created the Strategic Capabilities Office (SCO). According to then-Secretary of Defense Ashton Carter, "The

SCO is particularly focused on taking weapons systems that we now have. It has been one of the things—places where it's been more creative...and giving them new missions."[52]

Each of the military services has created its own rapid capabilities office (RCO). These organizations have demonstrated that improved capabilities that address critical capability gaps can be fielded more rapidly. The first was the Air Force's RCO, responsible for (among other programs) initial development of the X-37B space plane and B-21 bomber.[53] The Navy's Maritime Accelerated Capabilities Office has been instrumental in accelerating that service's MQ-25A unmanned tanker, Large Displacement Unmanned Undersea Vehicle, and Standard Missile-2 Block 3 system.[54] Similarly, the Army's RCO has begun to address deficiencies in electronic warfare, long-range fires, and non-GPS-based position, navigation, and targeting systems.[55]

Several important features of the SCO/RCO approach are relevant to the overall reform of the services' acquisition systems. These offices:

- Focus on what can be deployed in the near term (one or two years) based on available technology;
- Do not have to pursue full and open competitions;
- Are not only R&D organizations, but also have the ability to procure and field real capabilities; and
- Have a close working relationship with the warfighters that enables the rapid collection of feedback to improve their offerings.

The Army is taking its RCO to a new level by reorganizing it into a Program Executive Office. There will be two program managers under the new structure, one for rapid prototyping and one responsible for rapid acquisition.[56] The rapid prototyping program manager will support the cross-functional teams (CFTs) and, logically, the new Futures Command. The RCO also is working very closely with Army program managers to ensure that the latter benefits from the insights and data that the former develops.

The successes of the SCO and RCOs provide a template for reform of the services' acquisition systems. In essence, they have proven that there is an alternative approach to acquisition, one that is agile, creative, willing to take risks, and able to pull ideas from traditional defense companies, large commercial ventures, start-ups, government laboratories, and academia.

However, the work of both the SCO and service-based rapid capability offices is more about adaptation than innovation. They are working to fill critical capability gaps largely by repurposing or modifying existing systems. Their work does not require significant changes in organizations or operating concepts. Modernization—the transition to a new generation of capabilities with possibly revolutionary effects—is a more involved, complex, and time-consuming activity.

The current difficulty of maintaining adequate stockpiles of precision munitions is an excellent example of the problems facing today's defense industrial base. The Air Force has been rapidly depleting its stockpiles of smart munitions in order to meet the demands of the fight against ISIS. According to DOD's *Fiscal Year 2017 Annual Industrial Capabilities Report to Congress*, this is a result of decades of inconsistent funding, the lack of investment in new designs reflecting changes in component technologies, the loss of domestic suppliers, and a growing dependence on foreign sources for raw materials and components. The effects of these various challenges could be nothing short of catastrophic for the nation's security:

> The loss of this design and production capability could result in costly delays, unanticipated expense, and a significant impact to many current and future missile programs, damaging the readiness of the Department [of Defense] and negatively impacting a foundational national

> defense priority by placing the ballistic missile production capability at risk.[57]

In some instances, where foreign producers have the best products, it makes sense to acquire designs, components, and even entire platforms from foreign sources. This has been the case with Active Protection Systems for armored vehicles, light attack aircraft, and the Marine Corps' Amphibious Combat Vehicle Increment 1.1. In the case of the F-35 Joint Strike Fighter, eight foreign allies are part of the consortium to develop and build the aircraft.

However, over the past half century, more and more production of items that go into U.S. defense goods comes from foreign countries, including those that are our main competitors. It is difficult for DOD even to track the sourcing of many components that end up in U.S. weapons systems. There have been numerous reports of faulty and even fraudulent parts from China showing up in U.S. military systems.[58] Recently, the Pentagon banned the sale or use on U.S. military bases of telecommunications devices made by the Chinese companies Huawei and ZTE.[59] Under Secretary of Defense for Acquisition and Sustainment Ellen Lord has warned that U.S. dependence on China for materials and components that are essential to high-end defense products is "quite alarming." According to Lord, "We have an amazing amount of dependency on China, and we are sole sourced for rare earth minerals, energetics, different things. This is a problem for us as we move forward."[60]

Finally, the defense acquisition system and companies engaged in defense-related production and sustainment face a critical workforce shortage. The secular decline in manufacturing has resulted in a loss both of aerospace and defense workers and of the skilled technicians and artisans that produce the machines and tools needed to construct next-generation weapons systems. DOD's *Fiscal Year 2017 Annual Industrial Capabilities Report to Congress* identifies weaknesses in the workforce as a serious threat to the ability of the aerospace and defense industrial base to support military requirements:

> A&D [aerospace and defense] companies are being faced with a shortage of qualified workers to meet current demands as well as needing to integrate a younger workforce with the "right skills, aptitude, experience, and interest to step into the jobs vacated by senior-level engineers and skilled technicians" as they exit the workforce.[61]

The retirement of the Baby Boomer generation and the lack of sufficient opportunities for technical education are also exacerbating the workforce problem. "Throughout our defense industrial base, talented workers in these critically important trades are retiring and not being replaced in sufficient numbers to support our defense needs," according to White House National Trade Council Director Peter Navarro. "Shipyards, vehicle manufacturing and aircraft facilities are particularly hard-hit. Training the next generation of skilled trade workers will be essential to our military's future success."[62]

An additional workforce issue is the backlog in security clearances. The number of engineers, scientists, and even procurement officers awaiting clearances has grown exponentially over the past several years. Major defense programs are being hampered by the inability to get critical technical personnel cleared expeditiously. As one longtime observer of the aerospace and defense industry has observed, this shortfall also acts like a tax on defense procurement:

> The government is not keeping up with the demand for clearances. As of last month [April 2017], the National Background Investigations Bureau within the Office of Personnel Management—which performs 95% of federal background checks—had accumulated a backlog of 570,000 applications. Delays in granting initial Top Secret clearances are averaging over 500 days. Average time required to receive an initial Confidential/Secret clearance, one of the least demanding in

terms of required background checks, is 262 days.

These delays have been particularly hard on industry, because it is difficult to attract and retain talent when new employees may have to cool their heels for a year or longer before beginning work on classified programs. One big contractor reports that as of April, 72% of the clearances it has requested since January of 2016 were still awaiting initial clearance determinations. Another contractor reported 75% of requests for background checks or periodic reinvestigations were still pending after 18 months; 10% were still pending after 24 months.

The hidden cost to taxpayers of these long delays is huge. An engineer hired at a defense contractor for $100,000 per year will cost the company $725 per day in salary and benefits, which gets added to overhead if they cannot work on the project for which they were hired. If the wait to receive an initial clearance determination is 300 days, it will cost the company $217,500—which then gets billed to the government as a price of doing business....

But the waste does not end there. When clearances take a year or longer to process, programs are delayed, workers are under-employed, and holding on to the people who are most in demand becomes a challenge. Nobody rigorously tracks what all this inefficiency costs the government, but over time it is undoubtedly in the billions of dollars....[63]

Modernization and Innovation

In discussing the 2018 *National Defense Strategy*'s key messages, Secretary of Defense Mattis has made a particular point of the need to accelerate the pace at which weapons systems, military organizations, and concepts of operations are evolved to meet future threats. To meet this need, DOD "will transition to a culture of performance and affordability that operates at the speed of relevance" because "[s]uccess does not go to the country that develops a new technology first, but rather, to the one that better integrates it and more swiftly adapts its way of fighting."[64]

This formulation stands the traditional metrics of DOD's acquisition system on its head. Procurement programs must always balance performance against affordability or cost. The most noteworthy phrase used by the Defense Secretary is "the speed of relevance." Every current senior DOD leader has stressed the need to develop and deploy new capabilities faster, first to fill capability gaps and then to reestablish military superiority. The Secretary of Defense recently provided a very clear example of what he means by relevance and why speed in modernizing U.S. military capabilities is so vital:

I want to repeat here that we have no God-given right to victory on the battlefield. And in that regard, make no mistake that our adversaries are right now making concentrated efforts to erode our competitive edge. You know it, I know it. We can see it in the world around us. And I would say, too, that by contesting our supremacy in every domain, we can see it working against us in aggregate....

So our air, naval, ground, and logistics bases today are also under threat of precision, all-weather, day/night guided munition bombardment, which will complicate our operations, and make passive and active base defense absolutely critical in the future. So if we fail to adapt... at the speed of relevance, then our forces, military forces, our air force, will lose the very technical and tactical advantage that we've enjoyed since World War II.[65]

The other important part of Secretary Mattis's formulation is that new and advanced weapons systems are not enough to ensure

military superiority. Seeming to borrow from the theory of RMAs, Mattis asserts that reestablishment of meaningful military advantage in future conflicts requires changes to organizations and employment concepts.

But in order to allow the services to undertake the required change in organizations, operational concepts, and tactics, it is important to get new capabilities in the hands of the warfighter speedily. There is general agreement among defense experts that once soldiers, sailors, and airmen are able to work with new platforms and systems, they identify ways to improve performance and employ these capabilities. These ideas and suggestions from the field often were not envisioned by the developers or those writing the requirements.

The approach to modernization laid out by Secretary Mattis is orthogonal to the way the existing acquisition system has pursued modernization. The established acquisition system has rightly been criticized as excruciatingly slow, risk-averse, unable to transition new technologies from the R&D to fieldable systems, overly focused on costs at the expense of performance, and preferring process at the expense of results. The belief that adversaries are innovating more rapidly than the U.S. military has therefore sent DOD on the hunt for the magic elixir that will make its own acquisition system more agile and creative. The Office of the Secretary of Defense and the services are looking to cutting-edge commercial firms both for advanced technologies with military applications and as a source for the "spark" of innovation.

The Pentagon is using the Defense Innovation Unit Experimental to connect defense organizations that have critical capability requirements to private companies that offer potential solutions. Not surprisingly, the site for DIUx's first office was Silicon Valley. DIUx provides relatively small amounts of capital in exchange for commercial products that solve national defense problems. It currently is focused on five areas in which the commercial marketplace is leading in technology innovation: artificial intelligence; autonomy; information technology (IT); human systems; and space.[66]

DIUx has pioneered the use of other transaction authorities (OTAs) to access nontraditional technology providers and speed the process of awarding contracts. It also has created Commercial Solutions Opening agreements. DIUx solicits solutions to warfighters' problems, ultimately awarding contracts for prototypes based on OTA. A prototype contract can reach $250 million, must use a nontraditional defense contractor and have all of its participants be small businesses, or have at least a third of its total cost paid by parties other than the government.[67]

Seeking to replicate the DIUx model, the Air Force stood up the Air Force innovation incubator (AFWERX). AFWERX is exploring ways to develop an entrepreneurial commercial business base of companies that understand national security problems and are able to work with the Pentagon's acquisition system by running multiple programs and familiarizing companies with national security problems and how they can engage effectively with the government. The AFWERX methodology also includes so-called challenge events that bring together small businesses, entrepreneurs, and academia to provide innovative solutions to urgent service requirements.[68]

The Office of Naval Research has taken a similar approach by creating the Naval Innovation Process Adoption (NIPA) to exploit the opportunities created by new contracting mechanisms to connect with small, innovative companies and speed the development of militarily relevant technologies.[69] NIPA is embracing Hacking for Defense (H4D), a program designed by Steve Blank, an adjunct professor at Stanford University, and retired Colonel Pete Newell, former head of the Army's Rapid Equipping Force, of BMNT. H4D began at Stanford University and is now operating at 10 additional colleges and universities. It organizes teams of students at major U.S. universities to help solve difficult problems facing DOD. The goal is to produce a "minimum viable product." Among the problems currently under

investigation by H4D are detecting nuclear, biological, and chemical weapons in tunnels; identifying objects in U-2 high-resolution imagery; and battlefield energy self-sufficiency.[70]

One of the key barriers to innovation and faster delivery of relevant new military capabilities to the warfighter is the current acquisition system's requirements-driven approach. It can take up to a decade for a service to develop a fully validated requirement for a new capability. Too often in the past, the requirements developers did so without significant input from technologists, industry, or logisticians. As a senior corporate officer at Alphabet Inc. observed during an Air Force conference, the requirements-driven acquisition process is "more than inefficient, it's become dangerous."[71]

Testifying before the Senate Armed Services Committee in December 2017, Ellen Lord, then Under Secretary of Defense for AT&L, underscored the importance of reducing the upfront time it took to award a contract for major new procurement:

> I have placed priority across the Defense Acquisition System on reducing the time required to award contracts once the requisite funds are authorized and appropriated by Congress. Having reviewed data measuring the typical lead time following validation of a warfighter requirement until awarding the resulting major weapon systems contract, I've concluded that we have the ability to reduce this procurement lead time by as much as 50 percent; significantly reducing our costs while accelerating our timelines for fielding major capability.[72]

Each of the military services is engaged in an effort to respond to Secretary Mattis's initiative by making its acquisition process both faster and more relevant. The most radical reforms have been initiated by the Army. More than the other services, the Army is in dire need of modernization. As current Vice Chief of Staff General James McConville recently acknowledged, "we are at an inflection point where we can no longer afford to defer modernizing our capabilities and developing new ones without eroding competitive advantages of our technology and weapon systems."[73] For this reason, the Army's current modernization efforts deserve particular attention.

Army Secretary Mark Esper and Chief of Staff General Mark Milley have set ambitious goals for a revamped acquisition system. Secretary Esper has spoken of reducing the time it takes to formulate requirements from an average of five years to just one. General Milley wants new capabilities that are 10 times more lethal than those they replace. Getting there, he suggested in a recent speech, is as much about attitude and culture as it is about technology:

> I'm not interested in a linear progression into the future. That will end up in defeat on a future battlefield. If we think that if we just draw a straight line into the future and simply make incremental improvements to current systems, then we're blowing smoke up our collective fourth point of contact....[74]

The leadership of the U.S. Army has locked arms and is advancing like the proverbial phalanx on a single objective: to make that service's acquisition system faster and more effective. Rather than take the usual incremental approach to change, Army leaders are going big and bold. Even if only a partial success, the reform effort could produce an Army acquisition system that is speedier, more agile, less costly, and more likely to produce better outcomes than is possible under the current system.

As described by Army Secretary Esper in recent testimony before the Senate Armed Services Committee, the reform effort consists of five interrelated initiatives:

- Establishing a Futures Command;
- Streamlining and improving ongoing acquisition activities such as contracting, sustainment, and testing;

- Creating cross-functional teams focused on rapidly defining requirements for programs that address the Army's six modernization priorities;
- Refocusing science and technology priorities and investment; and
- Changing oversight and decision-making related to major acquisition programs.

The Army hopes that just by using CFTs it can reduce the time needed to develop requirements "from up to 60 months to 12 months or less."[75] "The overall goal," according to Secretary Esper, "is to shorten the acquisition cycle to between 5 and 7 years."[76]

But how fast can any acquisition system be when asked to come up with cutting-edge capabilities that can operate in any environment, survive combat, and last for decades? The history of Army programs shows wide variation in acquisition timelines. A review of successful major acquisition programs over the past half-century suggests that they take a minimum of a decade and more often 15–20 years to go from concept development to initial operating capability (IOC).[77] The history of the Army's vaunted Big Five modernization programs—the Abrams tank, Bradley infantry fighting vehicle, Blackhawk and Apache helicopters, and Patriot surface-to-air missile system—illustrates the challenges facing Army acquisition even after current reform initiatives are implemented.

Army planners recognize that in an environment short of national mobilization, true modernization of their service will take time—in reality, decades. In recent written testimony before the Senate Armed Services Committee, four senior Army leaders laid out a three-phase modernization strategy:

> In the near-term, the Army will invest in capabilities that address critical gaps and improve lethality to expand and maintain overmatch against peer competitors. In the mid-term, the Army will develop, procure, and field next generation capabilities to fight and win in Multi-Domain Battle. In the far-term, we will build an Army for a fundamentally different conflict environment—one that will require us to exercise mission command across dispersed and decentralized formations, leverage disruptive technologies at the small unit level, and operate with and against autonomous and artificial intelligence systems, all at an accelerated speed of war.[78]

The Army's proposed acquisition reforms are intended to eliminate the false starts and bets on immature technologies that marred a number of Army acquisition programs, but in many cases, these errors allowed technologies to mature and requirements to be refined. Prior programs could have been executed more efficiently but not necessarily much faster. The reality is that fielding next-generation capabilities inevitably takes a lot of time. The Army has been working on most of its modernization priorities for at least a decade. Even with the use of CFTs and implementation of the other reforms, it is unlikely that new capabilities will be fielded in less than another decade.

Like the Army, the Air Force is putting a great deal of emphasis on reforming the front end of the acquisition process. Secretary of the Air Force Heather Wilson has described her service's vision of acquisition reform in testimony before the Senate Armed Services Committee:

> The acquisition enterprise is currently optimized for industrial-age procurement of large weapons systems with extensive requirement development, military specifications and resultant long acquisition timelines. We must shift to align with modern industry practices in order to get cost-effective capabilities from the lab to the warfighter faster. We are changing the culture in the Air Force to focus on innovation, speed and risk acceptance while meeting cost, schedule and performance metrics.[79]

The Air Force is examining ways to improve the process of formulating requirements including by the increased use of prototyping and experimentation. According to the head of Air Force Materiel Command, General Ellen Pawlikowski:

> We have to truly embrace this idea of experimentation in prototyping. Recognizing that we will spend money to build things that we will never buy because we will find out early it doesn't do what we really want.... Money spent on things that we try and don't adopt—that will be more than recouped.[80]

Given the centrality of software in all of its platforms and systems, the Air Force is particularly concerned about changing the acquisition system to reflect the fast-paced evolution of this vital technology. This challenge is made all the more difficult by the reality that when it comes to software, DOD cannot shape the market. Unlike the market for fighter aircraft, tanks, or nuclear-powered attack submarines, when it comes to software, the Pentagon is dependent on commercial providers. Moreover, the commercial market operates under different rules with timelines and incentive structures that are unlike many of those in the traditional defense industrial base. As Secretary Wilson has observed:

> There are areas where the Air Force is still struggling to be exceptionally good buyers. Software is one. We need to improve the development and deployment of software-intensive national security and business information technology systems. As we move toward industry practices and standards, the line[s] between development, procurement, and sustainment for software are blurred. Development cycles of 3–5 years or longer do not align with the pace of technological advancement. They contribute to failures in software-intensive programs and cause cost and schedule overruns. We have initiated pathfinder efforts and are working to improve the speed of software development. Likewise, we are continuing efforts with Open Mission Systems architecture, and initiatives with Defense Digital Services, Air Force Digital Services, and Defense Innovation Unit Experimental, in addition to our organic development capabilities, to improve software agility, development, and performance.[81]

The Navy is pursuing multiple approaches to making its acquisition system more agile and innovative. It has established the Accelerated Acquisition Board chaired by the service chiefs and its Service Acquisition Executive. It has created specialized approaches to accelerate the system's response to urgent needs. One of these is the Maritime Accelerated Capability Office (MACO), which is tasked with addressing priority needs where a suitable material solution has been identified and a formal program can be established. In the absence of a clear material solution to a priority need, the Navy will pursue a Rapid Prototyping, Experimentation and Demonstration (RPED) project.[82]

The effort to encourage greater innovation makes sense up to a point. Unfortunately, there is a growing tendency for Pentagon officials and defense experts alike to view innovation and efficiency as increasingly the domains of commercial companies and to minimize and occasionally even disparage the U.S. defense industry's ability to produce cutting-edge capabilities. The reason for this is a growing tendency among Pentagon officials and defense experts to conflate advances in basic technologies with innovation in military capabilities. While it is true that more new technology today comes from commercial rather than government investment, innovation in high-end defense products remains almost the exclusive domain of defense companies.

The wars in Iraq and Afghanistan witnessed a veritable explosion of innovation, including platforms and systems, tactics, techniques, and procedures. This also is the same period when

innovation by commercial companies was increasing almost exponentially. In a number of instances, new military capabilities were based on commercial innovations, but the creation of entire suites of capabilities to counter IEDs or provide real-time, multispectral tactical ISR and to integrate them on a wide range of platforms was due to the skills and even genius of the public and private defense industrial bases.

Defense companies continue to demonstrate a capacity for innovation that far outstrips that of any commercial entity, not just in the United States but globally. The case of the F-35 Joint Strike Fighter illustrates this point. According to DOD's former Director of Cost Assessment and Program Evaluation (CAPE), Dr. Christine Fox, "from a CAPE perspective, the JSF is not over-cost, it's over-dreamed."[83] While it is true that the plan for the JSF was overly optimistic and underresourced, the program has been remarkably successful in meeting those dreams. Virtually everyone in the military who has been involved with the program over the years has declared it to be a "game changer."[84] The F-35 demonstrates that the defense industrial base can still make dreams come true.

Admittedly, there is one technology area that does pose a serious challenge for the acquisition system: information technology. The entire U.S. defense enterprise, from individual weapons systems to platforms, individual units, and command and control elements to supporting infrastructure, is becoming increasingly information-centric. The result is an orders-of-magnitude improvement in the U.S. military's ability to conduct the full range of missions. Much of the technology underpinning this revolution in military capabilities is commercial in nature. Moreover, the breadth and speed of innovation in commercial IT completely confound the traditional defense acquisition process.

This is even more the case when it comes to cyber security. It is clear that entirely new approaches to the acquisition of cyber capabilities and the management of military networks will be required if the Defense Department is to have any hope of staying abreast of the threat. If the U.S. military cannot successfully defend its systems and networks against this ever-changing threat, current efforts at innovation, which are largely based on IT, will be for naught.

Without question, commercial companies of all types will have a greater role to play in defense innovation during the coming decades than they have had in the past, but the ability of traditional U.S. defense companies to take the products of commercial innovation and create the systems, platforms, and capabilities that ensure U.S. military dominance will continue to be determinative.

Modernization and Procurement: How to Buy as Important as What to Buy

Most of the military services' reform efforts have been focused on the front end of the acquisition process: R&D, prototyping, and the formulation of requirements. As part of its effort to stand up the new Futures Command, the Army has focused to a great extent on where to locate its new headquarters. The desire is to imbed the command in an environment of technological and commercial innovation similar to Silicon Valley. The other services are similarly focused on injecting innovation and speed into the front-end or technology-development portion of the acquisition process.

Even more time is consumed by the complex and cumbersome processes of developing, testing, and producing new capabilities. Moreover, because the military acquires platforms and systems in relatively small quantities per year, continuing the current approach means that it will take decades to modernize the force even once new capabilities are developed.

Although the Army talks about having reached an inflection point and needing to rapidly counter the loss of overmatch vis-à-vis great-power competitors, recent programmatic and budgetary decisions suggest that when it comes to putting new capabilities in the field, not much has changed. In fact, some priority modernization programs actually appear to be moving more slowly than they were

before being highlighted as essential to national security.

According to documents submitted in support of its fiscal year (FY) 2019 budget request, the Army appears to be increasing the time it will take to field the Future Vertical Lift (FVL) replacement for current rotary-wing systems.[85] Despite having spent years conducting research and producing prototypes in FVL's precursor program, the Joint Multi-Role Technology Demonstrator, the Army still does not plan to field the system before 2030.

Similarly, a year appears to have been added to the development phase of the Long Range Precision Fires (LRPF) program.[86] The additional time will be used to assess the current state of technology and conduct analyses of key price drivers that could affect life-cycle cost estimates and force the program down an alternative path. Both of these factors suggest that further delays in the LRPF program could be coming.

For the Air Force, modernization is here and now. The Air Force currently has major modernization programs underway for virtually all of its aircraft fleets, the nuclear deterrent, space launch, and military satellites. As Secretary Wilson noted in a speech at an Air Force Association conference:

> The average age of our aircraft is 28 years old. We have to be able to evolve faster, to respond faster than our potential adversaries. We've got a bow wave of modernization coming across the board for the Air Force over the next 10 years—it's bombers, it's fighters, it's tankers, it's satellites, it's helicopters and it's our nuclear deterrent.[87]

The key to Air Force modernization is the rate at which it can bring new capabilities online. Unfortunately, current annual production rates for the major platforms on which the Air Force's modernization plan relies are too low. At 48 F-35As per year in FY 2019 and 54 per year in FY 2020–FY 2023, it will take more than 30 years for the Air Force to reach its acquisition goal of 1,700 Joint Strike Fighters. The current acquisition target for the KC-46A tanker is 15 aircraft per year. At this rate, the target of 187 new tankers will not be realized for 12 years. Even then, the Air Force will have to keep flying more than 200 obsolescent KC-135s.

The Air Force's acquisition reform initiatives do not address the fundamental problem of procurement numbers that are simply too low. This reality led one eminent defense expert to warn that:

> There's nothing wrong with pursuing the various leap-ahead ideas that the Air Force has recently embraced in its pursuit of future air dominance. But none of the leap-ahead ideas is likely to come to fruition anytime soon, including the B-21 bomber. One lesson of the Reagan buildup and similar spending surges in the postwar period is that new programs begun in the midst of a buildup tend to falter for lack of funding or feasibility long before they reach the force. It's a lot easier and faster to buy more of what is already being produced.[88]

For the Navy, there is an inherent tension between the desire to be more innovative, to invest in advanced technologies, and the need to increase the overall size of the fleet. It has long been recognized that the Navy is too small to fulfill all of its missions. Now a larger Navy is the law of the land. Section 1025 of the 2018 NDAA states, "It shall be the policy of the United States to have available, as soon as practicable, not fewer than 355 battle force ships...."[89]

The key words in the NDAA are "as soon as practicable." It takes years to build a warship. It also takes lots of money. Then there is the ability of the industrial base, including shipyards but also all of the mid-sized and smaller companies, to expand to meet the demand for more warships. The Navy plans to spend billions to upgrade the four public shipyards so that they can build additional warships and improve maintenance activities.[90] Finally, of

course, the size and quality of the workforce that builds the ships and their systems are crucial. Ensuring a continuing, predictable flow of work allows shipbuilders and their suppliers to improve the management and training of their workforces.

One proven way to make procurement of new warships more rapid while simultaneously lowering their cost is to buy them in bulk. The Navy currently purchases several of its most important platforms in groups, either as multiyear procurements or as block buys. The longest-running and most successful example of this approach is for the *Virginia*-class nuclear-powered fast attack submarine (SSN), which is now on its third multiyear procurement.[91] The Navy is preparing to issue its second multiyear procurement for the DDG-51 *Arleigh Burke*–class destroyer. The second multiyear, for as many as 10 advanced Flight III *Arleigh Burkes*, is expected to yield savings of up to $1.8 billion across the planned buy.[92] Block-buy contracts that encompass two providers with different designs are also being used to procure the Littoral Combat Ship (LCS).

Achieving the goal of a 12–aircraft carrier force as part of a 355-ship Navy means shortening the interval between the start of construction, currently five years, as well as finding ways to reduce their cost.[93] The acquisition strategy that has been employed successfully to procure surface combatants and submarines could also be applied to buying aircraft carriers. The Navy bought the first two *Ford*-class carriers, CVNs 78 and 79, as single ships. Initiating a block-buy procurement for the next several ships could help to reduce the interval between construction starts, shorten the overall length of time needed to complete construction, and save money. The only shipyard in the nation that can build nuclear-powered aircraft carriers, Newport News, believes that it could save $1.5 billion on a three-ship block buy and shorten the average construction time by up to two years.[94]

There is a recognition by the Pentagon that it must address industrial base issues in order to modernize. According to senior Army officials:

> The past trends of constrained resources in the Army's modernization account have led to significant challenges for the Defense Industrial Base (DIB), especially for companies that cannot leverage commercial sales and for small companies that must diversify quickly to remain viable. When developing our equipment modernization strategy, we have carefully assessed risk across all portfolios to ensure balanced development of new capabilities, incremental upgrades to existing systems, and protection of critical capabilities in the commercial and organic elements of the DIB.[95]

Weaknesses in the defense industrial base are only one of the challenges confronting military modernization. All of the services raise the challenge of moving good ideas from development to procurement. This transition is often referred to as "the valley of death." The DOD R&D establishment annually pursues hundreds of projects. Only a handful ever become programs of record.

Toward a 21st Century Defense Industrial Base

The Department of Defense needs a new model for the defense industrial base. In World War II, we created industrial enterprises modeled on the public arsenals and shipyards. During the Cold War, we encouraged the development of defense conglomerates. Over the past two decades, DOD managed the DIB's decline by supporting the development of a small number of relatively specialized defense giants. Today, the Pentagon needs an acquisition system that allows it to innovate rapidly in new areas, including those where commercial companies are leading, and manage large defense programs with very long life cycles.

The Department of Defense is in love with the idea of getting cutting-edge commercial companies to become part of a new defense industrial base. During the Obama Administration, the Pentagon pursued an acquisition reform initiative called Better Buying Power

(BBP). One of its key tenets was the need to leverage commercial technologies to achieve dominant capabilities while controlling life-cycle costs. In pursuit of the innovative spirit, former Defense Secretary Ashton Carter made a pilgrimage to Silicon Valley where he gushed about the IT sector's ability to achieve "boundless transformation, progress, opportunity and prosperity" while simultaneously making "many things easier, cheaper and safer."[96]

In recent years, Congress has sought to inject greater flexibility and speed into the acquisition system. The FY 2016 NDAA included a set of reforms focused on improving the system's efficiency and agility. DOD is now allowed to use rapid acquisition authority to meet urgent operation needs identified by the warfighter or to acquire critical national security capabilities. The FY 2016 NDAA also directed DOD to develop a rapid acquisition strategy for so-called middle-tier programs intended for completion in two to five years.[97]

In 2017, Congress gave DOD additional flexibility with respect to acquisitions. The FY 2017 NDAA expands on earlier acquisition reform efforts. It explicitly establishes the authority for prototype projects in response to a high-priority warfighter need resulting from a capability gap. It also permits DOD to initiate a prototype project when an opportunity exists to use commercial technology to develop new components for major weapon systems so long as the technology is expected to be mature enough to prototype within three years and there is an opportunity to reduce sustainment costs.[98]

What is being created today is a bifurcated defense acquisition system. One part of it centers on small, special organizations such as the Rapid Equipping Force, DIUx, SCO, RCO, and CFTs and employs alternative contracting approaches, accounting standards, and funding mechanisms. The primary goals of this acquisition "sub-system" are the rapid identification of promising technologies, exploration of their application for military purposes, and development of prototypes that can serve as the basis for a program of record. This sub-system seeks to tap into the entrepreneurial character of commercial companies, particularly small and start-up businesses. Its features include the willingness to take risks, acceptance of failure, ability to connect nontraditional sources of ideas, and capacity to bring new products and processes to market expeditiously.

The other part of the acquisition system, representing the overwhelming number of programs and the vast preponderance of expenditures, operates according to a set of complex, fairly restrictive rules set down in the Defense Federal Acquisition Regulations. This system is often accused of being risk averse. While this is true to an extent, its cautious behavior with respect to new and unproven technologies also reflects the reality that standards for the performance and sustainment of military equipment are of necessity much more stringent than those for commercial systems. Moreover, the Pentagon's fleets of aircraft, vehicles, and ships are required to operate under more stressful conditions and to be serviceable far longer than is the case with respect to almost any commercial equivalents.

The notion that DOD can convert its acquisition system to mirror the behavior of the commercial marketplace is largely without merit. At its heart, the difference between the agility and risk-taking culture of a Silicon Valley and the more deliberate, long-term perspective of the defense acquisition system also exists in the commercial world. It is the difference between the attitude, values, and behavior of so-called entrepreneurs at the head of small, start-up companies and the leadership of large, complex, and established businesses. The former are focused on creation; the latter, on production and maintenance. The entrepreneurial spirit driving Tesla would be misplaced in a company like General Motors. This is largely the reason why major commercial companies pursue innovation through acquisitions of or partnerships with smaller cutting-edge firms.

An outstanding response to this unrequited love that defense officials have for commercial companies was provided by Wes Bush, Chief

Operating Officer of Northrop Grumman, one of our leading defense companies. In a speech at the Center for Strategic and International Studies, Bush warned that "commercial solutions—while an important ingredient [in] much of what gets done—in and of themselves are not the answer for our national security and our technological superiority and therefore should not be used as an excuse for further reductions in R&D."[99]

Bush went on to point out that because commercial technologies are available to all, including U.S. adversaries, they will not provide any unique advantages to the U.S. military. Military systems, regardless of the degree to which they rely on commercial technologies, address a unique class of requirements and demand the application of the special skills and knowledge possessed by long-established defense companies.

Defense companies have demonstrated what can be achieved with rapid and innovative product development when not under the system's thumb.

So far, the discussion regarding leveraging advances in the commercial sector to support DOD has focused almost exclusively on developing technologies and producing new capabilities, but there are two fundamental acquisition challenges. One is to acquire dominant capabilities, and the other is to control sustainment and life-cycle costs. It is in the ability to control costs that commercial companies have the most to offer DOD. The revolution in supply chain management, epitomized by the concept of just-in-time manufacturing and delivery, has been every bit as transformational globally as has the invention of the smartphone. Moreover, the Pentagon can avail itself of the advantages of importing best-of-breed commercial supply chain management and sustainment practices more readily than it can adapt commercial technologies to achieve dominant military capabilities.

The Pentagon spends some $200 billion annually on logistics and sustainment. When one adds to this number those support and training functions such as military communications and pilot training that countries like the U.K. have privatized, the number could be as high as $300 billion, or nearly three times the current procurement budget. If DOD wants real budget savings and improved warfighting outcomes, it needs to adopt proven commercial-derived logistics and sustainment practices. Where it has done so, costs have gone down and aircraft availability has increased. Similarly, commercial logistics providers have spent more than a decade providing affordable logistics support to U.S forces in Iraq and Afghanistan. Privatizing non-core military functions could save tens of billions of dollars and free hundreds of thousands of uniformed personnel and government civilians for more important tasks.

Acquisition officials are trying to figure out how to get commercial companies to be part of the acquisition system and behave like traditional defense firms. This approach is not likely to be successful. However, one way to fulfill this wish is to allow traditional defense companies to serve as middlemen between the commercial vendors and DOD. Long-standing defense companies have all of the right contracting, accounting, and reporting systems in place.

DOD has resisted the widespread use of commercial best practices in logistics and sustainment because it means giving up some control of resources, people, and even equipment. What Pentagon officials, particularly program managers, have to realize is that the key to successful cost reduction is giving up control of much of the process and relying instead on the incentives of a free market–oriented approach with properly written contracts to drive the desired behavior by the private sector.

A proven way to reduce sustainment costs is by applying commercial best practices to defense acquisition and sustainment. One of these best practices when it comes to managing the maintenance, repair, and overhaul of major weapons systems and platforms is performance-based logistics (PBL). Unlike traditional fee-for-service or time-and-materials contracts, PBL works by specifying outcomes, not activities. The contractor commits

to meeting a specified level of performance, such as the percentage of a fleet of vehicles or aircraft available for operations, for a price that is usually below what the government was paying previously.

DOD has had some notable successes with PBL-based sustainment contracts. They are particularly useful in the management of aircraft fleets. There are PBL contracts in place to help support the C-17 Globemaster, MV-22 Osprey, CH-47 Chinook, AH-44 Apache, and MH-60R Seahawk.[100]

A similar situation is developing in the area of networking and software. Increasingly, the commercial world is focused on cloud computing and fee-for-service delivery of capabilities. This approach allows for the rapid advancement of applications, high-speed access to data, effective security, and reduced costs.

The federal government is beginning the transition to the new approach to managing its network and computing needs. The 17 members of the Intelligence Community (IC) are benefitting from a new contract with the private sector for cloud services managed by the CIA and NSA. This is essentially a public cloud on private property, a government facility built to IC security standards.[101] DOD is considering a number of large contracts with commercial cloud providers, such as the Defense Enterprise Office Solutions (DEOS) cloud-based e-mail and messaging contract and the Joint Enterprise Defense Infrastructure (JEDI), which is intended to support core DOD services, data management, and advanced analytics.[102]

There is a simple truth to all defense contracting: Private companies require appropriate incentives for innovating or improving production processes. Investments in R&D and infrastructure are costs that a company, at a minimum, must believe it can recoup once its invention hits the market. If a company is really lucky, it might even make a profit from its efforts.

The constraints of profits imposed on government contracts is a major barrier to commercial firms doing business with the Pentagon. For many high-tech commercial companies, particularly those involved in IT and software, pretax profits can be twice what is earned in the aerospace and defense sector.[103] By many standard measures, private companies have little incentive to do business with the Defense Department.

Every company that innovates, from the "lowly" inventor of an app for a smartphone to biotechnology and pharmaceutical companies looking for the next breakthrough drug and the makers of vehicles, ships, airplanes, and satellites, invest in new products or processes for one reason only: to make money. Wall Street severely punishes publicly held companies that behave in any other way.

Then there is the practice of structuring contracts based on the standard of the Lowest Price Technically Acceptable (LPTA) proposal.[104] Companies bidding on LPTA-type contracts have to demonstrate only the minimum level of proficiency. Providing a better product and high-quality service or proposing a more innovative solution does not increase a bidder's chance of success. In fact, any investments made to attract highly qualified personnel or expenditures made to develop a new solution increase costs for the vender, and thus for the product offered, and reduce the chances of winning.

The combination of declining defense budgets and increasing regulation and oversight has had a suffocating effect on the propensity of defense and aerospace companies to spend on R&D or infrastructure. Without procurements (in other words, purchases by the government), companies have struggled just to recover their costs and earn profits. It makes no sense for them to invest more in R&D when there is no prospect of increased revenues. As the head of a major profit and loss center for one of the largest U.S. defense companies made clear, "I cannot convince my senior management to invest any of our money without the clear prospect of a procurement program at the end of the day and incoming revenues."[105]

The good news is that recent commitments by the federal government to spend more on

defense, driven especially by Secretary Mattis's 2018 *National Defense Strategy* that emphasizes the reemergence of great-power competition, has led defense companies once again to spend their own money on R&D and capital improvements. In a recent series of earnings calls and discussions with Wall Street analysts, a number of defense firms announced that they were increasing their spending on R&D, facilities, and manufacturing capacity. In most cases, these firms are spending their own resources before higher defense budgets have materialized or contracts have been won.[106]

There are two reasons for this. The more obvious one is the Trump Administration's commitment to increase defense spending. While much of this increase inevitably will be used to improve readiness and even increase the size of the military, DOD has made it clear that it intends to buy more ships, aircraft, vehicles, missiles, and munitions.

An equally significant reason for defense companies to commit more resources to this effort is the apparent change in DOD's attitude toward the defense industry. In particular, there is a willingness to treat industry as a partner rather than as an adversary and to incentivize increased investment in innovation and manufacturing by increasing procurement. "If we can give industry some reassurance that there will be a contract on the other end, that there are dollars committed behind it, then I think you will see a lot more industry putting their dollars into the game and getting us there quickly," observed Army Secretary Esper recently. "What we are trying to do is improve collaboration with industry. That is how we see it moving forward."[107]

The Pentagon's top acquisition official, Ellen Lord, has proposed incentivizing industry to respond to proposals in 60 days or less and to reduce by half the time it takes for the government to review proposals and award a contract.[108] Since time really is money for these companies, a speedier contracting process matters.

Another roadblock to DOD's ability to access commercial technologies is the government's treatment of intellectual property (IP). There has long been tension between the government and private companies over the former's desire to acquire the rights to the latter's IP. At issue are the government's right to IP that is produced solely with private funds, the extent to which a contract with a defense prime allows the government access to the IP of subcontractors, and the ability of the government to protect that IP from competitors.[109]

DOD leaders have acknowledged that the way the Pentagon addresses the IP concerns of all companies involves serious difficulties. According to Assistant Secretary of the Army for Acquisition, Logistics and Technology Bruce Jette, the Army needs both to find new ways to conduct fair and open competitions that do not force companies to expose their best ideas to potential competitors and to ensure that it is clear who owns which IP.[110]

A 21st century U.S. defense industrial base must also be international. The pace of globalization in the aerospace and defense industry is quickening. In part, this reflects the great expense involved in many large aerospace programs. The Eurofighter and JSF programs are examples of countries pooling their resources and sharing the work involved in building new fighter aircraft. Russia is believed to have joined with India in developing the T-50, a stealthy competitor for the F-22 fighter.

In part, this also reflects the reality that many foreign countries, particularly U.S. allies in Europe and Asia, now possess critical design skills, production capabilities, and products. For example, several of the teams competing for the new Air Force trainer are offering a foreign-designed or foreign-made airframe. The two teams that competed for the Marine Corps' Amphibious Combat Vehicle 1.1 were providing a vehicle made overseas. U.S. Army tanks are being equipped with an Israeli-made active protection system. In many areas, including night vision systems, naval radar, sonar, air-to-air missiles, and even space systems, foreign companies' technologies and products are equal to or better than those provided by U.S. companies.

The fundamental challenge to military modernization in the 21st century is the need to change DOD's acquisition culture in order to incentivize both government and the private sector. Without a major change in DOD's own culture, the effort to make the acquisition system more efficient is more likely than not to enhance inefficiency. In particular, it will almost certainly engender a more combative relationship between DOD and the private sector.

The defense industry has repeatedly shown that it is willing to adapt to meet changes in the way the Pentagon decides to conduct itself. Whether it is fixed-price versus cost-plus contracts,[111] the use of commercial items, basic ordering agreements, small-business and minority set-aside, performance-based logistics, contractor logistics support arrangements, or systems engineering and technical assistance support, the private sector has responded to every invention and notion that the bureaucrats have devised and has continued to support the warfighters.

Conclusion

The U.S. military's ability to defeat its opponents in battle depends largely, though not exclusively, on the equipment, weapons, and supporting capabilities that it possesses. In turn, these depend on an industrial base that is viable and healthy enough to produce them and the relative effectiveness of new capabilities that spring from competition in design. All of this implies some level of competitive redundancy among manufacturers that can come only from a defense funding stream that is large enough and consistent enough to keep companies that produce the wherewithal of America's military power in business. To be clear: This is not some form of corporate welfare. It is an investment in the nation's fundamental security.

Modernization requires the ability of the military to keep place with the technological evolution of the battlefield. A force able to modernize in turn requires an industrial base healthy and diverse enough to develop and apply emerging technologies that are relevant to war. Failure in either area—a weak, moribund defense industrial base or obsolete forces—means failure in war and the fatal compromise of the nation's security. Conversely, a healthy and effective force, made possible by a healthy and relevant industrial base, means a secure and prosperous country.

The latter is clearly better than the former, and the country would be wise to view defense expenditures accordingly.

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