Topical Essays

Supplying the Manpower That America's National Security Strategy Demands

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Introduction

The first mention of the military in our nation's founding document refers, perhaps not surprisingly, to the authority, vested in Congress, to create an armed force in the first place. Article 1, Section 8 of the Constitution imbues the legislative branch with the power to "raise and support Armies." However, the Constitution provides little guidance as to what else Congress should take into account in raising an Army.

Fortunately, George Washington, soon to be our first commander in chief, laid out his vision for the U.S. military. Washington's "Sentiments on a Peace Establishment," written in 1783 three years before he assumed the presidency, might be the first treatise on American strategy.[2] In it, he of course touches on traditional questions of strategy—what threats the Army must defend against, where it should be positioned, or how large it should be—but Washington delves most deeply into questions related to the *who*, not the what or how, of military force: how to recruit troops, how long they should serve, the ideal composition of the military and officer corps, criteria for promoting troops, how to determine pay, and even the appropriateness of providing rum in soldiers' rations (vinegar, it turns out, is better).

As this document was meant for the "Commencement of our Military system," Washington argued that this focus on military personnel was necessary because it was "the proper time to introduce new and beneficial regulations, and to expunge all customs, which from experience have been found unproductive of general good."[3] The questions that Washington raises go beyond concerns about an incipient armed force and are critical to the strength of any military, but particularly one that depends, as the U.S. military does, on voluntary service.

Indeed, one could argue that the unrivaled superiority of the American armed forces over the past 70 years can be attributed in large part to the willingness of lawmakers and defense leaders to revisit and revise how servicemembers are recruited, managed, promoted, paid, and retained. The set of laws and policies that manage these functions, known collectively as the defense personnel system, provides the manpower supply—not just in terms of numbers, but also in terms of rank, skills, and specialties—that America's military needs to execute its mission and America's National Security Strategy demands.[4]

Although there is a surprising degree of continuity between the military envisioned by Washington and the one that exists today, the personnel system has evolved significantly over the past two-and-a-quarter centuries, shifting from volunteer militias to conscription and then finally to an all-volunteer standing force, accompanied by the growth of compensation and benefits and the inclusion of women. Many of these changes have been instituted in the past seven decades and reflect

the need to ensure that the force is able to protect American interests as effectively as possible in a changing security environment. The personnel system utilized by today's military, for example, was enshrined in statute shortly after World War II and was updated to address the evolving strategic context of the Cold War.

Given the currently shifting and ambiguous strategic landscape in which threats range from the high end (Russia and China) to the low (non-state actors), and with the military's missions varying from the technological (defending cyberspace) to the personal (security assistance), it might be worth evaluating whether the current personnel system is in need of another update. This sentiment is reflected in the FY 2019 National Defense Authorization Act, which made several statutory changes in the officer promotion system to allow for more flexible military career paths. The questions that should drive such an analysis, U.S. Naval War College Professor Jacquelyn Schneider suggests, include:

- "What does the warrior of the future look like?"
- "What are the roles and missions the United States will need to prepare its people for?"
- "What are the technologies those warriors must master in order to succeed at their mission?"[5]

The greater the variance between the answers to those questions and the servicemembers produced by the current system, the more reform the system might require.

The Evolution of "Up-or-Out": From World War II to DOPMA

World War II: The Origins of "Up-or-Out." While the origins of the modern U.S. military and some of the institutional structures can be traced back to the early years of the Republic, most of today's personnel policy emerged from the World Wars and their aftermath. For example, while conscription has been in use in a variety of different forms since the Revolutionary War,[6] the modern draft originated in World War I (when the phrase "selective service" was first coined).[7] And while basic units of the Army (and later the Navy, Air Force, and Marines), such as officers and enlisted personnel, date from well before the colonial era, the function of those components morphed with the evolution of modern military technology and strategies.

Before World War II began, the Army was ill-prepared (from a personnel perspective) for a large-scale conflict: The total number of officers before the war was only 15,000; older senior officers populated the ranks; and there were limited opportunities for new junior officers to proceed up the ladder.[8] The enlisted force swelled as the United States entered the war, rising from 269,023 in 1940 to 1,462,315 in 1941 to 8,266,373 at its height in 1945.[9] However, there were not enough experienced officers to lead these new troops effectively. At the time, the Army's promotion system was based on seniority, and Congress retained strict control of the number of officers allowed at each rank. This created a significant logjam for promotions between the two world wars. Then Army Chief of Staff and later Secretary of Defense George Marshall gained President Roosevelt's approval to address the issue by culling the Army's senior ranks in 1940.[10] The following year, Congress passed the Army Vitalization Act of 1941,[11] giving Army command further discretion to open senior slots to junior officers for promotion and thereby allowing new officers to be commissioned.

Problems with the seniority system persisted throughout the war because it was nearly impossible to remove officers from the service. Congressional approval was repeatedly required to fix the bloated, aging officer corps. By the end of the war, the Army had more than 385,000 officers,[12] about 19 times more than before the war began. After the war, testifying during hearings on the proposed Officer Personnel Act of 1947, General Dwight D. Eisenhower, then Army Chief of Staff, told the Senate Armed Services Committee that:

> I think that no great argument would have to be presented to show that our promotion system [seniority] has been unsatisfactory. Until we got to the grade of general officer, it was absolutely a lock-step promotion; and short of almost crime being committed by an officer, there were ineffectual ways of eliminating a man.[13]

General Eisenhower further explained that:

> If you look at General Marshall's difficulties in 1940 and 1941 I believe you will find that of the people he could make division commanders, and corps commanders, and certainly there were not over five of them who went through this war. All the rest of them had to be replaced and gotten out of the way and younger men had to come along and take over the job.
>
> We must keep this corps vital and youthful.[14]

Congress heeded Eisenhower's call and allowed for the drastic expansion of the officer corps.

While congressional action was required to clear the Army's logjams, the Navy operated quite differently. Instead of employing a seniority system for promotions, the Navy relied on an *up-or-out* promotion system, which holds that officers must separate from service after a predetermined length of time if they are passed over for promotion.[15] (In the modern force, with few exceptions, officers passed over twice for promotion must separate from service.) Compared to a seniority system, up-or-out has several advantages.

- First, and most important, it ensures that junior officers have opportunities to climb the ranks, preventing stalwart senior officers from occupying their posts for indefinite periods of time.

- Second, up-or-out is meant to be a meritocratic system that allows talented servicemembers to steadily climb the ranks, while a system based on seniority merely rewards time in rank.

Given its real and perceived advantages, up-or-out was applied uniformly across the services for permanent promotions after World War II with the passage of the Officer Personnel Act (OPA) of 1947. The services still had flexibility for temporary assignments.[16] The OPA also made a series of other policy changes with the goals of providing uniformity between the Army and the Navy, emphasizing "youth and vigor," and creating a force that could remobilize quickly if necessary.[17]

The 1954 Officer Grade Limitation Act (OGLA) further solidified up-or-out by imposing statutory limitations on the number of regular and reserve officers that could serve at each rank for all grades above major and eliminating the loophole in OPA which did not impose limitations on temporary promotions.[18] The last major change in personnel policy to occur before the end of the draft era in 1973 was the codification of the majority of U.S. military policy into Title X of the U.S. Code after the Korean War. Title X unified most existing permanent statutory military policies, including the OPA and OGLA, under one heading.

At the time, there was widespread agreement among military and civilian experts that up-or-out was a significant improvement. It was designed for the specific security environment in which the United States found itself at the time and for the military strategies it devised to manage that environment. World War II and the Korean War required the services to marshal large and bottom-heavy armies that were quickly assembled through the draft: U.S. peak military personnel was 12,209,238 in 1945 as compared with 458,365 in 1940.[19] These conscripted forces needed the steady leadership of experienced, competent, and energetic officers in order to fight and win the large-scale, industrial ground and naval battles that defined this era of war. Policymakers believed that enlisted and junior-officer personnel, brought in through the draft, could be trained quickly for

war but that more experienced commanders needed more time to prepare and could not therefore be recruited swiftly during a crisis. Consequently, the military maintained a much higher percentage of officers than it had previously. "In 1945," according to the Bipartisan Policy Center, "the military had a ratio of approximately 1.3 field-grade officers for every 100 enlisted personnel. Five years later, the ratio stood at 4 to 100."[20]

Moreover, in keeping with the strategic need for officers who could lead fresh recruits into battle, because up-or-out was intended to be meritocratic, the promotion path and criteria created by the post–World War II personnel system emphasized and rewarded the ability to command. Nevertheless:

> It is worth noting that even in 1947 some senators objected to the up-or-out personnel system, correctly noting that the retirement system would incentivize many, if not most, officers to retire from military service in their 40s. Senator Guy Cordon (R–OR) stated his concerns bluntly, saying that for those who reach the rank of colonel, the new personnel system "would mean that the average officer, figuring that he received his commission at age 22, would be forced to retire at 52 years of age. This seems to me to be a most wasteful and illogical requirement, particularly for the technical services." Senator Harry Byrd (D–VA) agreed, saying, "That seems to me mighty early to retire a man, at 52."[21]

Grinding Gears: The Shift to a Professionalized All-Volunteer Force. The era of the all-volunteer force brought significant changes to personnel policy beginning in 1968, when soon-to-be President Richard Nixon made a campaign promise to end conscription. That promise gave rise to the Gates Commission, a group of notable experts chaired by former Secretary of Defense Tom Gates fashioned to examine the viability of an all-volunteer force. On February 20, 1970, the commission officially and unanimously recommended to President Nixon that the United States shift to an all-volunteer force (AVF). Nixon accepted the committee's recommendation, and by 1973, the draft was officially discontinued.[22]

Multiple causes contributed to the demise of the draft, but the evolving strategic context and manpower needs played a role.[23] The Vietnam War showed that servicemembers who had been drafted were much more prone to disciplinary problems, while an AVF was expected to be more professional and motivated to serve. Furthermore, turnover rates were expected to be lower among enlisted service members in an AVF, which would result in longer careers and more experienced personnel.[24]

Several factors were expected to contribute to this evolution, including longer initial enlistments for volunteers, historically higher rates of reenlistment among volunteers, and generally higher pay and morale among volunteers as compared to draftees. In addition, members of an AVF would receive more on-the-job training and were expected, as a result, to be more productive and effective than members of a draft force.[25] All of these factors illustrate the benefit of an AVF over a conscripted force: Its servicemembers are better motivated, better trained, and more likely to serve for longer periods of time, all of which contributes to improved military readiness and efficiency.

There also were strategic reasons for shifting to an AVF at this point in history. Britain, which switched to an AVF in 1957, had simultaneously shifted its defense policies to emphasize nuclear deterrence over the utilization of land troops.[26] The U.S. military was undertaking a similar strategic and political shift in the 1970s away from major set-piece battles and a focus on mobilization toward the possibility of "come-as-you-are" warfare, where troops would quickly mobilize to respond to an immediate threat with little time to conscript fresh recruits.[27]

As the all-volunteer force emerged, policymakers slowly began to realize that in order to retain talent, they would need to compete

with the private sector, especially in terms of compensation. This lag occurred even though the final report of the Gates Commission recommended various changes in both the officer and enlisted personnel systems, including substantial pay increases and compensation reforms.[28] For the first time in U.S. history, the military began to manage its enlisted personnel *intentionally*.

As analysts at the RAND Corporation note, the history of enlisted personnel policy is a history of responses to immediate events, not long-term policy strategies.[29] For nearly all of American history, enlisted personnel were rapidly conscripted or organized in response to a forthcoming conflict, paid very little, and disbanded quickly following the end of the conflict. Furthermore, the military did not have to compete with the private market for talent because recruits were required to serve either through direct conscription or through the formation of ad hoc regional militias.[30]

DOPMA: One-Size-Fits-All. While the age of the all-volunteer force began in 1973, Congress waited nearly a decade to reform the personnel and promotion systems to account for this shift. Reform finally came in 1981 with the Defense Officer Personnel Management Act (DOPMA) and the Reserve Officer Personnel Management Act (ROPMA). These reforms were notable for a few reasons.

First, DOPMA brought changes to the personnel and promotions systems, including:

- An officer structure simplified and standardized across the services to 10 ranks (O-1 through O-10);
- A standardized promotion system for *regular career officers*;
- A legal *DOPMA grade table* for both permanent and temporary promotion (services previously had greater discretion over temporary promotions);
- A "sliding-scale" grade effect for officers (when the officer corps shrinks, the number of field-grade (0-4 through 0-6) officers increases).

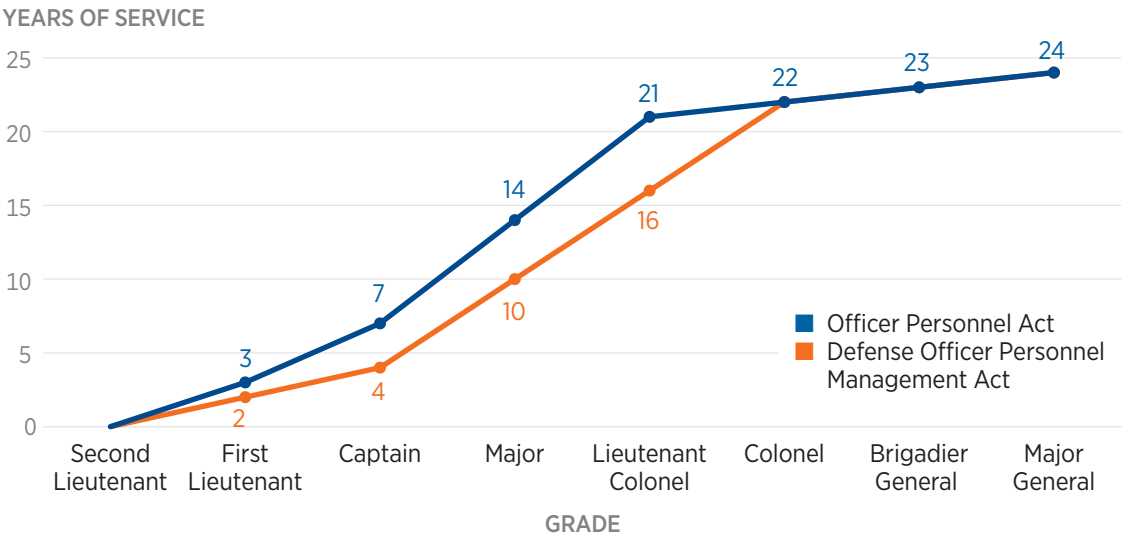
This standardization of career paths was largely welcomed, with a Member of the House of Representatives observing that "[t]o attract quality officers, we must be able to offer lieutenants and captains a reasonable, reliable career progression."[31] The Assistant Secretary of Defense for Manpower, Reserve Affairs and Logistics at the time, Robert B. Pirie, Jr., also praised the bill as "a viable piece of legislation that on one hand represent[ed] the wishes of the Congress and on the other satisfie[d] the needs of the Department."[32] DOPMA's reforms were a welcome change in a system instituted more than 20 years earlier and were instituted for much the same reason many are advocating for reforms today: the strategic need for high-quality officers.

These changes enshrined the one-size-fits-all military career, particularly for officers. This career, which is about the same length for most officers (regardless of specialty), is highly predictable from a management perspective and gives the services a stable officer corps in peacetime.[33] Still, while DOPMA was a wide-ranging law with significant effects, RAND analysts categorized it as a document that, rather than being truly revolutionary, merely expanded upon the post–World War II status quo.[34] This can be seen in Chart 1, which illustrates how, despite the changes in the OPA framework instituted by DOPMA, the basic system remained largely the same

While DOPMA and ROPMA provided reform for officers, Congress barely touched the enlisted side of the ledger during this period. The policies that govern enlisted personnel mimic the officer side (i.e., strict time-in-grade limitation, up-or-out, etc.), and, unlike officer personnel policy, are largely under DOD's discretion. It is worth noting that DOD does not often pursue radical changes in enlisted policy. Similarly, while ROPMA provided some clarity on the role of reserve officers in the overall structure of the forces, reserve personnel were still not well integrated with the active

CHART 1

Up or Out Promotion Path Pre- and Post-Defense Officer Personnel Management Act



SOURCE: H.R. 3800, Officer Personnel Act of 1947, Public Law 381, 61 Stat. 795, 80th Congress, 1st Sess., Title V, §512, https://www.loc.gov/law/help/statutes-at-large/80th-congress/session-1/c80s1ch512.pdf (accessed July 21, 2018).

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component—something that remains true today. Many analysts have noted that the reserve component is both culturally segregated and underutilized.[35]

After DOPMA and ROPMA, only one other piece of legislation attempted serious reform: the Goldwater–Nichols Act of 1986.

Goldwater–Nichols: A Push for Interoperability. Goldwater–Nichols was enacted in response to rising frustration that the forces were not sufficiently interoperable—that is, that they were not able to fight efficiently as a joint force. This frustration arose from military engagements in Iran (Operation Desert One); Grenada (Operation Urgent Fury); and Beirut.[36] During Desert One, an operation to extract hostages from Tehran, the U.S. lost eight servicemembers and significant amounts of equipment. The senior commander's description of the operation provides some insight into the causes of its failure: "four commanders at the scene without visible identification, incompatible radios, and no agreed-upon plan."[37]

Operations in Grenada were generally considered to be a success, but groups from the different services still had an extremely difficult time communicating with one another, particularly coordinating fire support. A Senate study of the Grenada mission concluded that "[t]he Services continue to operate as largely independent agencies, even at the level of the unified commands."[38]

In Beirut, where 241 servicemembers were killed in a tragic terrorist bombing, military leaders and policymakers further concluded that a distinct lack of interservice interoperability was to blame and that the combatant commanders still did not have enough direct authority to direct operations in the field.[39] Former Chairman of the Joint Chiefs of Staff Admiral William Crowe stated that:

> Like every other unified [combatant] commander, I could only operate through the Army, Navy, Air Force and Marine component commanders, who stood between me and the forces in the field.... Component commanders reported to their own service chiefs for administration, logistics and training matters, and the service chiefs could use this channel to outflank the unified commander. There was sizeable potential for confusion and conflict.[40]

As a result, Congress added additional requirements to the standard officer career path with the intention of improving the force's overall interoperability, especially regarding the experiences of general and flag officers (GFOs).[41] These policies included a requirement that all officers selected for the rank of GFO must have served in a joint duty assignment and stipulated that GFOs' joint duty assignments would be for two years, compared with three years for other officers. It further required all general/flag officers to attend a joint Capstone course.[42] This was the further evolution of and next logical step in the U.S. military's consistent emphasis on leadership and command ability since World War II.

One consequence of this change was the addition of four to five years to the standard military career. Some, including former DOD Undersecretary for Personnel and Readiness Bernard Rostker, were less than supportive of the change. In 2015, Rostker testified to Congress that Goldwater–Nichols "came at the cost of having less-experienced uniformed managers of the services."[43]

While ensuring that all general and flag officers would have joint force experience was generally accepted as a positive development and was intended to prevent a dangerous fissure from opening between operating forces and command staff without practical field experience, applying the policy uniformly across the officer corps effectively mandated that officers undergo training necessary only for a small subset. Goldwater–Nichols, along with the other reforms of the 1980s, led some to criticize the officer personnel system as "grooming all officers to be chief of staff."[44]

Prior to recent reforms included in the FY 2019 National Defense Authorization Act (NDAA), these were the last major reforms to the active-duty, enlisted, and reserve components, and they led to the structure of the armed forces as it stands today.

Does the System Work? The Challenges Facing America's Future Force

Overall, while the U.S. military personnel and promotions systems have evolved since World War II—thanks to DOPMA, ROPMA, Goldwater–Nichols, and other pieces of reform legislation—their fundamental structure and intent have remained largely the same. Ultimately, the majority of the force, especially ground-combat units, has continued to be made up of young and fit personnel, while officers have been presented with a single, uniform path for advancement with promotions based on and leading to increasingly higher levels of command responsibility.

The military created by this up-or-out, post–World War II personnel system has achieved significant strategic victories: It won the Cold War and protected the nation for 70 years. The system achieved precisely the outcomes that it was designed to achieve. Yet, given the changing security environment and new strategic needs, there are calls from some quarters for a more fundamental reimagining of the personnel system.

While core U.S. national security interests have largely remained constant in the quarter-century since the end of the Cold War, the threats arrayed against those interests are spreading geographically, transforming strategically, and evolving technologically. Once viewed as archaic, the threat of great-power conflict with the resurgence of Russia and rise of China is relevant once again. Add to that the more diffuse threats from malicious non-state actors that have mastered the techniques of unconventional warfare while metastasizing across much of the world. The tremendous

technological advances made by rogue nations could allow them to undermine much of the traditional military superiority long enjoyed by U.S. forces,[45] and new domains like cyberspace allow weaker powers to exploit unforeseen vulnerabilities.[46]

New Threats, New Challenges. In this new normal, a military that is designed only to wage conventional war against great powers will likely not be adequate. Success against future enemies on new battlefields will require not only physical strength and vigor, but also (and increasingly) mental agility, technical experience, and rapid innovation. As the 2018 National Defense Strategy states, "a more lethal, resilient, and rapidly innovating Joint Force...will sustain American influence and ensure favorable balances of power that safeguard the free and open international order."[47] Any changes in the strategies the military employs to counter these new threats and keep the nation safe should be reflected in the policies responsible for creating a force capable of executing those strategies, and this most definitely includes policies involving personnel. However, there are differing opinions on whether personnel reforms are necessary and, if they are, how extensive those reforms should be.

The most obvious personnel issue raised by the potential for conflicts waged as much on virtual as on physical battlefields is the need to attract a highly skilled and technologically savvy military workforce. But while constant news of increasingly grave cyber threats and the creation of a Cyber Force presents the most visible manifestation of the role of technology in a 21st century military, the implications are far more widespread and complicated. As Professor Schneider notes, "The defense community needs to do a better job [of] thinking about what this human looks like and how the U.S. military culture can adapt not only to technology, but [to] what we need for the warrior of the future."[48]

Sophisticated networked communications, drone-enabled reconnaissance, and even the integration of electronic warfare are being incorporated into platoon-level infantry tactics. Autonomous systems will likely press the military to delegate decision-making to lower grades in order to keep up with the speed of warfare.[49]

Perhaps the skills necessary to thrive in this environment can be taught, with updated military training being sufficient to turn recruits into 21st century warriors, but it is also quite possible that, unlike the physical strength and tactics needed for ground combat, some of the qualities the military will prize most in future servicemembers cannot simply be drilled into them. In that case, those with the skills to navigate this high-tech world could well be hotly pursued by private-sector firms that are able to pay many times more than the military and more interested in honing and maintaining their expertise than in commanding troops. If the military is to attract them, it might have to provide a value proposition other than the current one-size-fits-all career path.[50] To address this issue, the 2019 National Defense Authorization Act included provisions to allow for better-qualified officers to be placed at the top of promotion lists and for credit to be awarded to officers for experiences outside of traditional military service.

Another area in which changes in how the military carries out its mission affect how it recruits and manages personnel is train, advise, and assist missions. As the United States looks to other partner nations to share the burden of providing for mutual security, building the capacity of partner forces is likely to become a large part of the U.S. military mission. Traditionally, these operations are given to Special Operations Forces, who are comfortable working and embedding with partner militaries because of their high levels of training and experience. While Special Operations Forces offer impressive and unique capabilities, they have been heavily utilized over the past 15 years of fighting. Many such units have been required to focus their energy on counterterrorism missions, which makes it more challenging to prepare for the train, advise, and assist missions.[51]

To meet the train, advise, and assist demand in the future, the military will have to turn

to conventional units to satisfy much of the need. The cadre of mature, experienced, and well-trained personnel required for these missions can be found in the field-grade and noncommissioned officer corps, but the current promotion system also calls on servicemembers in these grades to be checking boxes as they carry out joint and other service-specific key assignments rather than devoting time in the field to teaching partner militaries. While these "check boxes" were initially established with the intent of ensuring that officers had experience with a wide scope of military affairs and operations, expanding security force assistance brigades within the conventional force would most likely require alternative promotion paths and more-flexible career models for both officers and enlisted personnel.

Relatedly, even as the military might increasingly need to rely on its Foreign Area Officers—servicemembers with specific linguistic, political, and cultural understanding of partner nations in which the military operates—there is currently little incentive for the best and brightest to pursue these careers Specializing in a single country instead of commanding forces is currently not the way to advance to senior grades.

Such concerns about whether the current system can attract and retain the skills the military will need to win against 21st century adversaries led the Center for a New American Security's Amy Schafer to argue that "[w]ithout a significant and long-overdue investment in our military's human capital, the United States will struggle to maintain military superiority."[52] But there also are reasons to favor the current system. Mastery of combat arms remains the preeminent demand on the military; changes in military culture that detract from what Secretary of Defense Jim Mattis calls "lethality" or tinkering with career paths, which makes it more difficult for military planners to generate a force that is deployable and ready to fight at a moment's notice, could do more to harm American military strength than to bolster it. Any changes in defense personnel systems must therefore be driven by careful assessment of the strategic environment and the force needed to protect U.S. interests in that environment.

A Whole New World. As the strategic challenges facing the military have evolved, so too have the ambitions, expectations, and lifestyles of U.S. society. In 1960, just over a decade after the passage of the Officer Personnel Act of 1947, only 25 percent of married couples with children had two income earners. In the 1970s, when the draft ended, this figure was around 32 percent.[53] Today, over 60 percent of married couples with children are dual earners.[54] This is a tremendous change and presents a particular challenge for a military system that typically relocates its personnel every two to three years. The operational tempo and ever-present duty requirements of the military often prevent spouses—the majority of whom are women—from holding regular jobs.[55] These challenges are gaining more visibility; in the most recent NDAA, Congress ordered DOD to review the effects of frequent change-of-stations on military families and military readiness.

Another factor to consider is who is serving. A relatively small percentage of the U.S. population serves in the military—"0.4 percent of the population in 2015," according to the Pew Research Center.[56] But military service is neither a duty heeded nor a burden shared by all. "[F]or a growing number of Americans," Defense Secretary Robert Gates warned in 2010, "service in the military, no matter how laudable, is something for other people to do."[57] Furthermore, those who join the military tend to have one thing in common: They come from military families.

A recent Blue Star Family survey shows that nearly three-fifths of servicemembers and their families have at least two other immediate family members who serve or have served in the military. According to a Department of Defense study, roughly 80 percent of new recruits have a military family member. The past 16 years of war, budgetary uncertainty, and troop reductions have exhausted the force. If today's troops are the siblings, parents, aunts, and uncles of our future force, wearing them

TABLE 1

Personnel Cost Per Active-Duty Service Member

DOLLAR FIGURES ARE IN 2016 DOLLARS

	FY 2001	FY 2016	% Change, 2001–2016	FY 2017
Active-Duty End-Strength*	1,386,000	1,311,000	–5%	1,301,000
Pay-Like Compensation	$50,670	$73,038	44%	$74,001
Basic Pay	$33,326	$40,450	21%	$41,299
Retirement Costs	$12,560	$16,635	32%	$15,906
Normal Pension Costs	$12,560	$12,699	1%	$12,102
TRICARE For Life	$0	$3,936	—	$3,804
Defense Health Program	$11,661	$24,940	114%	$25,979
Total Personnel Costs	**$74,890**	**$114,614**	**53%**	**$115,886**

* Not including Reservists or National Guard.
SOURCE: Bipartisan Policy Center, "The Military Compensation Conundrum: Rising Costs, Declining Budgets, and a Stressed Force Caught in the Middle," September 2016, p. 11, https://bipartisanpolicy.org/wp-content/uploads/2016/09/BPC-Defense-Personnel-Compensation.pdf (accessed July 21, 2018).

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down could limit tomorrow's recruits. Unfortunately, Blue Star Family data already show a worrying drop in the willingness of military families to recommend service to their children or to any young person.[58]

This illustrates another issue facing America's military: the civilian–military divide, which refers to the disconnect between America's servicemembers and its people at large as a result of cultural, locational, and other differences.[59] As the gap continues to grow, young Americans from nonmilitary families will likely become less inclined to consider volunteering for military service simply because they have no meaningful personal contact with or awareness of it.[60]

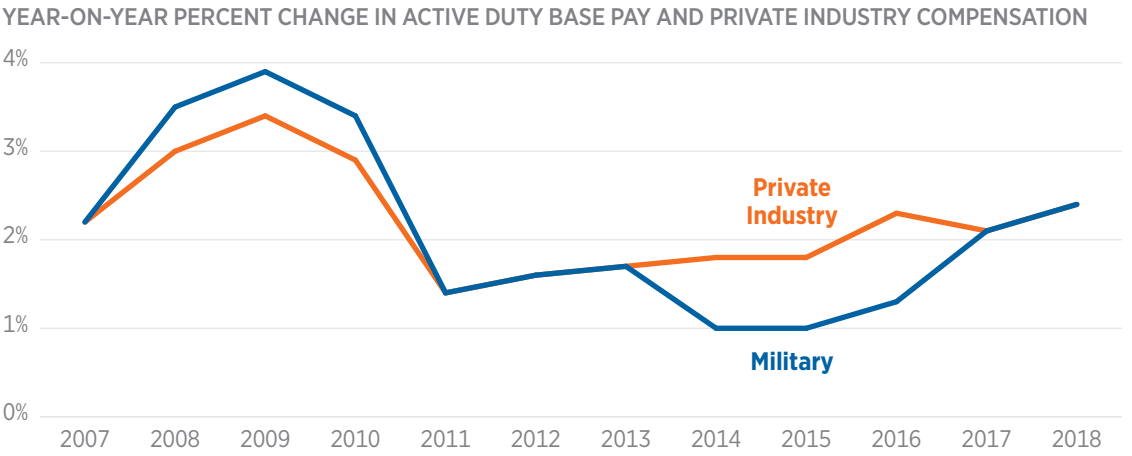
Meanwhile, leaning too heavily on one small segment of our population also could weaken our military. Already, because of obesity, a criminal record, or lack of educational achievement, only about a quarter of all 17-to-24-year-olds are eligible to serve. With so few able to serve, the military could struggle to fill its ranks should military families stop handing down their ethic of service.[61]

Experts in the field firmly believe that personnel policies are critical to meeting defense and national security objectives[62] and that defense personnel policy should therefore be driven by the objective of ensuring or improving military effectiveness, not by other social or political goals. It very well might be true that in some circumstances, the armed forces are institutionally stronger, more coherent, better trained and disciplined, and more dedicated to their mission when they stand apart from the general population, but this is not always the case, and the historical record shows several examples of culturally distinct militaries performing worse on the battlefield than their material strength of men and arms would otherwise have predicted.[63]

A responsible and effective personnel system must be mindful of the relation between the military and society, monitoring it for potential problems that could negatively affect the ability to attract sufficient recruits to meet end strength requirements—as the services' personnel chiefs recently told Congress

CHART 2

How Military Compensation Compares to Private Industry



SOURCE: Bipartisan Policy Center, "The Military Compensation Conundrum: Rising Costs, Declining Budgets, and a Stressed Force Caught in the Middle," September 2016, p. 13, https://bipartisanpolicy.org/wp-content/uploads/2016/09/BPC-Defense-Personnel- Compensation.pdf (accessed July 21, 2018).

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is already happening[64]—or to attract those with the skills and talents needed to execute military strategy. According to Representative Mike Coffman (R–CO), Chairman of the House Armed Services Committee's Military Personnel Subcommittee, recruitment and retention challenges are exacerbated "by a lessened overall propensity to serve, reduced pool of qualified candidates and a robust economy."[65] Some feel that this requires a reevaluation of traditional personnel regulations.

In an effort to address this, the 2019 NDAA repealed the age limit on enlisting in the officer corps and took steps to allow for credit to be awarded for nontraditional experiences. Keeping this in mind, closing the civilian–military divide should be the focus of personnel reforms in the coming years.

Budgetary Concerns. Yet another potential barrier to readiness is the increased reliance on fiscal retention bonuses to keep servicemembers in the military. As a result of the Budget Control Act of 2011, caps were placed on most defense spending. These caps have led to a significant reduction in the defense budget (relative to previous estimates) and cuts in total military end strength and the operations and maintenance budget.[66] This in turn affects military readiness, as there are fewer troops with fewer supplies. In addition to the budget cuts, this issue is exacerbated by the rising costs of military personnel, in part because of the military's very status as an AVF: Servicemembers must be competitively compensated in relation to the private sector, including costs of health care, retirement, and retention bonuses.[67]

However, as Chart 2 shows, military compensation occasionally still lags behind compensation in the private sector. Given this, and given that DOD has only limited funds to spend, many argue that it is time to reevaluate the system to find ways to incentivize servicemember retention without the use of further financial bonuses.[68] These incentives could address quality-of-life issues such as geographic stability, more opportunities for promotions, and longer assignments.[69]

CHART 3

Air Force Pilot Shortage Is Real, and Getting Worse

SOURCE: U.S. Government Accountability Office, "Military Personnel: DOD Needs to Reevaluate Fighter Pilot Workforce Requirements," April 11, 2018, p. 11, https://www.gao.gov/products/GAO-18-113 (accessed August 6, 2018).

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The Air Force's Recurring Pilot Shortages: A Microcosm

Issues with recruiting and retention affect the service branches in distinct ways. For example, the U.S. military is the world's preeminent air power, yet the Air Force is coming up short on the pilots needed to meet the U.S.'s stated national security objectives. The service is currently short at least 2,000 pilots, and that number is projected to increase substantially in coming years. As with previous shortfalls, the issue is multifaceted. As operations tempo (OPTEMPO) remains high, the service struggles to retain pilots, who feel burned out and overworked. At the same time, because the number of flight hours has decreased, pilots spend less time in the air training and more time on tasks unrelated to combat. Other factors have also contributed to the pilot shortage, including a lack of funding and excessive collateral duties.

Attempts to address the shortage, such as retention bonuses, have failed to stem the tide, and this failure indicates a deeper, structural problem with the Air Force personnel system[70]—a problem that echoes the problems many see in the military's personnel system as a whole. According to Lieutenant General Gina M. Grosso, Air Force Deputy Chief of Staff for Manpower, Personnel and Services, "Retaining our pilot force goes beyond financial incentives...it's about culture."[71] One fighter pilot who left the service agreed, stating that the reason most pilots leave is the same reason many join in the first place: They want to fly as much as they can, and Air Force pilots are often grounded by excessive administrative work[72] and a lack of available aircraft.[73] A senior Air Force leader has said that fighter pilots average only about 16 flight hours per month.[74]

This disconnect between the needs and wants of airmen and the structure of the Air Force personnel system translates into concrete financial losses for the Pentagon: Lieutenant General Grosso has testified that it costs approximately $11 million "to train a fifth-generation fighter pilot" and that "a 1,200-fighter pilot shortage amounts to a $12 billion capital loss for the Air Force."[75] In addition, in line with the broader historical trends in personnel policy, while the fighter pilot occupation has changed significantly in recent years, the services have not reevaluated fighter squadron requirements.

These changes in the position, which include changes in aircraft technology and tactics, additional training, and the removal of squadron administrative support positions, have led to an unsustainable increase in

workload that financial bonuses simply have not alleviated. Air Force officials say these changes have not been incorporated into the assessment of minimum personnel requirements because the Air Force has been prioritizing recapitalizing its fighter aircraft fleet. While the Air Force has attempted to alleviate the pilot workload by hiring contractors, the shortage remains significant.

The pilot shortage illustrates on a smaller scale what the military is experiencing as a whole. Changing strategic needs and technical advancements, as well as increased workload and budget cuts, have caused a troubling decline in U.S. military readiness. To address these problems successfully, we must consider the needs and desires of the servicemembers who are the most fundamental part of American military superiority.

Conclusion

The nation's future national security depends on attracting the service of capable men and women with the necessary skill sets. America's military is nothing without the dedication of those who choose to serve. To ensure that the United States maintains its military advantage over its adversaries, lawmakers and defense leaders will have to evaluate whether the ways in which the military attracts, promotes, and retains servicemembers is contributing to or hindering the creation of a force capable of countering 21st century challenges.

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Training: The Foundation for Success in Combat

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In no other profession are the penalties for employing untrained personnel so appalling or so irrevocable as in the military.

—Douglas MacArthur, 1933

It is astounding what well-trained and dedicated Soldiers can accomplish in the face of death, fear, physical privation, and an enemy determined to kill them.

—Lieutenant General Ace Collins, 1978

Death, fear, physical privation, and an enemy determined to kill them: These are the challenges that those who defend our nation face when they go to war. Whether one is a soldier, sailor, airman, or Marine; a brand new private or a grizzled old veteran; a fighter pilot, a submariner, a tanker, a military policeman, a transporter, or a medic, every serviceman and woman must be prepared to make contact with the enemy, survive, and accomplish the mission as a member of the team. That is what training the Armed Forces of the United States is all about: enabling those who serve to fight, win, and come home to their loved ones.

Warfare is always changing, always evolving.

- World War II saw the emergence of blitzkrieg and air operations over land and sea.
- Vietnam demonstrated the power of combinations of enemy regular and insurgent forces.
- The ongoing campaigns in Iraq and Afghanistan have demonstrated how improvised explosive devices can be significant killers on the battlefield.
- In 2006, the Israeli Defense Forces were stymied by Hezbollah's employment of a hybrid approach that combined sophisticated conventional weapons and tactics with terrorism and long-range missiles.[1]
- Most recently, Russia has employed what is termed "New Generation Warfare" to conquer the Crimea, secure the eastern Ukraine, and threaten the Baltic nations.[2]

Military training must therefore change as well. It must continually be forward-thinking, innovative, and aggressive, both in understanding how warfare is evolving and in adapting training to meet those challenges. Today, the Chinese military presents the threat of long-range missiles to deny the U.S. access to the western Pacific Ocean and to our allies such as Japan, South Korea, and Australia. Since the end of World War II, the ability of the U.S. to move freely as it pleases in the Pacific has been assured, but that freedom of action is increasingly at risk as the Chinese military invests in new technologies and capabilities. This growing challenge places a training requirement on all four services to learn how to defeat the threat of such anti-access/area denial tactics.[3]

Training is one of the key functions of each of the services within the Department of Defense (DOD). Others include manning, equipping, organizing, and sustaining, but it is training that wraps all of those functions together to create and maintain effective organizations. Training is so important that each service has its own major subordinate command dedicated to training:

- The Training and Doctrine Command for the Army,[4]
- The Naval Education and Training Command for the Navy,[5]
- The Training and Education Command for the Marine Corps,[6] and
- The Air Education and Training Command for the Air Force.[7]

Each of these commands respectively holds the service responsibility for designing, developing, resourcing, assessing the effectiveness of, and providing command oversight of its service's program. Additionally, for the Joint Force, the Joint Staff J-7 has responsibility for joint oversight, policy, and strategy for training and exercises that bring individual service forces together into a coherent whole.[8]

What Is Training?

The U.S. military defines training as "instruction and applied exercises for acquiring and retaining knowledge, skills, abilities, and attitudes (KSAAs) necessary to complete specific tasks."[9] Generally speaking, military training is divided into two broad categories: individual and collective. Individual training is exactly that: training designed to develop individual skills. Collective training is designed to integrate trained individuals into a cohesive and effective team, whether that team is a tank crew of four or an aircraft carrier crew of 5,000.

Training can be as small as an hour-long class for a four-person team on how to bandage a wound and as large as a multi-week joint exercise including tens of thousands of personnel and units from all four services. It generally occurs in three domains: the institutional domain, which includes the various formal schools in each service; the operational domain, which includes training in units and on ships, whether at home station, deployed, or underway; and the self-development domain, conducted by individuals to address the gaps they see in their own learning.

Training Realism

Their exercises are unbloody battles, and their battles bloody exercises.

—Flavius Josephus, 75 C.E.

No other activity prepares a military force better for combat than combat itself. The environment in which combat is conducted—one of violence, death and destruction, fear and valor, complexity and uncertainty—is one of the most challenging in which any human being or human organization must operate. It is so challenging and unique that it cannot be completely replicated outside of combat itself. Thus, to be effective, military organizations must train under conditions that are as realistic as possible and come as close as possible to placing the individual, the team, the unit, and the crew in the environment and situations they will face in combat. Training realism is one of the key measures of training effectiveness.

Much of the design and innovation in training is aimed at generating realism. Training design generally has three components:

- The *task* itself—the thing an individual or the element is expected to accomplish. An example might be to conduct an attack, conduct resupply of a vessel, or employ electronic warfare to jam an enemy system.
- The *conditions*—the set of circumstances in which the task is expected to be performed. Examples might be day or night, moving or stationary, opposed by an enemy or unopposed, or with full capabilities or some capabilities degraded.

- The *standards*—the level of competence and effectiveness at which the task is expected to be accomplished. Standards might include the speed at which the task is to be performed, the accuracy of hitting a target, or the percentage of operational systems that are ready and available.

Identifying the tasks, conditions, and standards drives training realism. Ultimately, as Flavius Josephus described the training of the Roman army, the goal is for military forces entering combat to have "been there before" so that they know they can fight, win, and survive.

Training Effectiveness

It's not practice that makes perfect; rather, it's perfect practice that makes perfect. It is, after all, the seemingly small disciplines and commitment to high standards that makes us who we are and binds us together as a force, an Army, in peace and in war.

—General Martin Dempsey, 2009

As former Chairman of the Joint Chiefs of Staff General Marty Dempsey's quote implies, the services do not train just for training's sake. They train in order to reach specific measurable levels of performance in specific tasks. Training, then, is both nested and progressive. It is nested because training in specific individual tasks is aggregated to enable training in small elements tasks, which in turn are aggregated into training in progressively larger organization tasks.

Take, for example, a carrier battle group. A carrier battle group consists typically of the carrier; several cruisers, frigates, or destroyers; and perhaps a submarine. On each of those ships, individual crewmembers, petty officers, and officers must be trained on their individual tasks. Those individuals then form teams such as a fire control party or an engineering team. Teams are then combined to make departments, such as the gunnery and engineering departments, which then train together to create an overall crew for the ship that is effective in sailing, attack, defense, or replenishment. The various ships of the carrier battle group then train together to enable collective attack or defense by the group of ships. At the same time, individuals and organizations are trained progressively under increasingly challenging conditions to increasingly higher standards. All of this must then be assessed for competence and effectiveness.

Because training involves both individual and collective learning, the military uses the standard approach of the educational profession to develop and conduct training. This is known as the ADDIE approach:

- **A**ssess. Organizations assess their training to identify gaps in proficiency or determine new training requirements.
- **D**esign. Training is designed to overcome gaps or to improve proficiency under a variety of conditions.
- **D**evelop. Once designed, training is developed, coordinated, and resourced to enable execution.
- **I**mplement. Developed training is implemented to train the requisite individuals and organizations.
- **E**valuate. Once conducted, training is evaluated for its effectiveness. Individuals and elements are retrained until proficiency goals are achieved.

Training assessments are a critical factor in achieving training effectiveness. On the front end of the ADDIE process, such assessments identify gaps in the achievement of standards, which in turn leads to the design, development, and execution of training to achieve those standards. At the back end of the process, training is evaluated to determine whether standards were met and, if they were not, what further training needs to be conducted to achieve those standards.

The Department of Defense uses the Defense Readiness Reporting System (DRRS)[10]

to track readiness, to include training. Under DRRS, each service uses its own readiness reporting system to report training readiness on a monthly basis for all of the elements in its organization. This monthly assessment is used to guide training management to ensure that training is conducted to achieve readiness goals.

Training and Leader Development

Training and leader development are two military functions that go hand in hand. It is of little use to have personnel and units that are well trained if they are not also well led; conversely, the best leader can accomplish little with poorly trained troops. Of course, both training and leader development are forms of learning, and there is significant overlap between the two functions. Consequently, the services invest considerable effort in leader development.

Each service has a Professional Military Education (PME) program for commissioned officers, warrant officers, and non-commissioned officers (NCOs) or petty officers. There is also a Joint Professional Military Education (JPME) program to ensure that officers are qualified to integrate service components into joint headquarters and joint task forces. In each case, PME consists of a progressive series of schools that begin with pre-commissioning education in the military academies, Reserve Officers Training Corps,[11] Marine Corps Platoon Leaders Course, and various officer candidate schools. PME continues with basic, advanced, and specialty education. Each service has a staff college for mid-grade officers and a senior service college, or war college, for senior officers. JPME has a National Defense University system that officers and civilians from all services and partner departments and agencies attend.[12] Within each service, there are parallel PME systems for junior, mid-grade, and senior warrant officers and NCOs.

Leader development represents a significant investment by the Department of Defense. During a 20-year career, a leader is likely to spend between two and four full years in the various PME schools: between 10 and 20 percent of total time served. The investment is necessary because of the unique and complex features of the environment and conduct of warfare. Senior leaders always confront the tension between time in schools and time in operational units. During periods of intense deployment, such as the high points of the Iraq and Afghanistan campaigns in the mid-2000s, attendance at leader development schools is sometimes deferred. When this happens, however, leaders face a challenge: determining whether it is better to have an untrained person present in the unit or a vacancy in the unit while that person is being trained.

Historically, interwar periods—the years between major wars like the 1920s and 1930s between World War I and World War II—have been periods during which leader development flourished and innovation occurred. The military's war colleges, the highest level of leader development, were instituted during interwar periods. Similarly, all of the services' advanced schools, such as the Army's School of Advanced Military Studies, the Marine Corps' School of Advanced Warfare, and the Air Force's School of Advanced Airpower Studies, were started during the Cold War. Clearly, such innovation needs to take place in the post-9/11 environment of seemingly continuous warfare, but how this will happen has not been determined.

Initial Entry Training

Virtually all members of the armed services enter the profession at the ground-floor level. Whether they are recent high school graduates, graduates of a university or one of the service academies, or transitioning from another job or career, they are thrust into an organization whose culture, shaped by the demands of warfare, is significantly different from anything they have previously experienced. At the same time, they are confronted with a myriad of new tasks that they must learn in order to be valued members of the team.

Each of the services has an Initial Entry Training Program, generally divided into two phases: a basic phase, often called "basic" or

"boot camp," to develop the foundational skills required of everyone in that specific service and inculcate them into the culture of that service and a more advanced phase to develop specific skills for their chosen or assigned specialty, whether as an intelligence analyst, a dental hygienist, a mechanic, or an air defender.

Initial Entry Training is a significant undertaking. Each year, the U.S. Navy trains approximately 40,000 recruits at Great Lakes Naval Training Center,[13] and the U.S. Air Force trains approximately 35,000 in Basic Military Training at Lackland Air Force Base.[14] The Marine Corps trains approximately 20,000 recruits a year at Parris Island[15] and another 17,000 at San Diego.[16] The U.S. Army trains more than 80,000 recruits each year at Fort Jackson, South Carolina,[17] and three other major training installations. All told, DOD is conducting Initial Entry Training for almost 200,000 young men and women each year.

The design and resourcing of Initial Entry Training always present a challenge. Obviously, senior leaders would like to train new recruits to the maximum extent possible before those soldiers, sailors, airmen, or Marines join their units or their ships, but more training means more time, and each individual has enlisted in the military only for a certain period of time, usually three or four years. As a result, there is a trade-off between time spent in initial training and time spent actually serving in support of a mission.

Another consideration is the investment of more senior, experienced people who serve as the training cadre. The services rightly send their very best to be the first leader under whom a new recruit will serve, but that means that the best leaders, who are limited in number, are not always with the fighting forces.

Command and Staff Training

A central component of training military organizations and units is the training of commanders and staffs. Each of the services has dedicated training programs and resources for such training, which normally employs simulations because it would be wasteful to use large numbers of troops and equipment simply for staff training. Much of this training is aimed at planning, coordination during execution, and decision-making.

- The Army Mission Command Training Program trains the commanders and staffs of large units at the brigade, division, and corps levels.[18]
- The Marine Staff Training Program trains the senior commanders and staffs of Marine Air-Ground Task Forces.[19]
- The Red Flag Series of exercises at Nellis Air Force Base is the U.S. Air Force program for training the commanders and staffs of Expeditionary Air Force elements.[20]
- The U.S. Navy operates several different programs tied to its regional fleets. For example, Carrier Strike Group 15 is responsible for training the commanders and staffs of Pacific-based carrier battle groups, amphibious ready groups, and independent ships.[21]

Another key factor is the training of joint headquarters and joint staffs. U.S. military forces never fight simply as Army, Navy, Air Force, or Marine units. Even if a particular operation is predominantly in one domain, the execution is necessarily joint.

Since 9/11, for example, the U.S. has conducted military operations in Afghanistan. Afghanistan is entirely landlocked, and counterinsurgency and counterterrorism operations are conducted exclusively against targets on the ground, against an enemy with no navy and no air force. Yet U.S. military operations in Afghanistan have been completely joint as the Air Force has provided precision attack from the air, the Navy has provided electronic warfare and training for Afghan National Security Forces, and Marine Corps forces have conducted counterinsurgency operations in specific sectors within the country. In addition,

special operations forces from all four services have conducted sensitive missions throughout the war.

Previously, training of joint headquarters and staffs was conducted by U.S. Joint Forces Command (USJFCOM) under a comprehensive program that was not unlike the Mission Command Training Program conducted by the Army. However, in 2011, USJFCOM was disestablished, and a very robust capability was lost. Since then, joint staff training has been conducted by the services, by regional Combatant Commands, or to a limited extent by the Joint Staff. Thus far, because the ongoing campaigns in Iraq, Syria, and Afghanistan have not faced multidimensional enemies, the change has not had adverse consequences. However, as the Department of Defense focuses training and readiness on more capable potential enemies such as North Korea, Russia, China, or Iran, the lack of a robust joint training capability will increasingly be an issue.

Training Simulations

Simulators and simulations have a long history of enabling training for military forces. Simulators include capabilities that replicate actual systems in order to maximize training opportunities, reduce cost, promote safety, or preserve equipment for wartime use. Early examples were flight simulators that reproduced the cockpit, wings, and tail of an airplane in order to train pilots in the control, maneuvering, and reaction to emergencies on the ground before they took an airplane up in the air. Other simulators in use today recreate the entire bridge of a navy destroyer so that officers and petty officers can learn to maneuver, fight, and safeguard the ship under tactical conditions.[22]

Simulations enable the training of organizations by creating battlefields or operational environments. Early examples of simulations were tabletop war games in which maps recreated the terrain of a battlefield and markers were used to signify the various units of opposing sides. Participants would fight out battles for training in the art and science of warfare.

Today's simulations are far more sophisticated and often far more integrated. The military uses four general classes of simulation: live, constructive, virtual, and gaming. Each of these classes of simulation has a specific purpose and training audience, and two or more classes of simulations can be integrated to make training of individuals and units even more effective. The goal of much simulation research and development is not just to create the most effective individual simulation, but to create a true *integrated training environment* that combines all four classes to maximize training effectiveness.

- ***Live simulations*** are the training simulations that most closely represent training as historically conducted with individuals and units using real equipment in training environments that most closely reflect actual combat. This means using actual land, sea, air, space, or cyber terrain; actual weapons using either live or dummy/inert ammunition; and actual vehicles and other equipment, often against an enemy force that is also live and simulated by some portion of the U.S. military.

  For example, Red Flag exercises are live training simulations in which Air Force, Navy, and Marine Corps aircraft fight against an enemy portrayed by U.S. aircraft and crews that are trained specifically to represent various enemy capabilities. In a similar manner, Army and Marine Corps ground forces have Combat Training Centers (CTCs) at which large formations of thousands of troops and hundreds of armored and wheeled vehicles and weapons systems fight battles against a well-trained and well-equipped opposing force (OPFOR) and conduct large-scale live-fire training at distances and ranges that they would expect in actual combat.

- ***Constructive simulations*** are representations of military forces and operational environments, usually aimed at training

for large-scale combat involving whole naval fleets, Army Corps, Marine Divisions, or Air Force Wings, to include joint constructive simulations that combine forces from one or more of the services. Originally, constructive simulations were conducted using tabletop war games with pieces representing military units, but today, most constructive simulations are computer-based. Given the size of forces and the fidelity with which military units, ships, and aircraft can be represented, constructive simulations are usually used to train leaders and staffs.

- ***Virtual simulations*** are computer-based representations of individuals, teams, units, weapons systems, and other capabilities, usually with great fidelity to the operational environment (terrain, weather, urban areas, etc.) to include not only enemies, but also local populations. Virtual simulations are best suited to training individuals, teams, or small units. For example, Conduct of Fire Trainers (COFTs) are used to train individual tank or fighting vehicle crews, and Close Combat Tactical Trainers (CCTTs) are used to train platoon and company-size groupings of tanks or armored fighting vehicles. Virtual simulations have the virtue of training aircrews, ship's combat systems crews, and tank and fighting vehicles crews in many repetitions and situations—in other words, lots of practice—without the large costs for fuel, munitions, and maintenance and without the need for the large spaces that live training requires.

- ***Gaming*** is the newest class of training simulation. While war games have been used for centuries in the form of board games or tabletop games, the advent of computer gaming brought with it whole new opportunities. The military recognizes that digital games improve rapid decision-making, cognitive processes, and synchronization and integration of different systems and capabilities while providing almost countless variations of situations and complex problems with almost immediate feedback on performance. The military even uses games to educate new recruits about the military service they have chosen before they actually attend their Initial Entry Training.

Resourcing Training

When personnel are not actually engaged in combat, training dominates military activity in all four services on a daily basis. Soldiers, sailors, airmen, and Marines are trained from the first day they enter the armed forces until the last day of their service. Commanders at every level consider training for future combat and military operations to be one of their primary responsibilities. Institutionally, each service expends significant time, money, and personnel on generating, conducting, and sustaining the most effective training possible for individuals, teams, units, and organizations at every echelon. Failure to conduct such training or conducting training that does not attend to the harsh realities of war will likely lead to failure in battle.

Of all the training resources we have, time is the most precious. Military organizations start the year with 365 days, but with 104 weekend days and a dozen or so holidays, the start point is soon around 250 days. Then training has to compete with other critical events such as maintaining equipment, moving units from one place to another, personnel-related tasks such as medical checkups, and preparation for deployment.

Therefore, in a really good year, a unit might have six months of actual training time. Then commanders must manage that time. How much is devoted to individual training? How much is devoted to collective or unit training? How much is small-unit or individual ship or squadron training, and how much time is spent on large-scale training? How much is live training, and how much time is spent in simulators? Management of the training calendar becomes one of the most important leader tasks.

Providing adequate personnel for training is also a critical resourcing effort. Great training requires great trainers. The basic training that each service provides is only as good as the drill sergeants and other non-commissioned officers who are taken out of combat-ready units and provided to the training base. Similarly, professional military education at all levels requires dedicated and well-educated faculty, both uniformed and civilian. Senior leaders must make strategic decisions about the management of personnel to provide the best support to training while still ensuring that units and ships are adequately manned to go to war if necessary while meeting the needs of ongoing conflicts.

Of course, the most visible resource necessary for training is money. Money pays for all of these capabilities. It pays for training areas, ranges, training ammunition, and fuel. It pays for flight hours for training aircrews, for transporting units to and from training areas, and for the training simulations. The services also must pay for development of future training capabilities such as virtual, constructive, and gaming simulations and for modernization of training forces as the conflict environment and the threats and enemy change. Money also pays the personnel costs associated with training.

Training budgets are very complex across the Department of Defense. Part of the cost of training is contained in a unit's operations and maintenance budget. Other training costs are in infrastructure or base maintenance budgets. Others are found in modernization budgets as the services improve capabilities or field new systems. Some costs are related to pre-deployment training for units that are preparing to go into combat in places like Iraq or Afghanistan. Costs are also spread over several years, or "across the POM" (Program Objective Memorandum) as the five-year DOD budget planning cycle is termed. This means that some training costs are short-term, year-to-year, while others, such as the costs of building training infrastructure, are spread out over several years.

Resourcing training with enough money is a national endeavor, not just a military one. The Department of Defense, in conjunction with other federal departments and agencies, submits budgets to the Administration that include all of the various training requirements. The Administration submits that budget to Congress as part of its overall budget. Congress considers all of the training requirements and costs in crafting an appropriations bill, which eventually is subject to a vote, approved, and signed by the President. At the same time, the various states are developing and approving budgets that include their own defense-related training costs, such as for the Army and Air National Guards and state-level training areas and facilities. And every two years, when Americans vote, the readiness, modernization, and training of the military forces is a consideration.

In other words, military training is every American's business.

Conclusion

Warfare continues to change as new operational methods like hybrid warfare are combined with new technologies such as cyber, drones, and 3-D printing. Military training also must continue to change so that the U.S. military is prepared to confront emerging threats and potential enemies that are growing in strength and ambitions. Training innovation and training resourcing are critical to achieving new and better ways to train the force.

Ultimately, the goal of military training is to ensure that when the nation goes to war or engages in conflicts or military operations short of war, the armed forces of the United States will be able to accomplish strategic, operational, and tactical objectives. The ultimate goal of training is to win battles and engagements and to do so with the lowest cost in terms of national resources and with the lowest loss of life among those who have volunteered to fight to defend the nation.

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An Overview of the DOD Installations Enterprise

John Conger

With six aircraft carriers and dozens of cruisers, amphibious assault ships, guided missile destroyers, submarines, and other ships, Naval Station Norfolk is home to the world's largest concentration of naval power. Its ranges extend well into the Atlantic Ocean, offering those forces a place to train and establish their readiness for war. However, without a place to refuel and resupply, a place to repair and maintain its ships, a headquarters for their sailors and their families to live when those ships are not deployed, that incredible concentration of naval power would attenuate, lose its readiness, and become less effective over time.

In contrast with the enormity of Norfolk, the U.S. Army and Marine Corps and allied NATO forces maintain small forward bases across Afghanistan to support ongoing operations. These bases are usually comprised of fortified locations from which our forces can launch. They need to be resupplied continually, but, again, they give U.S. forces a place from which they can project power.

From one end of the spectrum to the other, from domestic locations to those in active combat zones, from the very largest base to the very smallest, installations are critical to maintaining and projecting our warfighting strength. As I testified before Congress many years ago, "Our warfighters cannot do their job without bases from which to fight, on which to train, or in which to live when they are not deployed. The bottom line is that installations support our military readiness."[1]

Today, however, despite its incredible value to the warfighter, the DOD installations enterprise faces serious challenges. Budget shortfalls (even with recent increases in the overall budget) continue to eat away at its foundations, encroachment challenges impose constraints even as requirements increase, and leaders struggle to build resilience to external impacts like cyberattacks and climate change.

Scope and Scale

To begin to understand the impact and contribution of the Defense Department's installations enterprise, it helps to consider its sheer size. DOD maintains a global real property portfolio consisting of 568,383 facilities, valued at approximately $1.05 trillion, with more than 2.2 billion square feet of space located on 27.2 million acres of land at over 4,793 sites worldwide.[2]

The 568,383 facilities include more than 275,000 buildings, from operational facilities to administrative ones, from barracks to hospitals, from sophisticated research facilities to wastewater treatment plants. They also include a wide range of non-building structures including piers, runways, roads, fuel tanks, and utility lines. For comparison, the General Services Administration—in theory, the real estate manager for the federal government—maintains only 9,600 buildings. DOD's 2.2

TABLE 2

Real Property Managed by Military Service, FY 2016

Military Branch	Buildings	Total Facilities (including structures)	Plant Replacement Value (in billions)	Land (acres)
Army	139,458	278,299	$417.95	13,340,778
Navy	61,368	111,937	$238.50	2,213,663
Air Force	47,738	126,215	$302.58	9,126,467
Marine Corps	26,748	51,112	$79.40	2,504,943
DOD Total	**275,312**	**568,383**	**$1,038.43**	**27,185,851**

NOTE: DOD total excludes Washington Headquarters Service.
SOURCE: U.S. Department of Defense, "Department of Defense Real Property Portfolio," https://www.acq.osd.mil/eie/Downloads/Fast_Facts_2016.pdf (accessed May 23, 2018).

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billion square feet dwarfs the GSA's 377 million square feet.[3]

DOD's 27.2 million acres is certainly smaller than the acreage held by other federal landholding agencies such as the Bureau of Land Management or the U.S. Forest Service, which maintain 245 million acres[4] and 193 million acres,[5] respectively, but DOD installations still comprise a land area that is roughly the size of the State of Virginia.

The DOD facilities footprint is dominated by the Army, which maintains about half of the buildings, facilities, and land managed by the department. (See Table 2.)

Another element of DOD's scale is its scope. As the number of buildings implies, there are many different kinds of facilities on DOD bases supporting a wide array of missions.

Consider a base like Fort Hood, Texas, home to the Army's III Corps and the 1st Cavalry Division. Fort Hood alone maintains more than 5,000 facilities on more than 200,000 acres with a value of approximately $9 billion.[6] These buildings include operational facilities like headquarters buildings, motor pools, aircraft hangars and runways, training centers, instrumented training ranges, weapons storage facilities, deployment railheads, and more. They also include the buildings that support the troops and their families including barracks; family housing; fitness centers; dining halls; a hospital and several medical clinics; exchanges and commissaries; and morale, welfare, and recreation facilities. Moreover, there is the basic infrastructure of the base: miles of roads, utilities infrastructure, fuel lines, dams and bridges, access control points, and fencing. Other federal agencies manage many similar facilities, such as Department of Veterans Affairs hospitals or GSA office buildings, but each DOD installation must contend with diverse arrays of facilities and a concomitant diversity of challenges.

Each base has its own mission and its own specialized facilities, and those facilities are critical to the forces that employ them. Where Fort Hood has motor pools and tank ranges, Norfolk Naval Base has piers and dry docks, and Nellis Air Force Base in Nevada has hangars and runways. A research-focused base like Fort Detrick or Wright-Patterson Air Force Base will have sophisticated lab facilities, intelligence-focused missions will require computer centers and communications equipment, and arsenals and depots will have industrial operations.

A final element of scale in the DOD installations enterprise is its global nature. DOD facilities are located in every state, in multiple

U.S. territories, and in 42 different nations.[7] The largest part of our international footprint is an artifact of World War II and the Cold War, with thousands of U.S. facilities located in East Asia (Japan and South Korea) and Europe (predominantly Germany, the United Kingdom, and Italy). This global presence not only deters aggression, but also allows the United States to respond quickly to regional crises as they emerge.

How Installations Contribute to Military Power

With that context in place, consider how that trillion-dollar portfolio contributes to the military power of the United States. Our installations serve to generate the force, train it, and sustain it. From our bases, these forces can be projected and deployed, and once the mission is complete, they come back to those bases to recover, reconstitute, and ready themselves for redeployment.

Installations may contribute to combat power as power projection platforms, such as Fort Hood or Joint Base Lewis-McChord, which regularly deploy troops to theater, or an Air Force Base like Whiteman AFB, from which B-2 bombers can launch attack operations directly. Some bases conduct operations directly, whether it is a forward operating location in Afghanistan or an airman flying Reaper aircraft over Syria from a facility in the United States. Intelligence operations generally have reachback to critical hubs for processing intelligence and distributing it back out to the field. Transportation and logistics installations are critical elements of that ability to project power, moving people and equipment around the world.

America's global footprint is critical to that power projection capability. Our forces in Japan, for example, provide the ability to reach crises in the Western Pacific much more quickly than forces stationed in the continental United States can reach them. Similarly, Europe is a critical launch point for reaching theaters of operation in the Middle East. The Landstuhl Regional Medical Center in Germany has been a critical hub for casualties from Iraq and Afghanistan.

In addition to conducting operations and projecting power, installations are essential to building readiness in the first place. Installations from Parris Island, where they make Marines, to Columbus Air Force Base, Mississippi, which specializes in pilot training, are part of the enterprise that provides initial training to the force. Other bases, such as Fort Irwin, California, provide larger-scale maneuver training. In fact, readiness recovery is limited by the throughput capacity (the number of rotations you can schedule in a given year) at bases like this. Readiness is also sustained at logistics bases, whether they be shipyards or depots, where critical military platforms go through regular scheduled maintenance or recovery from battle damage so that they can be available for future operations.

Even as the military services look to equip the force, they turn to critical capabilities at installations. Research centers like Wright-Patterson Air Force Base enable the development of advanced technologies that are fed into new weapons and platforms, and test ranges like Naval Weapons Station China Lake or White Sands Missile Range provide the essential capabilities needed to confirm that our weapons operate as intended. These ranges are some of the most important assets in the installations enterprise, providing capabilities that would be nearly impossible to recreate elsewhere. For example, the pristine spectrum environment (the lack of background signals from cell phones, electronics, or other transmitters that corrupt test results) at a place like Fort Huachuca is a critical ingredient of its Electronic Proving Ground, just as the immense size of the fully instrumented White Sands Missile Range, at 3,200 square miles, makes it possible to test longer-range weapons than cannot be tested anywhere else in our enterprise.

Even the Base Realignment and Closure (BRAC) process evaluates installations based on their "military value." The legally defined definition used in BRAC has several elements, but it is comprised of:

- The current and future mission capabilities of the base and its impact on operational readiness;
- The availability and condition of land, facilities, and airspace;
- The ability to accommodate contingency, mobilization, surge, and future requirements; and
- The cost of operating at that location (in other words, a base that provides a capability cheaply has more military value than one that provides the same capability at a higher price).[8]

Explicit in these criteria is that a base brings military value to the force. It brings mission capabilities, affects operational readiness, provides essential resources such as training land or airspace, and offers the ability to support wartime surges in operations. When we measure military value for an evaluation like this, we recognize the truism that each base contributes military value to the enterprise.

Current and Emerging Challenges

The DOD installations enterprise faces several categories of challenges as it seeks to support the warfighter, generate readiness, and ensure that the force is properly equipped. One recurring challenge is the budget, which even with recent increases continues to be a lower priority than other parts of DOD. Another is encroachment, a problem that emerges when development occurs at the installation-community boundary and negatively affects a unit's ability to train or DOD's ability to test equipment in development. One large category of challenges swirls around questions of resilience: a base's ability to continue to operate or to recover quickly from exterior shocks, whether they be power outages, severe weather damage, or cyberattacks.

Budget Challenges. When trying to maintain more than $1 trillion worth of infrastructure, the sheer scale demands a significant recurring investment in maintenance, repair, and recapitalization. If infrastructure is not maintained, it will decay and eventually have tangible readiness impacts. New facilities need to be built each year in response to new or growing mission requirements, and as maintenance backlogs grow, recapitalization needs increase.

In general, it is more compelling to speak about the tip of the spear or the tooth versus the tail, which tends to leave support programs like facilities at the back of the funding line. This is not necessarily the wrong choice. With the constraints imposed by the Budget Control Act (BCA), DOD certainly concluded that it made more sense to fund warfighting activities over construction. I testified before Congress that "facilities degrade more slowly than readiness, and in a constrained budget environment, it is responsible to take risk in facilities first."[9] However, that cannot go on indefinitely without affecting that spear tip that we have been fighting so hard to protect.

Reviewing the military construction budget is instructive as we see the historical support for facilities investment. In Chart 4, you can clearly see the increased investment in the most recent BRAC round (2005–2011) and the decrease imposed by the BCA. During the BCA period, DOD has focused its new construction on new mission requirements rather than recapitalizing failing facilities or increasing efficiency. As a result, buildings in poor condition have been retained, imposing higher maintenance costs on the enterprise.

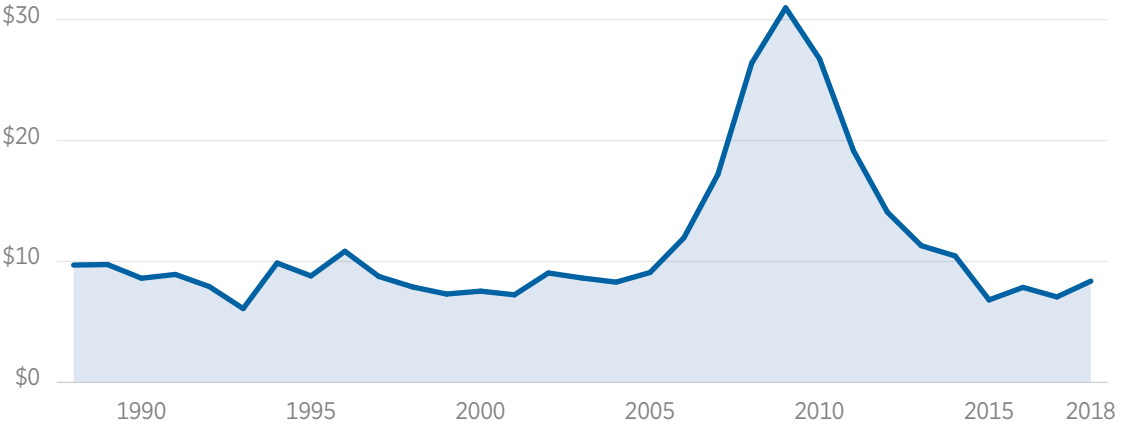
Recent trends are more positive, although the fiscal year (FY) 2018 military construction funding level of $8.4 billion is less than the historical average over the past 30 years, adjusted for inflation. This figure represents less than 1 percent of DOD's aggregate plant value, or a recapitalization rate of about 125 years. While DOD does not currently use a recapitalization rate goal, its historic goal was a 67-year rate.[10]

In addition to military construction, the Defense Department regularly takes risk by underfunding its Facilities Sustainment, Restoration and Modernization account, which

CHART 4

Military Construction Funding

MILITARY CONSTRUCTION TOTAL OBLIGATION AUTHORITY, IN BILLIONS OF FY 2018 DOLLARS



SOURCE: U.S. Department of Defense, Under Secretary of Defense (Comptroller), "National Defense Budget Estimates for FY18," revised August 2017, http://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2018/FY18_Green_Book.pdf (accessed May 22, 2018).

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includes regular and emergency maintenance of its buildings and facilities. The department maintains a model that recommends funding levels for this account, but those figures generally are not met except in some specialized accounts like medical facilities, which must be properly maintained to ensure accreditation.

For example, in its FY 2019 budget request, the Navy indicates that it includes 80 percent of the modeled requirement, up from 78 percent in its FY 2018 budget. When funding is short, it must be prioritized, so as it discusses this shortfall, the Navy's budget states, "The Navy continues to take risk in infrastructure funding but mitigates this risk by focusing investments on capabilities directly supporting critical warfighting readiness and capabilities."[11] In other words, the Navy is going to put its funding in runways and piers before fixing administrative facilities, and the other services have similar approaches. Underfunding perpetuates the deferral of preventive maintenance in favor of emergency repairs, a cycle that not only perpetuates itself, but also imposes much larger life-cycle costs on the department.

During the early BCA years, this was even worse. In FY 2013, the year in which sequestration was imposed, facilities accounts were severely curtailed. The U.S. Government Accountability Office reported that the Army, for example, cut back nearly 40 percent of its original budget.[12] Because operations and maintenance funds are relatively flexible, facilities funding could bear more of the burden of sequestration to insulate operations in theater.

As context for how much DOD should be investing in maintenance of its facilities, consider the National Research Council's recommendations on infrastructure maintenance. The NRC recommended funding levels of 2 percent–4 percent of plant replacement value as the appropriate benchmark for facilities maintenance.[13] That would result in a facilities maintenance budget requirement of $21 billion to $42 billion for DOD. In contrast, the FY 2018 appropriation was $9.9 billion.

Years of underfunded facilities maintenance accounts have resulted in widespread condition problems across DOD's facilities

portfolio. On April 18, 2018, the department reported that 23 percent of its facilities were in poor condition and another 9 percent were in failing condition. To address these and other maintenance challenges, it faces a maintenance backlog of more than $116 billion.[14]

Funding shortfalls can result in mission or readiness impacts. For example, deteriorating runways have immediate mission impacts, and debris could cause damage to expensive aircraft; burst pipes cause flooding damage with the potential to affect critical electrical systems; and inoperative air conditioning at a minimum can make life miserable for military personnel but could also cause sensitive computers to fail. Of course, mission facilities are prioritized, but that leads to worsening conditions in warehouses, maintenance shops, and other facilities that are not seen as the tip of the spear. Ultimately, failure of those facilities will affect the mission as well.

Base Realignment and Closure. The divestiture of excess infrastructure, saving money without undermining capability, is one of the most important tools that DOD has for reducing costs, particularly when it results in the closure of an entire installation. Due to the highly charged political dynamics that surround the prospect of closing a base and the prospect of losing a regional economic engine, the apolitical process known as BRAC was created. This apolitical, analytical process is focused on assessing excess capacity and realigning units by incorporating them within those installations that have the highest military value, closing those bases with the least military value and then reaping savings.

Through five rounds of BRAC (1988, 1991, 1993, 1995, and 2005), DOD has achieved recurring savings of more than $12 billion[15] that have resulted in 121 major closures, 79 major realignments, and 1,000 minor realignments and closures.[16] The department's most recent proposal for BRAC authority was projected to result in $2 billion in additional annual savings once fully implemented.[17] In theory, those savings could be plowed back into the enterprise to alleviate some of its funding pressures. From a practical perspective, however, the beneficiary of those savings is DOD as a whole, not the installations enterprise. There is no "fencing" of the dollars mandating that savings must be used on other installations requirements.

Despite the fact that BRAC is designed to remove political influence, requiring Congress to vote on an entire package of closures and realignments without making changes, the debate over giving DOD the authority to conduct a round of BRAC is extremely political. Members of Congress assess their prospective risk and generally will oppose even conducting the analysis in the first place for fear that they will be held responsible if the department's recommendations lead to the closure of a base in their district or state. Without question, the department's assessment of 19 percent excess capacity[18] begs for a good-government solution to eliminate waste, but Members of Congress cannot help but weigh the political risk against the prospect of $2 billion in annual savings that comes to fruition six years in the future.

Despite the prohibitions on BRAC, the department was able to conduct a review of its European infrastructure. DOD's 2013–2015 European Infrastructure Consolidation effort did not require congressional approval and did not evoke the same protective instincts that domestic bases evoke. That effort resulted in 26 recommendations designed to save more than $500 million annually when fully implemented without reducing the overall U.S. presence in Europe.

Recent arguments in favor of BRAC have focused on increasing lethality instead of securing savings,[19] harkening back to the 2005 round, which focused on "transformation." Without question, there are important management actions the department can take under BRAC authority that it cannot take otherwise, and many of these actions do not save money. In the 2005 BRAC round, for example, roughly half of the recommendations were never designed to save money. They resulted in $29 billion in costs and only $1 billion in savings but achieved DOD management objectives, such as collocation of law enforcement activities at Quantico

Marine Corps Base or the return of forces from Europe. The efficiency recommendations—the ones designed to save money—cost $6 billion up front but achieved $3 billion in recurring savings.[20] In total, the 2005 BRAC round alone is saving $4 billion every year, allowing $4 billion in other requirements to be funded within the budget caps.

As we consider future arguments about or alternatives to BRAC, particularly if the motivation is budget savings, it is important to recognize what drives those savings: reductions in personnel. While there are some savings to maintenance requirements or utilities from divesting individual buildings, the most significant recurring savings from BRAC are from civilian job cuts, particularly the number of cuts that come from complete closure of a base.

Partnerships and Privatization. Another approach that DOD takes to reducing costs is to find others to take on non-core functions. This might involve privatization, like the Military Housing Privatization Initiative in which DOD divested the preponderance of its family housing to private developers, or it could be as simple as turning to the local community to provide a service like trash collection.

To be a good candidate for privatization, a function should be generally commercial in nature (common in the installations world) and have an associated revenue stream that a private entity can leverage to secure financing. However, the department has taken on these tasks to shore up parts of the enterprise that have been chronically underfunded and is not commonly motivated to explore privatization where things are going well, even if a function is commercial in nature.

All of these factors come into play with the highly touted Military Housing Privatization Initiative. Under authority provided by Congress in 1996, the department has privatized approximately 200,000 housing units on its installations, conveying the homes and providing leases for the underlying land.[21] The families living in that housing receive Basic Allowance for Housing and pay rent just as if they were off base. Developers leveraged the projected income and conveyed assets to secure loans and front-load a huge recapitalization effort, dramatically improving the quality of on-base housing. DOD was able to leverage about $3.4 billion in government investment to generate $31 billion in private capital.[22]

Another successful example is the privatization of utilities. Again, in this part of the portfolio, the condition of DOD-owned assets was extremely poor, but electricity, water, and wastewater infrastructure are quite commercial in nature, and monthly utilities bills provide a regular revenue stream. Utilities privatization contractors accept the assets and make capital improvements up front, leveraging the economics of 50-year agreements.

Finally, the degree to which local communities are indispensable to the installations they surround is not always acknowledged. These communities provide a wide range of services to the base that it simply would not have the capacity to provide on its own. In most locations, communities provide utilities infrastructure, housing, education, transportation infrastructure, and a source of civilian employees and contractors. Absorbing those functions back into the base would be cost-prohibitive, and as they look for efficiencies, installations have been looking at more functions to divest to local municipalities. Congress recently provided the department with authority to sign Intergovernmental Service Agreements that allow bases to turn to their local municipalities to provide more services, saving money for both through economies of scale,[23] and the services have been working to leverage the new authority.

Energy Efficiency. Without question, there is inefficiency in the DOD installations enterprise, though it is not always easy to excise. Looking at the foregoing BRAC discussion, macro-level changes and cost reductions involve huge political hurdles, but they are the clearest route to achieving savings in the DOD enterprise. At the installation level, the two largest categories of costs are public works (as noted, maintenance is systematically underfunded) and utilities. Significant effort

has been made to reduce energy usage as the department looks to reduce costs.

In 2017, the Department reported that it spent $12.4 billion on energy in FY 2016: $8.7 billion for operational energy (largely fuel), of which $3.7 billion was attributable to installations energy costs, most of which pay for electricity and natural gas.[24] The department has been tracking its energy use since 1975 and has made significant progress over the years, reducing its energy intensity (BTUs per square foot) by 49 percent, but as its *Annual Energy Management and Resilience Report* explains:

> These reductions were a result of substantial low- and no-cost energy efficiency and conservation measures that impacted behavioral changes, and project investments such as insulation or lighting upgrades. As similar, viable low- and no-cost energy efficiency and conservation initiatives continue to diminish, DoD will be challenged to make broad reductions in energy intensity.[25]

This challenge is exacerbated by the underfunding of facility maintenance. To put it bluntly, there is a limit to how much improvement from sophisticated energy management systems is possible when there is a hole in the roof.

Readiness and Encroachment Challenges. Another set of challenges stems from encroachment, which is the negative impact on military readiness and base operations that stems from the growing competition for and limitations on land, sea, air, and even the electromagnetic spectrum that is increasingly crowded by the proliferation of cell phones and Wi-Fi.

Although a case could be made that huge bases like Camp Pendleton, Norfolk Naval Station, or Fort Bragg are the crown jewels of the DOD installations enterprise, the "hidden" gems are the testing and training ranges where our servicemembers have the land, sea, and airspace they need to test new weapons systems and train using the equipment they will bring to war. Mark Twain once said, "Buy land, they're not making it anymore." For DOD, the land that comprises these ranges is priceless.

From bases like Fort Irwin or Twentynine Palms Marine Corps Air Ground Combat Center, where soldiers and Marines practice large-unit operations to prepare for combat, to sophisticated weapons testing ranges like Naval Air Weapons Station China Lake or the White Sands Missile Range, which have sufficient space to conduct realistic testing of new weapons systems, to the pristine spectrum environment at Fort Huachuca's Electronic Proving Ground, DOD counts on its ranges to generate readiness and test its newest weapons systems.

The land, air, sea, and spectrum environments at these ranges have become increasingly constrained. Range managers have been able to use work-arounds to accommodate constraints, but they are exacerbated both by the increased requirements associated with weapons of greater speed and range and by the continual development in the surrounding civilian or commercial communities that creeps closer and closer to installations that once were completely isolated. DOD even set up a separate office to engage with wind companies whose proliferating turbines, if placed in the wrong locations, could affect DOD radars or block aircraft training routes.

DOD's *2017 Sustainable Ranges* report to Congress identifies the encroachment challenges that are of the highest concern:

- Managing threatened or endangered species, which includes requirements that troops ensure that they do not inadvertently affect these populations and that they adhere to the Endangered Species Act. More than 400 endangered species can be found on DOD bases, in no small part because they have held back the surrounding development and species have taken refuge on our bases.

- Commercial development near our ranges and bases, which can have a range of impacts including noise restrictions,

constrained munitions activities due to required safety zones, or cell phone signals that corrupt sensitive electronic testing.

- Foreign investment located near sensitive testing and training ranges that require DOD to conceal or change its activities to protect against intelligence gathering.

- Reallocation of electromagnetic spectrum to commercial activities, which forces DOD systems to change their operating parameters.

- Climate impacts such as increased high-heat days, which constrain soldier activities, or drought conditions that block the use of live-fire training or testing because of increased wildfire risk.[26]

The department has developed several ways to meet these challenges, aside from imposing constraints that force testing and training to be less realistic. One key response is the establishment of buffer land around bases, which is done in a variety of ways. In many of the western states, where the surrounding land is controlled by the Bureau of Land Management, the U.S. Forest Service, or the states themselves, DOD is able to collaborate with other government institutions to minimize development in locations that would affect training or testing.

In addition, buffer programs like the Readiness and Environmental Protection Integration (REPI) program leverage unique authorities that allow DOD to share the costs of conservation easements around our bases. In these cases, the department will pay a portion of the costs of an easement, as will a non-governmental conservation organization, and each side gets what it wants—an undeveloped natural resource next to a military installation—for half price or less.

Another key tool is the Joint Land Use Study (JLUS). Under this authority, DOD and local communities work together to inform future development efforts to minimize impacts to the base. Communities are able to pursue compatible development without jeopardizing the local military base, which is usually a principal economic engine.

In recent years, the construction of wind turbines near installations has presented a particular problem. The tip of a turbine blade moves quickly and is often picked up by radar as an aircraft, thereby interfering with radar operations and testing. Moreover, given their height, most commercial turbines present significant obstructions to military training routes. To address this issue, DOD established a DOD Siting Clearinghouse, providing developers and land-use authorities a single point of contact to ask whether a proposed turbine site would affect DOD operations. The clearinghouse reaches into the testing and training expertise of the services and works to mitigate unintended problems.

Resilience Challenges. An emerging category of challenges that the installations leadership is facing today are resilience or mission assurance challenges. Can the installation continue to operate and support its missions, or at least recover quickly, when there is a shock to or disruption of its systems? Recently, this has been focused on energy resilience and ensuring that an installation can continue to operate if the electricity grid is knocked out through severe weather, cyberattack, or even equipment failure. DOD reported 701 utility outages lasting eight hours or more in FY 2016.[27]

The most common way that DOD insulates itself from the impact of electricity outages is through diesel generators. Generators are relatively inexpensive and easy to acquire and for that reason are sometimes purchased by mission owners rather than by installation engineers. However, they are inefficient and are suboptimal solutions for medium-term or long-term outages, and DOD has pursued a more comprehensive strategy.

In addition to backup generators, DOD's energy resilience strategy notes that resilience can be achieved in a number of ways. Recent DOD studies describe increasing energy production on base, installing sophisticated

microgrids that can steer power across an installation and insulate key facilities from the impacts of outages, diversifying its fuel supplies, improving testing of its current backup generators, and creating non-energy solutions such as ensuring backup mission facilities at different installations.[28] It is reasonable to expect that the increased attention being paid to these issues will lead to increased investment in these options to ensure energy availability.

Cyberattacks and climate impacts will affect more than just the supply of energy to installations, and DOD has begun to explore the vulnerability of its installations to each of these threats. During his confirmation process, Secretary of Defense James Mattis stated:

> [T]he effects of a changing climate—such as increased maritime access to the Arctic, rising sea levels, desertification, among others—impact our security situation. I will ensure that the department continues to be prepared to conduct operations today and in the future, and that we are prepared to address the effects of a changing climate on our threat assessments, resources, and readiness.[29]

In January 2018, DOD reported that approximately half of its bases reported damage from climate impacts, including flooding and storm surge, wind damage, drought, and wildfires.[30] The Navy, with its preponderance of coastal installations, is already experiencing challenges from sea-level rise at bases like Norfolk or Annapolis,[31] and the Assistant Commandant of the Marine Corps has testified that he is considering a seawall to protect Parris Island.[32]

In many cases, this is about avoiding expenses and reducing risk by selecting where future facilities are placed. An illustrative example of the need to consider climate in planning is the multibillion-dollar radar site on Kwajalein Atoll,[33] which DOD estimates could be unable to support human habitation by as early as 2030.[34] Consideration of climate impacts might have helped planners choose a more enduring site for the investment. Congress has begun to focus on the impacts of climate on national security and has directed DOD to assess its overall vulnerability and develop mitigation plans for its most vulnerable installations.[35]

The cyber threat has received considerable DOD attention and investment, but the vulnerability of installations is only beginning to be understood. Industrial control systems are vulnerable to attack and intrusion, but DOD has no inventory of the systems inside its facilities. New guidance has been issued to govern the cybersecurity of these systems,[36] but installation personnel do not always have the specialized expertise needed to deal with cyber threats. Efforts to hire additional cyber experts will be undermined by the funding problems that DOD's installations face, particularly as they try to meet targets for staff reductions. The staffing challenge makes it even more important to have strong relationships with partners in the cyber community such as those at Cyber Command.

Outside the scope of this discussion but equally critical is the issue of vulnerability to military attack. This is ever-present in the minds of those in our contingency bases in Afghanistan, Iraq, or Niger, but we must begin to consider how to insulate the critical mission that our installations perform and the assets they support when we consider the threat from nations like Russia and China, whose weapons easily possess the range to reach our major enduring installations in Europe and the Western Pacific. Without these bases, our ability to project power in these regions would be severely diminished, and we ignore them at our peril. This is a challenge that the warfighters and the installations communities must address together.

Conclusion

DOD's vast installations enterprise is essential to the military mission in an incredibly diverse number of ways. It faces decay from years of underfunding, tightening constraints from encroachment, and threats from cyberattack

and the climate itself, but the men and women of the enterprise continue to make it work and support the warfighter.

I have often been asked about the base of the future and what it would look like, and I have responded that if it continues along its current trajectory, it would be dilapidated, understaffed, underfunded, and underutilized. Just like a car owner who chooses to save money by choosing not to change the oil, the nation will have to pay a much larger price down the line.

The Administration and the Congress have an opportunity and an obligation to change this trajectory. Efficiency and reform are most certainly valuable and even essential when dealing with budgets that are short of the need, but they are not enough to solve the underlying problems that DOD faces. Ultimately, the department will need more money for its facilities and a holistic strategy for recovery. It needs to reinvest in its installations or divest them.

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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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Logistics: The Lifeblood of Military Power

John E. Wissler, Lieutenant General, USMC (Ret.)

The end for which a soldier is recruited, clothed, armed, and trained, the whole objective of his sleeping, eating, drinking, and marching is simply that he should fight at the right place and the right time.
—Major-General Carl von Clausewitz, *On War*

The term "logistics" was not commonly used until shortly before World War II, but the concept and understanding of logistics have been around since the earliest days of warfare. In Clausewitz's words, getting the force to the "fight at the right place and the right time"[1] is the true essence of military logistics.

The Merriam-Webster online dictionary defines logistics as "the aspect of military science dealing with the procurement, maintenance, and transportation of military materiel, facilities, and personnel."[2] The Joint Chiefs of Staff's *Logistics* elaborates on this definition and quotes Rear Admiral Henry E. Eccles's 1959 statement that "Logistics is the bridge between the economy of the Nation and the tactical operations of its combat forces. Obviously then, the logistics system must be in harmony, both with the economic system of the Nation and with the tactical concepts and environment of the combat forces."[3]

This simple two-sentence statement effectively captures both the complexity and far-reaching implications of military logistics. From the farthest tactical edge to the economic system of the nation, military logistics has far-reaching implications for the nation and the military element of national power and therefore affects every aspect of organizing, training, equipping, deploying, and employing the force.

Logistics is perhaps the most complex and interrelated capability provided by today's military. Unfortunately, to those unfamiliar with its intellectual and technological breadth, depth, and complexity, it can be considered an assumed capability—something that simply happens—or, worse yet, a "back office" function that is not connected to warfighting capability.

The success of military logistics during the past 16-plus years of overseas combat operations is partly to blame for anyone's assumption that continued logistical success in the ever-changing national security environment is a given across the entirety of the military logistics enterprise. This dangerous assumption tends to exclude logistics from the conversation regarding the nation's current and future warfighting needs. As a result, the logistics enterprise is rarely debated outside the logistics profession with the same intensity as other more publicized warfighting needs, especially the need to regain our military technological advantage over major competitors like China and Russia, are debated. Failure to understand the implications of *not* modernizing logistics in a time of great technological change potentially spells doom for the success of the modernized force.

In addition to ensuring that modernized logistics capabilities are appreciated as central to regaining our military advantage, logistics

capabilities must be considered in the ongoing discussion of solutions to overcome the current readiness shortfalls of today's military. Logistics is nearly absent from the recent testimonies by military leaders, members of congress, and industry.[4] While all of the testimonies highlight the need to modernize the U.S. military in order to regain our technological advantage, few specifically highlight the need for modernized logistics capabilities.

Alan Estevez, former Principal Deputy Under Secretary of Defense for Acquisition, Technology and Logistics and a career Department of Defense Senior Executive Service logistics leader, recently stated, "Logistics isn't rocket science...it's much harder!"[5] Logistics is fundamental to the readiness of the entire Joint force—those at home, deployed in operational settings, and permanently stationed abroad—given that it must operate around the world and across every domain of activity in spite of enemy efforts to frustrate its operations. Consequently, it is far more complex than even the most sophisticated global business enterprises.

The Logistics Enterprise

You will not find it difficult to prove that battles, campaigns, and even wars have been won or lost primarily because of logistics.

—General Dwight D. Eisenhower

Logistics touches every aspect of military strength and is the sum of the capabilities brought to bear by all of the U.S. military services and those of a wide array of international partners.[6]

The core functions within logistics are supply, maintenance, deployment and distribution, health services, logistic services, engineering, and operational contract support (OCS).[7] Logistics includes planning and executing the movement and support of forces as well as those aspects of military operations that deal with:

- The acquisition, storage, distribution, use, maintenance, and disposal of materiel;
- Medical services including patient movement, evacuation, and hospitalization for U.S. and partner personnel as well as indigenous personnel affected by operations;
- Facilities and infrastructure acquisition, construction, use, and disposition;
- Provision of food, water, and operational hygiene and sanitation support;
- Operational contract support including contract management;
- Infrastructure assessment, repairs, and maintenance;
- Common-user logistics support to other U.S. government entities, intergovernmental and nongovernmental organizations, and other nations;
- Establishing and sustaining large-scale and enduring detention compounds;
- Planning, coordinating, and integrating host-nation support from overseas partners;
- Disposal operations that deal with the removal and remediation of waste and unusable military property;
- In-transit visibility of sustainment and asset visibility of all major military end items; and
- Engineering support including horizontal and vertical construction of ports, airfields, and other military support infrastructure.[8]

Thus, military logistics' defining attributes—agility, survivability, responsiveness, and effectiveness—are measured by the breadth and depth of these core functions, which affect the military from force generation to training

to the readiness of units stationed at home and abroad.

Logistics is the oxygen that allows military muscle to function, grow, and strengthen. Just as DNA represents "the fundamental and distinctive characteristics or qualities of someone or something,"[9] logistics planning and modernization define the distinctive characteristics or qualities of the military force and ultimately provide the military commander the freedom of action, endurance, and ability to extend operational reach that are necessary to achieve success. Logistics is the foundation for the success of military operations from entry-level training to the most complex operations across the spectrum of conflict. From providing the facilities that house the members of the force and the ranges where they train, to sustaining the equipment warriors operate and wear, to providing fuel and ammunition in operations and training, the interconnectedness of logistics inextricably links logistics to military combat power.

U.S. Transportation Command (USTRANSCOM) provides daily examples of what it takes to keep U.S. forces and their sustainment moving around the world. USTRANSCOM conducts more than 1,900 air missions during an average week and has 25 ships underway and 10,000 ground shipments operating in 75 percent of the world's countries. It does this with a total wartime personnel capability of 45,945 active-duty soldiers, sailors, airmen, Marines, and Coast Guardsmen; 73,058 Reserve and Guard personnel; and 19,104 DOD civilian personnel—numbers that do not include the significant contributions of USTRANSCOM's commercial partners or the contributions of foreign entities.[10]

Utilizing its people, trucks, trains, railcars, aircraft, ships, information systems, and distribution infrastructure, as well as commercial partners' 1,203 aircraft in the Civil Reserve Air Fleet (CRAF) and 379 vessels in the Voluntary Intermodal Sealift Agreement (VISA), USTRANSCOM provides the U.S. military with highly responsive strategic mobility.[11] Its handoff to service logistics personnel around the globe creates a distribution pipeline that moves critical sustainment from the factory to the tactical edge of U.S. military operations.

In coordination with USTRANSCOM's distribution functions, the actions of the Defense Logistics Agency (DLA) as supplier for the military are equally staggering in scope and scale. During fiscal year (FY) 2017, DLA provided more than $35 billion in goods and services, coordinating the actions of 25,000 military, civilian, and contract personnel who provided food, clothing, fuel, repair parts, and other items across nine supply chains distributing approximately 5 million distinct consumable, expendable, and reparable items. DLA's activity is spread across 48 U.S. states and in 28 different countries.[12]

These are far from "back office" functions and are truly what sustain the force and support its warfighting readiness. The criticality of logistics is not a new phenomenon, however; logistics has a significantly more complex nature today because of its integration across air, land, sea, space, and the information and cyber environments.

The Timelessness and Ever-Changing Nature of Logistics

Amateurs think about tactics, but professionals think about logistics.

—General Robert H. Barrow, USMC

Alexander the Great noted with dark humor the importance and complexity of logistics during his campaigns of conquest nearly 2,400 years ago: "My logisticians are a humorless lot...they know if my campaign fails, they are the first ones I will slay."[13] Alexander's ability to move a force from Greece to India and back, conquering adversaries in Europe, Africa, the Middle East, and Central Asia and leaving functioning outposts along the way, attests to his logistical prowess.

In the modern era, the appreciation of logistics by Admiral Ernest J. King, Commander in Chief of the United States Fleet and Chief of Naval Operations during World War II, is equally telling: "I don't know what the hell this

'logistics' is that [General George C.] Marshall is always talking about, but I want some of it."[14] Similarly, in his timeless treatise on warfighting, *Defeat into Victory*, British Field Marshal Viscount Slim commented that building his theater's logistical infrastructure and supply reserves and maintaining his army's health were two of the three "foundations of victory" in his campaign in Burma and India. The third foundation, the morale of his troops, was directly affected by the first two.[15] Slim's ability to innovate in planning, organizing, and sustaining his logistics enterprise was critical to his logistics success.

These historically rooted truths of the centrality of logistics to success in war are reflected in the 2018 National Defense Strategy (NDS) in which Secretary of Defense James Mattis notes the criticality of logistical preparation to the resilience and agility of U.S. forces in any setting. For the U.S. to be able to sustain effective combat operations in the modern era, it must "prioritize prepositioned forward stocks and munitions, strategic mobility assets, partner and allied support, as well as non-commercially dependent distributed logistics and maintenance to ensure logistics sustainment while under persistent multi-domain attack."[16]

Demands of Today and Tomorrow

Logistics is critical not only to employing the force, but also (and perhaps even more importantly) to building the everyday readiness of the force. At the tactical level, one need only look at the various elements of readiness reporting reviewed by senior leaders to discern that the fundamentals of logistics directly affect the majority of elements that define readiness across the services—personnel, equipment, and supply readiness—which in turn directly affect the ability of the services to meet the recurring needs of ongoing deployments and generate the forces needed for war.

For example, Secretary of Defense Mattis's recently announced intention to reduce non-deployable personnel is one aspect of force readiness that is affected by the health services component of logistics.[17] Large numbers of non-deployable personnel reduce the available strength of military units, and without the full complement of personnel, teams cannot be trained effectively, whether they are ground units, ship's crews, or aviation formations. Personnel readiness is also affected by other logistics-related issues such as the lack of training throughput caused by insufficient, inadequate, or nonfunctional training facilities or the disruption caused by manpower transitions across the force that limit the availability of ready personnel.

Equipment readiness is another area of concern. Military units cannot perform their mission without the equipment needed to do so. Availability and delivery of parts and spare components, maintenance capability and the capacity to surge increased maintenance volume on short notice, the ability to contract additional support when necessary—all of these logistical elements are essential to military effectiveness.

Within logistics, the supply function is critical to equipment readiness. Simply stated, supply readiness is the ability to have the right types and amount of equipment available for a ground unit, a ship, or an aviation unit. Perhaps not so obvious is the interconnectedness of supply readiness to all other aspects of unit readiness. Without the right equipment, units cannot train to the full complement of their mission sets. Lacking something as simple as power generation capability on a ship, on the ground, or on an aircraft can prevent a unit from establishing the command and control capabilities that are vital to modern warfighting. As cyber and electronic warfare capabilities are introduced to the forward edge of the battlespace, individual capabilities represented by on-hand quantities of various technologies and trained personnel will truly define a unit's ability to execute the mission-essential tasks demanded in the complex warfighting environment of a peer adversary.

Supply readiness has been the subject of various testimonies to Congress regarding the readiness of the force on land, in the air, or on the sea. Shipyard capacities and the impact of deferred maintenance due to shortages of

parts in the Air Force, Army, and Marine Corps have been highlighted as factors in the need for improved force readiness.[18]

The impact of logistics beyond readiness grows exponentially when taken in the context of the larger complexities of strategic logistics capabilities such as national and international highway, rail, port, and sealift capacities. Reductions in the size and capability of the industrial base, limitations on our national sealift capacity, and aging of the infrastructure needed to move personnel, weapons systems, ammunition, and fuel all directly challenge the ability of the United States to project military power.

Port facilities capable of handling critical munitions movements are critical to force deployment and sustainment. The U.S. has only 23 designated Strategic Seaports—17 commercially operated and six under military control—that make it possible to sustain overseas forces daily and keep them sustained during wartime. Airlift, composed of the Civil Reserve air and cargo fleets[19] and thus a critical capability that directly affects our ability to move large portions of our force and their associated sustainment to points of crisis around the globe, is similarly limited.

At first glance, the challenges of military logistics may appear to be the same as, or at least very similar to, those experienced by FEDEX, Walmart, Amazon, DHL, or any other major supply chain operation supporting vast numbers of customers both internationally and across the United States. On deeper inspection, however, the differences are profound.

- Military logistics involves the interaction of military and government entities with private, commercial, foreign, and multinational organizations worldwide.

- Unlike commercial companies with global distribution operations, the military faces conflicts that usually erupt with very little warning and immediately create enormous demands for support akin to the Christmas rush, the Black Friday crush, and Cyber Monday rolled into one.

- Unlike commercial firms that can prepare by the calendar, the military must operate without knowing when the date of each event occurs and still have the ability to respond to a sudden change in the "latest hot item" within hours, if not minutes.

- Military forces must receive such support regardless of how limited or intermittent their access to the Internet may be, and supporting logistics forces must meet the demand while an enemy is trying to kill the customers, both at home and in the parking lot, and is destroying the delivery fleet at every opportunity.

To say the least, the challenges of military logistics are unique. Although many of industry's best practices and technologies are relevant and even vital to the modernization of military logistics, the agility, survivability, responsiveness, and effectiveness of military logistics require another level of integrated innovation in technology and operational concepts.

The Challenge

To appreciate the challenge confronting America's logistical capabilities, imagine having to execute a future operation similar in scale to the major deployment of U.S. combat power to Kuwait in preparation for Operation Iraqi Freedom (OIF) in March 2003. Now imagine doing this in an environment devoid of modern infrastructure in a manner that defeats an adversary's desire to prevent our use of air, land, sea, space, and cyberspace to project military power, all in consonance within the complex interrelationships and intricacies that support current collective defense arrangements. Imagine further that this must be accomplished against a force that has near-parity with our technological capabilities and the ability to engage us from fixed, friendly facilities with engagement timed on their terms.

While significant force-protection requirements affected the deployment of military capability to Kuwait for combat operations in Iraq, the U.S. and partner-nation forces did not

have to "fight their way to the fight" in Kuwait. Additionally, U.S. and partner-nation forces had significant time to deploy military capability, ultimately using a single point of entry with mature facilities and infrastructure and Internet access.

In preparation for combat operations in Iraq, logisticians had six months to deploy the force and its associated sustainment. U.S. forces initiated the deployment with Military Sealift Command (MSC), a USTRANSCOM subordinate command, prepositioning assets moving to Kuwait beginning in October 2002, with the off-load of increased military capability beginning in earnest in January 2003 and wrapping up in April 2003, completing the six-month force buildup.

Six months may seem a long time, but the volume of activity was immense. According to one account:

> In January 2003, MSC began the build-up for what would become Operation Iraqi Freedom. In January 2003 momentum was really gaining and APS-3 downloaded several ships of equipment into theater. In late March 2003 MSC reached a peak of 167 ships in the "Steel Bridge of Democracy", carrying "the torch of freedom to the Iraqi people" in the words of Rear Admiral D. L. Brewer III, Commander, Military Sealift Command.
>
> The span of that bridge was literally a ship every 72 miles from the US to Kuwait. That was more than 78 percent of the total MSC active fleet of 214 ships that day—ships dedicated to supporting the US forces.... The mix of ships encompassed all four of MSC's programs, and included the U.S. Maritime Administration's Ready Reserve Force, and more than four times the normal daily number of commercial ships. Twenty-five of 33 Naval Fleet Auxiliary Force ships were providing combat logistics for the carrier strike groups and amphibious strike groups involved in Operation Iraqi Freedom. Three of 25 Special Mission ships were directly supporting Navy combatants with telemetric, hydrographic and acoustic data....
>
> During the height of Operation Iraqi Freedom, MSC had 167 of its 214 active ships directly supporting the war. Of these ships, 26 were operated by federally employed mariners and 141, or 84 percent, were crewed by merchant mariners employed by commercial companies under contract with MSC. Of the 141 ships, 127 ships were carrying combat equipment and cargo from the U.S. or Europe into the theater of operations or were en route to load cargo for the operation.[20]

The same account further reflects that from January 2003 through the end of April 2003, MSC delivered more than 21 million square feet of warfighting equipment and supplies, 260 million gallons of fuel, and 95,000 tons of ammunition to the Persian Gulf area for the Army, Marine Corps, Air Force, and Navy warfighters involved in Operation Iraqi Freedom. More than 90 percent of the military cargo to support OIF was delivered by MSC ships. While 10 percent of the cargo was delivered by other means, primarily aircraft, understanding the magnitude and significance of sea-based sustainment is critical to understanding what it takes to deploy and employ the U.S. military.

At the same time, Naval Fleet Auxiliary Force oilers pumped more than 117 million gallons of fuel to Navy combat ships for bunkering and aircraft fuel. Of the 42 ships in the Prepositioning Program, 33 were underway or had already off-loaded gear for warfighting forces in the Persian Gulf area.

In the MSC Sealift Program, 106 of 115 ships, including government-owned surge sealift ships, Maritime Administration Ready Reserve Fleet ships, and chartered commercial ships, were carrying equipment and supplies for the Army's 3rd and 4th Infantry Divisions, 82nd and 101st Airborne Divisions, and V Corps and the Marine Corps' I and II Marine Expeditionary Forces. Additionally, two of

the three Maritime Prepositioning squadrons supporting the U.S. Marine Corps were unloaded at the Ash Shuayba Port in Kuwait. By late April 2003, more than 150 MSC ships had off-loaded in Kuwaiti ports.[21]

It should be noted, however, that in the years since these tremendous accomplishments, the size of the force available to execute these missions has shrunk considerably.

Admiral Brewer put these accomplishments into context: "The amount of cargo we delivered could fill all 119 Division 1-A college football fields three times over."[22] Specifically:

> From November 2002 to May 2003, nearly 85,000 pieces of cargo and 4,000 containers of ammunition, requiring 16 million square feet of cargo space, were loaded aboard MSC ships under MSC Atlantic's operational control. This was enough military cargo to fill the deck space of 58 Nimitz class aircraft carriers.
>
> These figures comprised equipment loaded in Texas, Georgia and Florida for the U.S. Army's 3rd and 4th Infantry Divisions and 101st Airborne Division, which included thousands of Abrams main battle tanks, Bradley fighting vehicles, humvees and helicopters....
>
> In February, MSC Pacific provided direct support in the activation of 10 MSC cargo ships at various West Coast ports. They also coordinated the loading of another 10 MSC ships at Tacoma, Wash., and San Diego, Calif., which resulted in the movement of over 1 million square feet of military equipment for the U.S. Marine Corps 1st Marine Expeditionary Force and the U.S. Army's 101st Airborne Division....
>
> MSC normally operates 120 civilian-crewed, non-combatant ships for a variety of missions around the world. The number of ships expanded to about 214 in mid-March as additional ships were activated from reduced operating status or chartered for the command's support of U.S. forces in OIF.[23]

While the immensity of this undertaking is staggering, it pales in comparison to the requirement laid out for the future military force in the National Defense Strategy (NDS). The future fight will require significantly greater responsiveness and diversity in the face of a greater threat. The NDS requires a military that will "be able to strike diverse targets inside adversary air and missile defense networks to destroy mobile power-projection platforms. This will include capabilities to enhance close combat lethality in complex terrain."[24] With regard to mobility and resilience, our military will be required to field "ground, air, sea, and space forces that can *deploy*, survive, *operate*, maneuver, and *regenerate* in all domains while under attack. Transitioning from large, centralized, unhardened infrastructure to smaller, dispersed, resilient, adaptive basing that includes active and passive defenses will also be prioritized."[25]

These challenges become infinitely harder when considering the vastness of the Pacific or the intricacies of meeting challenges across the depth and breadth of Europe. The force of tomorrow must be ready to defeat a peer competitor in a broad battlespace that requires security for each logistics movement, the ability to off-load across various widely distributed locations, with minimal infrastructure, and in a communications-degraded environment.

The ability to meet the NDS requirements requires a significantly more agile force. It must be able to dictate the time and tempo of its buildup and control the massive capabilities of the U.S. military. It must coordinate with allies and partners to place combined force capabilities against the adversary's weakness and develop and sustain a broad array of overseas advanced bases that will change frequently and provide the responsiveness and effectiveness needed to prevail despite enemy efforts to prevent U.S. forces from getting to or operating within the theater of combat. The U.S. military has not had to "fight its way to the fight" since World War II. Equally absent since that time

has been the need to apply combat power to preserve logistics capabilities.

Given the evolution of competitors' abilities to threaten the logistical underpinnings of U.S. combat power, force logistics planning now requires innovation in both technology and operational concepts. In a time of constrained fiscal resources, this means doing differently with less. There is no option to fail, and there is no hope of unlimited resources. The combination of innovation and new technology is therefore critical to maintaining the competitive logistical advantage that U.S. forces have enjoyed since World War II.

The NDS focuses on investments needed to improve the ability of forces deployed abroad to maneuver against an enemy and ensure that the posture of those forces (how they are arrayed in theater) has resilience (the ability to sustain losses and remain effective). Not explicitly addressed in the NDS but fundamentally implied is the equally daunting challenge of winning the "home games" by having the critical military–industry partnerships and dedicated infrastructure that serve as the preparation and launching pads for our forces.

The shrinking military–industrial base that provides the wherewithal of national power faces significant challenges because of unpredictable budgets and inconsistent program funding. During World War II, from 1939 to 1945, the United States delivered 1,089 warfighting ships to the fleet that today would be classified as battle force ships. These 1,089 ships included 32 carriers, 10 battleships, 62 cruisers, 442 destroyers, and 563 frigates and destroyer escorts.[26] Compare this to the Navy's *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for Fiscal Year 2019*, which proposes the construction of 54 battle force ships during the five years from 2019 to 2024.[27]

It should be noted that the current shipbuilding plan projects 11 more battle force ships than were projected in the 2017 plan. This trend is very similar across the industrial capacity capabilities that produce aircraft and major land-component warfighting systems. While procurement is not exclusively a function of logistics, the country's industrial capacity affects the availability of spare parts, the availability of technical support for contract maintenance, and the ability to replace warfighting platforms that are well beyond their service life, be they ships, aircraft, or major land-component systems (tanks, artillery, reconnaissance vehicles, personnel carriers, radars, ground vehicles, etc.).

When the instability of funding that results from continuing resolutions and an inability to pass budgets on time is added to these challenges, one can see that the problems confronting the industrial base are magnified at a time when they most need to be reduced so that our ability to supply the force is responsive and resilient. Perhaps counterintuitively, a constrained ability to build "new iron" (ships, aircraft, and major ground weapons systems) actually increases the logistical burden and budget because the cost of maintaining older systems necessarily increases.

The problem is made worse by the complexity of dealing with both old and new technologies in a single logistics enterprise. Add to these challenges the reduction of skilled manpower in the active and reserve forces, the increased difficulty of retaining seasoned military personnel, and a decreasing number of civilian and contractor artisans in the logistics workforce, and the need for modernizing the logistics force, from training to developing new concepts, becomes even more obvious.

Modernizing "home game" infrastructure must also include improved, state-of-the-art ranges and maintenance facilities, which are critical to supporting the readiness of new platforms that are being acquired in every service. Such facilities must also be made resilient in the face of cyber challenges, now a common feature of modern conflict. Integrating simulators and virtual reality capabilities into range design will also help to reduce the logistical impact of home-station training and generate much-needed efficiencies in major range training opportunities while also improving overall warfighting readiness.

Success Now and in the Future

New principles must be embraced to achieve the requirements for successful logistics capabilities in support of operational commanders and the National Defense Strategy. Many have written on the challenges of logistics in the 21st century, but Lieutenant General Michael Dana, Marine Corps Deputy Commandant for Installations and Logistics, has captured the requirement succinctly in his term "hybrid logistics," which he defines as the era "where 'old' meets 'new.'"[28] This is a period in logistics operations in which the combination of old and new technology and innovative concepts will provide precise logistics support to a widely distributed force instead of a large logistics footprint that delivers through a central hub.

The hybrid logistics attributes that Dana describes are a mixture of legacy and evolving technologies. They are delivered from the sea by means of modern connectors, platforms, processes, and concepts with the flexibility to enable multi-domain fires and maneuver. They are innovative in thought and practice, with a command and control architecture that is immunized against cyber and electronic warfare threats, and data-driven through predictive analytics. They also are applicable across the entire U.S. military from the strategic level to the tactical level. Ultimately, the effectiveness of any logistics capability is determined at the tactical level, but sustained success at the tactical level requires effectiveness further upstream at the operational and strategic levels.

Success at the operational level requires the integration of logistics capabilities contributed by all entities involved in military affairs, to include service, coalition-partner, interagency, governmental, private/commercial, and host-nation capabilities. The operational integration of these various capabilities provides the linkage between the tactical and strategic levels: a means to leverage the "Arsenal of Democracy"[29] in the hands of the men and women who serve in harm's way around the globe.

In assessing the true value of logistics, however, one needs to distinguish between efficiency and effectiveness, even though the former certainly affects the latter. Effectiveness is ultimately what matters at the tactical edge. Efficiencies should be pursued to free resources for use elsewhere, but those efficiencies must never be taken at the expense of the soldiers, sailors, airmen, or Marines who have been committed to battle. Many logistical challenges will remain unchanged in the near future because of the sheer physics of distributing ammunition and bulk liquids and the requirement to move major ground warfighting equipment and personnel. Nevertheless, changes that positively influence the agility, survivability, responsiveness, and effectiveness of logistics systems can and must be made.

Change must be made that ensures logistics agility by designing procedures and acquiring systems that adjust to changing requirements across a widely distributed force constantly and with domain-wide visibility, highlighting the needs, resources, and capabilities of the force. An understanding of the changing requirements must be achieved in the absence of direct input from the supported force through predictive capabilities that are enabled through improved artificial intelligence and machine learning capabilities.

Future logistics command and control systems can ensure agility by operating despite an enemy's efforts to disrupt communications through cyber and electronic warfare. This can be done by developing the means to transfer logistics data systems seamlessly from digital-based processes to analog-based processes and back. This requires both technological and training/conceptual change across the force, not exclusively in the logistics enterprise.

The use of unmanned platforms will be critical to the future of agile logistics. Unmanned platforms that support ground distribution will complement unmanned aerial platforms that deliver vital sustainment to widely distributed forces. In addition, unmanned platforms that can evacuate the injured from the point of injury without sacrificing high-cost combat platforms and additional combat capability will be critical in the dispersed battlefield. Every facet of military logistics must embrace unmanned platforms, from

unmanned sea-based ship-to-shore connectors to platforms for the refueling of ships to the use of unmanned platforms for aerial refueling.

Logistics survivability upgrades can achieve reduced targetability of the logistics force through development of manageable electronic signatures, a reduced logistics footprint, and improved distribution with reduced static inventory. Static inventory is distribution moving at zero miles per hour, and anything that is static on the modern battlefield has little chance of remaining survivable.

The ability to make the force more survivable requires both technological improvements that reduce the need for large footprints in bulk liquids and ammunition and refocused training and logistics concepts. Technologies such as additive manufacturing, improved man–machine interfaces, and advanced robotics will contribute significantly to improved survivability. Ultimately, change must ensure both speed and reliability of logistics systems that build trust from the tactical level to the strategic level. Improvements in munitions and energy systems will directly improve the speed and reliability of the force and, thus, its logistical survivability and effectiveness.

Responsiveness can be improved by leveraging industrial-base support from the point of manufacture to the tactical edge forces. Improved responsiveness through domain-wide visibility and predictive logistics capabilities driven by improved artificial intelligence capabilities will provide sustainment based on finely tuned metrics that eliminate the need to request support. In short, we need to have the ability to autonomously anticipate the needs of the commander, not simply respond faster to bottom-up needs identification.

Improvements in logistics effectiveness require improved integrated capabilities and authorities that allow logistics challenges to be resolved at the lowest levels, leveraging shared awareness, and focused on effectiveness. The ability to measure effectiveness against efficient performance is critical. This focus on effectiveness will prioritize the force's critical logistics needs by evaluating all requirements against mission success and differentiating the critical requirements from the multitude of inputs: in essence, providing the nail at the right time and place that prevents having to build a complete inventory of shoes, horses, and riders in order to win the battle.[30]

Conclusion

Logistics is critical to success on the battlefield. To remain a vital contributor to military success, logistics must adapt continuously so that it bridges old systems and capabilities while embracing new technologies and concepts. In addition, the success of every new system and concept, every new technology and military organization, must be evaluated against the commensurate evolution and revolution in logistics sustainability.

While not a new consideration in designing a force for tomorrow that remains relevant today, the development of integrated, agile, technologically advanced, and effective logistics systems that drive efficiencies into every corner of the military is increasingly essential in today's dynamic, fast-paced, and ever-changing national security environment. The shift in our military focus to competing in an era of great-power competition demands an even greater understanding of logistics and highlights the breadth of the requirement to support the entirety of the force in innovative ways, from training in the United States to deploying far from home.

Whether the unit engaging the enemy is in the air, on land, at sea, or in space or cyberspace, it must embrace innovation in logistics that not only integrates new technology, but also innovates in the "hybrid" environment of old and new in order to retain our military's true advantage as the world's only force that can "prevail in conflict and preserve peace through strength,"[31] both today and well into the future.

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