

BUILDING THE FUTURE FORCE

Guaranteeing American Leadership in a Contested Environment

Shawn Brimley

with Dr. Jerry Hendrix, Lauren Fish,
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Foreword by Michèle Flournoy

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About the Project

This report supports the *Evolving the Future Force* effort. *Evolving the Future Force* is a multi-year project designed to examine how the joint force should adapt to adversary innovations across the spectrum of conflict. State and non-state actors are investing in novel capabilities and concepts of operation that challenge traditional U.S. modes of power projection. U.S. military forces must evolve and adapt to respond to these challenges. This project explores the necessary attributes and capabilities of the future joint force and how to evolve it in a cost-effective manner. This effort examines opportunities to build on existing programs, capitalize on emerging technologies, leverage a high-low mix of assets, and experiment with new operational paradigms.

The *Evolving the Future Force* project is assisted by a high-level advisory council composed of experts from industry, academia, and former government officials. The authors would like to thank the council members for their support through the multi-year effort.

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Foreword

Foreword

by Michèle Flournoy

This report was the last project that Shawn Brimley, CNAS Executive Vice President and Director of Studies, worked on before he died of colon cancer in January 2018. Both the ideas in this report and the collaborative way in which it was developed are a testament to the extraordinary leader Shawn was.

As a thought leader, Shawn was always pushing us all to look farther into the future – to assess what was coming over the horizon, and to think creatively about how to ensure that the United States would be ready to meet the coming challenges and seize emerging opportunities. The seminal report he coauthored with then–CNAS CEO Robert O. Work, “20YY: Preparing for War in the Robotic Age,” became the intellectual foundation for the “third offset strategy” that Work drove forward in the Pentagon when he became Deputy Secretary of Defense. Much of that visionary thinking about the future of warfare and what the United States must do to ensure it can deter and, if necessary, prevail in an environment of intensified great power competition is updated and refined in this important and timely report.

Today, the recommendations outlined in this report are even more critical given the return of a more aggressive Russia and the rise of a revisionist China. The United States must pursue the steps outlined in this report with a new level of focus, resources, and urgency if it is to maintain its military edge in a far more contested future security environment.

But just as important as the substantive insights and recommendations in this report is the way in which it was put together. It is hard to think of someone who was more committed to – and impactful in – growing the next generation of national security thinkers and leaders than Shawn Brimley. Shawn could have written this report alone, or perhaps with a senior colleague like Dr. Jerry Hendrix, who leads the CNAS defense team. But he chose instead to recruit three young CNAS researchers to be his collaborators and coauthors. Shawn understood the opportunity that a report like this represents to bring the voices of a new generation of defense experts into the debate and to further their development as defense analysts.

Since its founding, CNAS has always been about “futures, not formers” – growing the next generation of national security leaders has been a core part of our mission and our culture from the start. But Shawn was a role model for us all in how he translated this institutional value into practice. He lived it every day, mentoring dozens and dozens of young professionals while also actively supporting the advancement of his peers.

This report is dedicated to the memory and example of our dear colleague, Shawn Brimley, who not only drove our analysis to be more strategic, bold, and innovative, but also dedicated himself to mentoring and advancing so many others in the field.

Key Takeaways and Next Steps

KEY TAKEAWAYS AND NEXT STEPS

- The rates of technological advancement and proliferation are hastening. To understand what this means for the future requires long-term forecasting, an inherently difficult task. Admiral Arleigh Burke's Task Force 70 effort, Andrew W. Marshall's work within the Office of Net Assessment, Michael Vickers' 1993 work for the Office of Net Assessment, and Robert O. Work's 2014 Center for a New American Security work on robotic warfare all represent accurate predictions of the future threat environment. Successful forecasting does not always produce the necessary policy changes, however. The challenge is thus less one of recognition than of translating this recognition into an appropriately designed defense program.
- The militarization of interstate politics should be expected to persist for the foreseeable future. This trend will be paralleled by the diffusion of advanced military technologies and new ideas for how to use them. The success of the future force will depend on its ability to find, fix, and finish targets more rapidly than its adversaries. Equally, the future force should expect adversaries that seek to conduct warfare at a pace unmatched by the United States or its allies.
- The range and lethality of modern weaponry mean that whichever state's forces are consistently able to stay hidden long enough to find and strike enemy targets first will have a significant military-strategic advantage. The challenge for the U.S. Department of Defense, then, is to procure a resilient intelligence, surveillance, and reconnaissance (ISR) architecture, enabled by artificial intelligence (AI) and advanced computing, that allows for the collection, analysis, and dissemination of actionable information in real-time. This will require greater investment in space-based, hypersonic, and stealth ISR assets in addition to AI-enabled analysis capabilities.
- Adversary access to a diverse array of defensive countermeasures means that sustained target acquisition cannot be assured. To ensure a kill, future forces will need to deliver one or more munitions on-target quickly, before an adversary is able to escape tracking. This is possible by either moving shooters as close to the target area as possible or by acquiring a suite of prompt strike weapons that can be fired from outside – or within, if feasible – an enemy's A2/AD bubble. If the future force wishes to ensure a kill, smart small-diameter bombs, robotic swarms, hypersonics, and directed-energy weapons should be a critical procurement focus for the Department of Defense.
- The pace of technological improvement, coupled with intensifying challenges to U.S. national security interests worldwide, demands that the United States dare to imagine ways of fighting that may defy conventional wisdom but that harness America's unique advantages. American strategists must also identify the doctrinal innovations that will make best use of new technologies, or best mitigate the vulnerabilities of older systems, inasmuch as it is not the technology that wins a war, but how that technology is employed.

Introduction

Introduction

The United States sits at an inflection point in its military history. Rising powers and nuclear-armed states pose novel and enduring threats to U.S. allies and interests in key regions worldwide. The spread of advanced technologies has allowed many of these actors to contest U.S. military primacy. This proliferation – accompanied by the rise of foreign hubs of technological innovation – promises to complicate the strategic picture further. To uphold its far interests, the United States must act decisively to assure that its future force can deter – or if necessary, defeat – foreign aggression in the year 2025 and beyond.

This means ensuring that America’s future force can penetrate adversary anti-access/area denial (A2/AD) networks and hold high-value targets at risk early on in future conflicts. Critically, it also means doing so as cost-efficiently as possible. Absent a bold and wise move to overturn the 2011 Budget Control Act (BCA) – and likely even after elimination of these budget caps – defense budget pressures should be expected to endure for the foreseeable future. The U.S. Department of Defense will consequently need to do more – namely, address potential threats in multiple theaters worldwide – with less. The first step toward these objectives is a candid appraisal of both the risks and opportunities posed by emerging military-technological trends. This report seeks to provide just that.

A Brief History of Long-Term Forecasting

This report is an exercise in long-term forecasting, an inherently difficult practice. Most attempts to peer into the future fail due to inadequate approximations of the relevant – and usually interacting – political, demographic, economic, ideational, and technological trends. The Soviet Union’s collapse was due, in large part, to Moscow’s inability to foresee that its economy could not sustain the expenditures required to match America in an arms competition.

There are, however, examples of successful attempts at forecasting. Admiral Arleigh Burke’s Task Force 70 effort in the late 1950s and Andrew W. Marshall’s work within the Office of Net Assessment both stand out for their process and incisiveness of perspective. So too did Michael Vickers’ 1993 work for the Office of Net Assessment on the effects of guided munitions and battle-network parity on global military competition and, more recently, Robert O. Work’s 2014 Center for a New American Security prescient monograph on robotic warfare. All of these efforts took a hard look at current technological trends and projected them forward against the future threat environment. Additionally, Burke, Marshall, Work, and Vickers all established innovative concepts of operations and suggested changes in the nation’s strategic approach to the world.

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Admiral Arleigh Burke

In 1955, President Dwight Eisenhower, no stranger to military protocol, recognized Arleigh Burke’s brilliance and promoted the two-star rear admiral over the heads of 92 officers more senior to him to become the four-star chief of naval operations (CNO).¹ Burke went on to become the longest-serving CNO in American history. His major contribution was to marry the Navy’s technology development strategy and its shipbuilding programs into a coherent future force. Writing in 1957, after an intensive three-year study by Task Force 70, Burke foresaw the rise of nuclear-powered ships, long-range aircraft, guided missiles, and advanced radars as the key, rapidly maturing technologies of his day.



During his service as the chief of naval operations, Admiral Arleigh Burke played a central role in conceptualizing the future naval force, foreseeing many technological capabilities that remain important today. (U.S. Naval Institute)

Using these elements, Burke established new concepts of operations for the American fleet that centered on the carrier strike group with its offensive air wing being surrounded by a flotilla of defensive missile shooters. This configuration allowed American carriers to operate close in to enemy positions and launch their air wings for maximum penetration of the enemy’s strategic depth. Burke’s new strategy created a fleet for the 1970s that would have over 900 ships and 7,000 aircraft, all harnessing the projected advanced technologies of their day.² What is remarkable is that the naval force he projected – which had largely come into being by 1975, with the advent of the *Nimitz*-class carrier, the *Ohio*-class submarine, and the *Ticonderoga*-class cruiser – remains the backbone of America’s fleet today, nearly 40 years later. Moreover, it is still considered the most advanced navy in the world.

The Office of Net Assessment

In 1949, Andrew W. Marshall was working on his graduate degree at the University of Chicago when the Rand Corp. recruited him to do statistical analysis of mental illness among draft-age males. Over the next two decades he emerged as one of the luminaries of Rand’s

“golden age,” as he began to create a new method of strategic analysis that is now known as “net assessment.”³

Marshall’s work took him to Washington during the Nixon administration. He worked first for Henry Kissinger at the National Security Council before moving to the Pentagon to establish the Office of Net Assessment, where he served as its director for the next four decades.⁴ Marshall’s primary claim to fame was a series of net assessments provided to the secretary of defense that saw the potential for advanced technologies to offset America’s conventional military inferiority vis-à-vis the Soviet Union, projected the Soviet Union’s collapse under the weight of its military spending, and forecast China’s rise as a great power positioned to challenge the United States on the world’s stage.⁵ Marshall’s string of forecasts demonstrated the utility of rigorous examination of a series of trends as a means of diagnosing current and future competitions.



Andrew Marshall (right), as director of the Office of Net Assessment, was influential in identifying the potential for emergent technologies to offset numerical advantages enjoyed by the Soviet Union. Decades later, Bob Work (left) continued this legacy, conceptualizing future technologies and changes that might facilitate a Third Offset Strategy. (Department of Defense)

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20XX

Shortly after the Cold War ended, the Office of Net Assessment sponsored the seminal 20XX series of war games. This series explored how the joint force of 2025–2030 would be sized and shaped to fight and win a conflict against a peer competitor. The 20XX effort assumed that most of the capabilities that had created America’s clear military-technological advantage would be widely proliferated by 2025. It forecast that any plausible near-peer competitor would fully absorb and field guided munitions in various forms, sensor grids to detect and track enemy capabilities, and various forms of stealth in the air, on the sea, and undersea, helping to obscure movement and enable surprise.⁶

The 1993 paper that spurred the entire 20XX effort, “A Concept for Theater Warfare in 2020,” was written by Michael Vickers. It argued that the wide proliferation of guided munitions and the “battle networks” that enabled their use would likely transform the conduct of war between large state adversaries. Put simply, the essential question facing U.S. military planners over the long haul was how the joint force could fight and win wars under conditions of conventional guided munitions and battle network parity.⁷

20YY

The remainder of the 1990s witnessed the proliferation of guided munitions and battle networks. By the 2000s, this trend was joined by another: an upsurge in the use of uninhabited systems, more commonly known as drones. By the late 2000s, the proliferation of uninhabited systems – and in particular, of the increasingly sophisticated algorithms and programs that enabled early forms of autonomous operation – suggested that the world might be on the precipice of another revolutionary change in warfare.

Robert O. Work was confirmed as the 32nd deputy secretary of defense in April 2014. Prior to this, while serving as CEO of the Center for a New American Security, he and Shawn Brimley co-authored “20YY: Preparing for War in the Robotic Age.” This monograph forecast a massive disruption in military affairs. As they wrote: “The shift to something resembling guided munitions parity is only a predicate challenge to a potentially deeper revolution afoot – a move to an entirely new war-fighting regime in which uninhabited and autonomous systems play central roles for the United States, its allies and partners, and its adversaries.”⁸ These insights – first, Vickers’ recognition that parity in guided munitions and battle networks could erode U.S. military advantage; and second, Work and Brimley’s finding that the emergence

of robotic warfare would be a catalytic, discontinuous shift in the nature and practice of war itself – defined Work’s approach to defense strategic planning from 2014 to 2017. His signature effort, the Third Offset, drew on precisely these insights as it sought to restore America’s military-technological lead.⁹

The Contours of a New Future Force

The rates of technological advancement and proliferation are hastening. The trends that Vickers, Work, and Brimley foresaw are unfolding, only faster and often in different ways than anticipated. The challenge before us is thus less one of recognition – inasmuch as the work of Marshall, Vickers, Work, and others has already moved these disturbing trends to the forefront of the debate on military modernization – than it is about translating this recognition into an appropriately designed defense program. What follows is a modest attempt to peer into the future once more, to catalog the kinds of military capabilities and investments that will be necessary to build a future force that is better prepared to fight and win increasingly plausible conflicts against modern adversaries.

The rates of technological advancement and proliferation are hastening.

The Future of Anti-Access/Area Denial

The past decade has witnessed a growing militarization of interstate politics. Russia has used force or the threat thereof to reassert itself in Eastern Europe and Central Asia. China has done likewise in South and East Asia, bringing it into confrontation with India, Japan, South Korea, and members of the Association of Southeast Asian Nations (ASEAN). For its part, North Korea's relentless pursuit of a survivable nuclear force that can strike the U.S. homeland is nearly complete. Iran is simultaneously using a host of non-nuclear military options – and an implicit threat of re-nuclearization – to expand its influence in the Levant and the Persian Gulf.

The militarization of interstate politics should be expected to persist for the foreseeable future. This trend will be paralleled – and indeed, abetted – by the diffusion of advanced military technologies and new ideas for how to use them. China, Russia, North Korea, Iran, and perhaps others will seek to incorporate these capabilities into asymmetric military strategies designed to exploit U.S. military technological and doctrinal weaknesses. These asymmetric strategies will focus first on deterring or defeating U.S. attempts to use force against adversary homelands. By the same token, the United States will need to penetrate adversary A2/AD networks in future conflicts in order to compel favorable changes in adversary behavior. It will also need to do so quickly, so as to minimize cost and risk of escalation.

This section uses current trends in adversary A2/AD networks to identify a range of problems that the future force will be called on to solve. It is worth noting that the specific problems – and the severity thereof – confronted by the U.S. military will depend on the identity of its opponent. Findings are organized by information dominance; naval, air, and missile defenses; and long-range strike.

Information Dominance

America's adversaries believe that information superiority – or the ability to secure access to and control the flow of mission-critical data – will overwhelmingly dictate the course of future wars.¹⁰ To that end, these states are investing in highly sophisticated command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) suites, which will form the backbone of adversary integrated air defense systems (IADS) as well as sea and undersea defense networks. These suites will rest atop multilayered sensor arrays made up of undersea sensors; sonic buoys; over-the-horizon (OTH) radars; high-altitude, long-endurance (HALE) uninhabited aerial vehicles (UAVs); and expansive ISR satellite constellations for OTH targeting.¹¹ Paramilitary forces will likely augment states' intelligence services by flooding contested waters or skies with ISR buoys, drones, electronic sensors, or other devices.¹² These sensor arrays will be densest closer to adversary



MQ-9 Reaper UAV in action. States continue to invest heavily in UAV technologies in support of C4ISR missions. (U.S. Air Force)

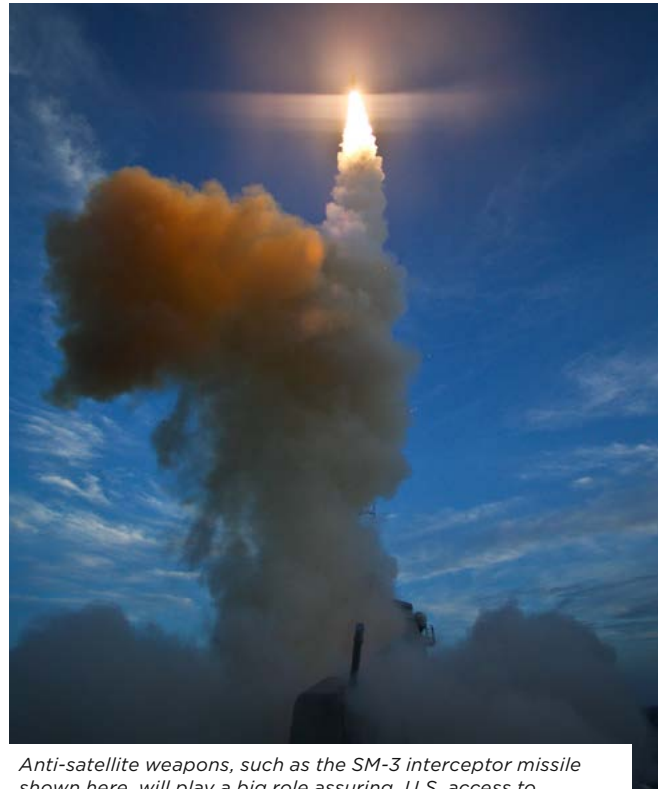
shorelines, as they already are. However, the diffusion of OTH and space-based sensors will likely allow dense sensing patterns to extend farther from shore.

Adversaries will use artificial intelligence (AI) to make sense of the massive amounts of data collected by proliferating sensors.¹³ Data fusion systems will be especially attuned to defeating the U.S. stealth advantage. By synthesizing data on a range of target signatures (e.g., radar, electronic, heat, visual) from multiple angles, adversaries may be able to acquire sufficient targeting data to engage low-observable submarines, ships, aircraft, and ground forces.¹⁴ Quantum radar, which can detect targets with magnetic or gravitational signatures at long range, may be an especially useful tool for adversaries seeking to offset U.S. stealth.¹⁵

If the first step toward information superiority is securing access to mission-critical data, the second is denying one's opponent the same. U.S. adversaries are making rapid progress on this front. In the future, adversary electronic warfare (EW) units will jam or spoof transmission of intelligence data, radar signals, GPS coordinates, and communications, including by satellite communications. They will also use targeted electronic attacks to disrupt radio-controlled or GPS-dependent precision-guided munitions. In addition, maneuver-level forces will be able to identify the sources of adversary emissions and, in conjunction with strike units, destroy enemy C4ISR infrastructure in the sea, air, and land domains. Many of these capabilities already exist.¹⁶ States will expand these capabilities in the next two decades, all the while striving to stay ahead of U.S. EW countermeasures.

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Foreign nations will use cyber operations for similar effects.¹⁷ Cyber weapons may be used to severely disrupt or degrade U.S. C4ISR; positioning, navigation, and timing (PNT); and even strike asset operations. They may also be used to damage dual-use infrastructure – such as water or food supply networks – used by the U.S. military worldwide. States' anti-satellite (ASAT) weapons will have similar global reach. Weapons such as ASAT cyber weapons, missiles, jammers, “dazzling”



Anti-satellite weapons, such as the SM-3 interceptor missile shown here, will play a big role assuring U.S. access to information and operational data. (U.S. Navy)

lasers, and kamikaze and kidnapping satellites will be used to disrupt or deny U.S. access to mission-critical data, ranging from targeting data for the theater of operations to logistical data enabling troop movement in the continental United States.¹⁸

States will also continue to employ more traditional modes of concealment. Adversaries will use underground facilities to evade detection and attacks by U.S. and allied forces.¹⁹ They will also use obscurants (e.g., aerosolized smokescreens), foliage, and urban terrain to evade U.S. and allied forces. These low-cost methods of concealment, along with adversary advances in electronic, cyber, and counterspace warfare, will complicate U.S. efforts to find, fix, and finish adversary targets. So too, crucially, will enemy use of mobile platforms for naval defense, air defense, and long-range strike missions.

Naval Defenses

U.S. adversaries will endeavor to keep U.S. naval forces as far from their shores as possible in future conflicts. They will rely first on anti-ship missiles (ASMs) to do so. These missiles are of increasing long range. Anti-ship ballistic missiles (ASBMs) can already reach targets out to 3,000 to 4,000 km.²⁰ Anti-ship cruise missiles (ASCMs) launched by air, surface, and undersea platforms will

pose a long-range threat to U.S. ships, as well.²¹ ASM range will improve as adversary missile and C4ISR technologies mature. In addition, state competitors are actively seeking new bases for ASMs. Russian ASMs stationed in the eastern Mediterranean or North Africa may threaten U.S. ship passage in the Suez Canal.²² Chinese ASMs on artificial islands in the South China Sea will threaten U.S. vessels past the second island chain.

At the same time, adversaries will invest in new and creative ways to complicate U.S. defensive operations by making it harder to find and fix enemy targets. To that end, most if not all ASM launchers will be road-mobile – many will be off-road-capable, as well. This increases the area in which these systems might be able to seek concealment.²³ Mobility may also make it possible for ASM launchers to exploit breaks in U.S. ISR coverage, for instance, by requiring that multiple ISR assets maintain overlapping coverage. Others will be built for concealment, for instance, within standard-size shipping containers.²⁴ States will also use sheer numbers to complicate U.S. targeting. They will deploy advanced ASCMs on large numbers of networked, dispersed, and cheaply produced UAVs, uninhabited surface vehicles (USVs), and uninhabited undersea vehicles (UUVs), in addition to cheap manned platforms such as corvettes.²⁵

ASMs themselves will also be equipped with counter-countermeasures (CCMs). Hypersonic ASBMs with terminal velocities in excess of Mach 10 will proliferate.²⁶ So too will hypersonic ASCMs, though technical limitations may prevent them from matching ASBM top speeds.²⁷ ASMs will also be designed to fly below the radar horizon and dodge U.S. defensive fires.²⁸ They will likely integrate missile stealth technology, making

it more difficult for U.S. space, air, or surface ISR platforms to collect targeting data in time, especially if ship defenses have only a minute to intercept a missile once it has breached the radar horizon.²⁹

As of 2015, China could produce 1,200 DF-21Ds for the cost of one U.S. aircraft carrier.³⁰ Similar or better ASM-to-target cost-exchange ratios will likely persist for the foreseeable future, as the United States continues to invest in expensive surface platforms. Consequently, adversaries will use sheer masses of cheaply produced weapons to overwhelm U.S. defenses. These weapons will be increasingly autonomous. ASMs will self-coordinate targeting to hit priority targets in sequence and ensure that missiles do not strike targets that have already been hit.³¹ Less-advanced actors will use swarms of ASCM-equipped manned vessels, USVs, and UAVs to overrun ship defenses.³²

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The undersea environment will be increasingly lethal, as well. States will deploy tens or hundreds of thousands of sea mines to slow or deny U.S. sea power projection near vulnerable coastlines.³³ Adversary submarine fleets are also growing.³⁴ In addition to ASCMs, submarines will fire wake-homing and high-speed maneuvering torpedoes. They will also use supercavitating torpedoes with speeds possibly exceeding 200 knots to bypass or outpace U.S. countermeasures.³⁵ More resource-constrained adversaries will exploit other asymmetries. Iran, for instance, will deploy midget submarines in shallow waters of the Persian Gulf, Strait of Hormuz, and Gulf of Oman, where sonar interference enables deadly ambushes.³⁶

Air and Missile Defenses

Competitors' anti-ship defenses will be complemented by integrated air defense systems. The defining feature of adversary IADS will be their use of multilayered sensor arrays, coupled with new data fusion technology, to contest the U.S. stealth advantage and air dominance. As described above, U.S. competitors are firm in their belief that information superiority will dictate the course of future wars and are investing accordingly.



Chinese anti-ship missiles (such as the pictured DF-21) pose major threats to U.S. ships and aircraft carriers in particular, presenting an advantageous cost-exchange. (Sino Defence)

Adversary investment in C4ISR is paralleled, however, by a heavy focus on long-range air defenses. To wit, advanced surface-to-air missile (SAM) systems such as the S-400 are proliferating worldwide. Russia is expanding its industrial base to produce S-400s more rapidly.³⁷ China is also entering the SAM market, increasing the likelihood of proliferation.³⁸ In the future, adversary short-, medium-, and long-range SAM systems will form layered defenses that can intercept aircraft, cruise, missile, and ballistic missile threats at ranges past 600 km.³⁹

The defining feature of adversary IADS will be their use of multilayered sensor arrays, coupled with new data fusion technology, to contest the U.S. stealth advantage and air dominance.

Longer-range SAM models will be deployed in larger numbers. These systems, enabled by the aforementioned C4ISR systems specially designed to offset the U.S. stealth advantage, will make it difficult for U.S. stealth aircraft to operate within their threat radii. While U.S. aircraft are currently able to track narrow paths through enemy IADS networks, those paths should be expected to shrink, or in some places disappear entirely, unless advances in penetrating technologies outpace those in anti-access technologies. New methods of concealment

and the number of SAMs will also make it more difficult for U.S. forces to reopen – and keep open – lanes through enemy IADS.

Adversary air forces will not improve as steadily as their IADS. Nonetheless, enemy aircraft operating deep within friendly IADS bubbles will be able to reach out with longer-range air-to-air missiles to push nonstealthy U.S. aircraft – such as refueling or airborne early warning and control (AEW&C) – even farther from contested shores. Likewise, advanced state adversaries will deploy swarms of UAVs for close air defense against manned and uninhabited U.S. attack aircraft and missiles.⁴⁰ Moreover, as swarm delivery vehicles mature, swarms may also be used to target loitering AEW&C, ISR, and refueling aircraft – or even naval ships – beyond the range of shore-based IADS. State adversaries will also deploy directed-energy (DE) weapons and electromagnetic railguns for air and missile defense on shore-based and surface platforms.⁴¹

Long-Range Strike

Lastly, U.S. defense analysts should not lose sight of the *offensive* aspects of U.S. adversaries' defensive strategies. America's adversaries should be expected to use pre-emptive strikes against intraregional military targets to degrade U.S. naval, air, and space power projection capabilities prior to the outbreak of open hostilities.⁴² Pre-emptive strikes may also be used against extra-regional military targets.⁴³ That is, enemy leaders may determine that forces in the U.S. homeland or en route via the Atlantic or Pacific oceans must be disabled before they enter theater, in order to prevent U.S. commanders from bringing overwhelming firepower to bear. These pre-emptive attacks may be conducted using kinetic means, such as submarine, surface, ground, or air-launched cruise or ballistic missiles. They would also likely incorporate nonkinetic strike options, such as cyber or EW capabilities or nonkinetic ASAT weapons.

Adversaries will also use strikes on political targets to deter or defeat American attack. North Korea will hold Seoul and other South Korean cities hostage for the foreseeable future, by a combination of mobile artillery pieces⁴⁴ and short-, medium-, and intermediate-range ballistic missiles.⁴⁵ These weapons will be capable of delivering chemical and biological munitions in addition to conventional ones.⁴⁶ Ballistic missiles will also likely be capable of delivering nuclear warheads of varying yields and perhaps special effects (e.g., electromagnetic pulse). Other adversaries – particularly Russia – may target dual-use or civilian infrastructure in the U.S. or allied homelands, such as hydroelectric plants, the electric grid,



Designed to offset U.S. advantages in and reliance upon stealth technology, advanced Russian and Chinese air defense systems, such as the pictured Russian S-400 air defense system, present major challenges for U.S. operability. (Russian Kremlin)



U.S. adversaries may seek to act offensively, striking political targets to deter attack. North Korea, for example, may seek to use its artillery to hold Seoul hostage. (Stefan Krasowski)

or public communications infrastructure, to frighten U.S. or allied publics into submission.

Some pre-emptive strike options – particularly surface- or submarine-launched cruise and ballistic missiles – will be launched at U.S. and allied targets from outside of the protective envelope formed by adversary shore-based ASMs and IADS. Most other weapons, however, will be used from within adversary A2/AD bubbles. As with ASMs, SAMs, and other defensive platforms, offensive strike options will be road-mobile and, in many cases, off-road-capable. They will also be produced, dispersed, and concealed in large numbers.

To minimize the threat of pre-emptive strike, U.S. forces will need to penetrate A2/AD networks and quickly find, fix, and finish enemy targets. This will be no easy task. Adversary advances in C4ISR and electronic, cyber, and anti-satellite warfare threaten to place the U.S. military at an information disadvantage in a future fight. Likewise, enemy investments in mobile naval and air defenses will make it harder to bring strike assets to bear on identified targets. To overcome these obstacles, the future force will require a diversified ISR architecture capable of evading or withstanding adversary counter-ISR operations.

U.S. defense analysts should not lose sight of the offensive aspects of U.S. adversaries' defensive strategies.

Finding and Fixing Moving Needles in a Shifting Haystack

As CNAS Director for Technology and National Security Paul Scharre has testified, a contest of hiding and finding will define much of the future of warfare.⁴⁷ The range and lethality of modern weaponry mean that whichever state's forces are consistently able to stay hidden long enough to find and strike enemy targets first will have a significant military-strategic advantage. America's adversaries are developing their forces to fight in precisely this manner – to “look first, shoot first, kill first.” To that effect, as previously discussed, even as U.S. state competitors expand their ISR architectures, they will persistently seek to disrupt, deceive, or oversaturate American ISR.

The challenge for the U.S. Department of Defense, then, is to procure an ISR architecture that can outpace enemy attempts at disruption, deception, and oversaturation. Today's U.S. ISR networks are often inefficient and vulnerable to countermeasures. The future force requires ISR systems and analytic capacities that can more rapidly surveil larger numbers of objects of interest, identify mission-relevant targets, and disseminate data to commanders and operators. Moreover, in addition to finding targets, the future force's ISR architecture must be able to track – or fix – mobile targets in dynamic conditions until terminal guidance is secured.⁴⁸ In other words, if the reconnaissance

The range and lethality of modern weaponry mean that whichever state's forces are consistently able to stay hidden long enough to find and strike enemy targets first will have a significant military-strategic advantage.

asset – or network thereof – that finds a target lacks endurance, sensing bandwidth, and survivability, an enemy asset may escape targeting by exploiting environmental conditions (e.g., adverse weather or lighting) or countermeasures (e.g., mobility, decoys, jamming, or fires) prior to a munition's arrival. Hence, the future force will rely to a significant degree on a persistent web of sensors over a target area.

Finally, the future force's ISR suite must be highly resilient, to offset rapidly improving adversary electronic, cyber, and counterspace weapons. It must also integrate high levels of automation in order to efficiently analyze and transmit data. In sum, the future force will rely on ISR networks made up of more numerous, inexpensive, and easily replaced sensors than are deployed today, linked by secure, reliable communications to artificial intelligence-enabled data fusion assets.

Sensors

U.S. ISR sensors are currently limited by four compounding factors. The first is inadequate mission duration. Low Earth orbit (LEO) satellites can spend a few hours over a target area. Certain UAVs can spend several days above a target however, according to open sources these systems are not designed for contested environments. As such, available sensor platforms are unable to spend sufficient time on station to flush out hidden targets or track mobile ones on its own. Mission duration is further constrained by human physical requirements, which limit flight times or hinder mission continuity through shift work. Satellites in geosynchronous orbit (GEO) can provide continuous coverage of designated target areas. However, the U.S. GEO satellite fleet does not have enough assets to fully offset LEO satellites and airborne ISR limitations. Many missions can also be done more economically by satellites located in LEO. Moreover, all the platforms named here are vulnerable to adversary air and space defenses. This is especially problematic for ISR satellites, since the United States does not possess many of them to begin with.

The future force requires a more robust and resilient space-based ISR infrastructure. Advantages in affordability and resiliency⁴⁹ suggest that small satellites should make up the core of the future LEO ISR

satellite network. These satellites range in size from .25 to 400 pounds⁵⁰ and cost as little as \$150,000 as compared to larger ones, which cost an average of \$200 million per unit.⁵¹ Consequently, small satellites can be produced and launched in larger numbers. While \$200 million satellites can perform a wide range of tasks – for instance, surveilling multiple signature-types simultaneously – individual small satellites will perform a more limited task set.

Small satellites' lower per-unit cost may make it possible, however, to produce ISR constellations made up of thousands of small satellites. Within each constellation, sets of small satellites would be assigned to perform each of the tasks previously done by single, expensive satellites. The sheer number of satellites would also allow each constellation to observe a far larger target set than previously feasible. In addition, the redundancy built into ISR constellations would complicate adversary



More durable space-based ISR will be key to the future force, ensuring that the United States is capable of retaining its sensor advantage. (U.S. Air Force)

ASAT targeting, as the number of satellites adversaries would be forced to engage to cripple U.S. ISR would be orders of magnitude greater than it is today.

Adaptive constellations would need to be built with open architectures so the U.S. future force could quickly replace obsolete or damaged satellites with new, interoperable ones. Rapid reconstitution of ISR constellations will also require low-cost, short-notice launch capabilities, such as those being tested by the Defense Advanced Research Projects Agency's (DARPA) Airborne Launch Assist Space Access (ALASA) program.⁵² In addition, U.S. policymakers should invest in hardening and other defensive measures for small-satellite constellations' ground stations. Because satellites in LEO operate relatively close to the Earth's surface, a larger number of ground stations will be required to maintain line-of-sight communication with these assets. Adversaries may attack these stations to prevent satellites' operators from using data collected by those assets during phases of orbit when the satellites pass over inoperable ground stations.

Finally – and importantly – it is not assured that these larger constellations of small satellites will cost less than smaller numbers of larger, more exquisite satellites. While the per-unit cost of small satellites is far less than their larger counterparts, the additional costs of new terrestrial communications stations, intraconstellation data-sharing capabilities, and related enablers will add to the total constellation costs. That said, the operational benefits afforded by a shift toward more resilient small-satellite constellations may make even a modest increase in the cost of the U.S. military space architecture worth the added expense.

While small satellites should make up the core of America's LEO ISR architecture, the future force will likely require a complement of larger, more exquisite ISR satellites in GEO. These satellites will continue to be built on modular platforms that house more sophisticated and varied antenna, sensor, and power source configurations and can therefore carry out larger task sets than small satellites. By virtue of their cost, these large satellites in GEO will be unable to find protection in numbers like their smaller counterparts in LEO. However, unlike small satellites, larger assets could be protected using a combination of hardening and active defense.⁵³

Furthermore, whereas LEO is within 2,000 km of the Earth's equator, GEO is 36,000 km above it. The distance factor offers some protection, inasmuch as adversaries will require more advanced – and costly – missiles and directed-energy and electronic weapons to strike satellites at that range.⁵⁴ The terrestrial support infrastructure for GEO satellites will also be less vulnerable to adversary attack. That is, since satellites in GEO can see a third of the Earth at any time, satellite ground stations can be dispersed over a larger area, thereby complicating adversary targeting. As small-satellite technology matures, the U.S. government should re-evaluate the benefit and application of larger satellites in GEO. At this time, however, it appears that GEO satellites will have a place in the U.S. military space architecture for the foreseeable future.

Beyond satellites, the United States should also invest in new generations of airborne ISR platforms as a hedge against unanticipated vulnerabilities in its ISR architecture. These platforms may be able to fill gaps in space-based coverage, tactical conditions permitting.



In securing the space domain, numerous small satellites will play an important role in developing both resilient ISR capability and redundancy in U.S. satellite systems. (Department of Defense)



A Global Hawk UAV, a high-altitude Air Force ISR platform, conducts an observation mission. (U.S. Air Force)

Large enough quantities of airborne ISR assets may also help to ensure hot turnovers of a surveillance area from one platform to another with no break in service, so as to avoid the loss of targeting data for a mobile enemy platform. As far as specific aerial platforms, hypersonic UAVs may be able to provide crucial multisignature counter-IADS targeting data for missile trucks or other aerial strike platforms operating at standoff distances.⁵⁵ Large swarms of HALE UAVs that can stay aloft for weeks, for instance, by riding thermal currents may do similarly by evading or absorbing defensive fires.⁵⁶

Beyond satellites, the United States should also invest in new generations of airborne ISR platforms as a hedge against unanticipated vulnerabilities in its ISR architecture.

These UAVs should be built for all-aspect, multi-spectral stealth. They should also be equipped with countermeasures for adversary quantum radar and directed-energy weapons.⁵⁷ Furthermore, as with satellites, investments in airborne ISR platforms should prioritize open architectures, interoperability, and low cost so assets can be updated or replaced quickly due to obsolescence or combat attrition. Lastly, all space-based and airborne ISR constellations should feature a mix

of sensors, both passive and active, that span the active spectrum and can defeat environmental impediments (e.g., adverse weather or lighting) and target countermeasures (e.g., enemy use of underground facilities, foliage cover, or obscurants).

Data Analysis

A large share of intelligence analysis is now done by humans, whose ability to make sense of large data sets is limited by several factors.⁵⁸ First, proliferating sensors are already collecting more data than available intelligence personnel can realistically analyze due to insufficient time, cognitive limitations, and physical requirements, such as sleep.⁵⁹ Shortened decision cycles that require constant feeds of actionable intelligence exacerbate the problem.⁶⁰ Performance-enhancing drugs,⁶¹ synthetic biology,⁶² brain-computer interfaces,⁶³ and the like may offset some of these constraints. However, as proliferating sensors produce orders-of-magnitude greater amounts of data, human analysts will be forced to rely more heavily on machine-run data fusion. They will also need to share data more efficiently among intelligence agencies. Too frequently, intelligence agencies do not transmit data to other agencies in an actionable time frame due to incompatible technical infrastructure, inadequate protocols for information-sharing, or jurisdictional complaints.⁶⁴

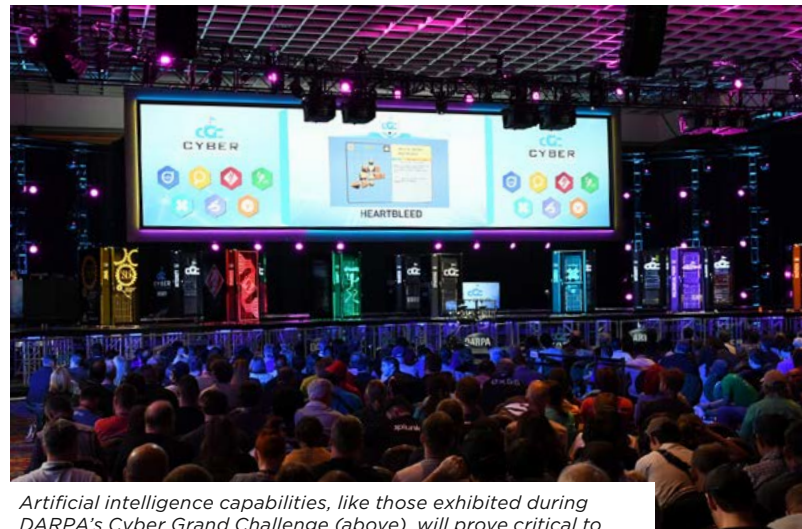
Artificial intelligence will form the backbone of the future force's ISR architecture. Humans will turn to machine learning algorithms to synthesize and, in

many cases, find actionable patterns in vast quantities of unstructured intelligence – that is, data that is not organized according to any known rule set – in image, text, signal, electronic, or other forms.⁶⁵ These machine tools, through their ability to rapidly process data, enable shorter decision cycles, and accelerate the operational tempo,⁶⁶ offer new ways to improve the speed and accuracy of target identification, tactical and strategic behavioral forecasting, and counterdeception (e.g., counterconcealment and counterdecoy) measures in dynamic information environments.

As proliferating sensors produce orders-of-magnitude greater amounts of data, human analysts will be forced to rely more heavily on machine-run data fusion.

Advances in artificial intelligence are paralleled by progress on quantum computing. Quantum computers promise to allow AI, human, and man-machine teams to process even larger quantities of information far more rapidly, by virtue of their ability to perform nearly infinite calculations simultaneously rather than sequentially, as standard computers and supercomputers do.⁶⁷ For these systems to be effective, however, they must be part of a shared network architecture that links all relevant stakeholders using a common technical infrastructure. Critically, machine learning algorithms use big data to hone pattern recognition.⁶⁸ A shared architecture would give AI tools access to the largest possible data sets, thereby accelerating pattern recognition improvement and consequent intelligence outcomes.

The Department of Defense has already begun work to harness artificial intelligence for intelligence purposes, as in the case of its Algorithmic Warfare Cross-Functional Team (AWCFT).⁶⁹ So has the U.S. intelligence community.⁷⁰ The U.S. government is also investing in quantum computing.⁷¹ U.S. policymakers should make these investments a priority. They should also continue to support public-private partnerships, such as through Defense Innovation Unit Experimental (DIUx) and In-Q-Tel, in order to support and harness commercial advances in these areas. Finally, many of the United States' closest allies are leading innovators in artificial intelligence and other high technologies.⁷² These alliance relationships may be crucial sources of advantage, particularly as neither China, Russia, Iran, nor North Korea has access to as large or diverse an array of innovators.



Artificial intelligence capabilities, like those exhibited during DARPA's Cyber Grand Challenge (above), will prove critical to strategists making sense of complex information and intelligence. (Department of Defense)

Shortening the Interval Between Target Acquisition and Kill

Ance the future force has found and fixed a target, it will need to bring force to bear as soon as possible. Adversary access to a diverse array of defensive countermeasures means that sustained target acquisition cannot be assured. To ensure a kill, forces will need to deliver one or more munitions on-target quickly, before an adversary is able to escape tracking by way of mobility, retreat to buried facilities or forested areas, or activation of jamming or other active countermeasures. This effect may be achieved by moving shooters as close to the target area as possible, thereby decreasing the interval between detection and attack to the bare minimum. Alternatively, it may be achieved by a suite of prompt strike weapons that can be fired from outside – or within, if feasible – an enemy’s A2/AD bubble, cover the intervening distance before the target can react effectively, and penetrate enemy area, point, and target defenses.

Moving the Shooter Closer

The most obvious way to move shooters close to the target area would be to integrate the sensor and shooter together on one platform. For instance, future long-duration uninhabited ISR aircraft equipped with multispectrum active and passive sensors could also be equipped with small-diameter bombs, electromagnetic weapons, or DE weapons. Provided a robust power supply, such a sensor-shooter platform would be able to provide coverage strike options at high altitude, over a long-endurance mission profile, with an exceedingly deep magazine. Alternatively, the future force may equip deep-magazine, all-aspect, multispectral stealth bombers such as the B-21 with a strong suite of active and passive sensors. This could enable a bomber to refuel at a tanker outside of an A2/AD environment, fly into the contested area, search for and detect multiple targets, destroy them, and egress the area within a single mission profile.

In a fully equipped A2/AD environment, all sensor-shooter or shooter platforms would need to be built for all-aspect, multispectral stealth, again, with a special eye toward adversary advances in quantum radar. Stealth has the potential to direct adversary focus along certain attack corridors, raise enemy ordnance expenditures against shadow sensor returns, and sow confusion, more generally. Passive stealth alone, however, will be necessary but insufficient in such an environment. The future force will need to be equipped with active stealth measures, as well, including a combination of magnetic, gravitational, electronic, cyber, visual, acoustic, heat, and other countermeasures. This suite of active countermeasures has the potential to “thicken” the fog of uncertainty that hangs about the enemy, thereby further increasing his costs, lowering his confidence, locking him in place, and providing additional opportunities for targeting and kills.

Prompt Strike Weapons for the Future Force

The future force requires a set of weapons that can strike fixed targets rapidly, before they can slip U.S. ISR assets. These weapons must be built to penetrate adversary defenses – both above and below ground – through a combination of speed, stealth, and smart technology. They must also offer increased magazine depth so U.S. warfighters can out-saturate or outlast enemy defenses. Lastly – and relatedly – they must be of sufficiently low cost that they can be quickly procured and replaced in large quantities. Kinetic options to these effects include smart bombs and land-attack missiles, deployed in heavy bombers, missile trucks, or reloadable vertical launch system (VLS) tubes. They also include robotic swarms and hypersonic weapons, such as hypervelocity projectiles (HVPs) fired by powder guns or electromagnetic railguns, scramjet-powered cruise missiles, boost-glide vehicles, or satellite-launched HVPs. Nonkinetic options include directed-energy weapons, particularly high-power microwave (HPM) and high-energy laser (HEL) technologies.

Smart Bombs and Missiles

The future force will need to deploy multiple kinds of smart munitions for different operational contexts. Small-diameter bombs (SDBs), for instance, will allow U.S. aircraft to hold soft targets – including key enemy personnel in unhardened structures or vehicles – at greater risk than before. These weapons will be manually retargeted in-flight using a combination of radar, infrared, GPS, and laser guidance, in virtually any weather conditions.⁷³ They will also be



The B-21 Raider offers a critical “shooter” capability, bringing long-range, stealth, and deep-magazine capabilities to the fight. (U.S. Air Force)



Former Deputy Secretary of Defense Bob Work examines an HVP, an emerging technological capability that promises to bring added lethality to the joint force. (Naval Sea Systems Command)

capable of autonomous target recognition. This would allow SDBs to target specific platforms in an array based on criteria designated or authorized by humans.⁷⁴ In doing so, it would create redundancy, so that even if theater-level ISR is compromised for a particular strike mission, the bomb can still reach the target. It would also make it possible for these munitions to strike the highest-value targets first. Lastly, since bombers can carry up to four times as many 250-pound SDBs as 1,000- or 2,000-pound bombs,⁷⁵ they will be able to hold larger numbers of soft targets at risk on each mission profile.

SDBs will likely continue to be cheaper than supersonic land-attack cruise or ballistic missiles. However, the latter options will play a role in the future force's operations for the foreseeable future. Cruise and ballistic missiles can be fired from beyond the range of adversary IADS and sea defenses early in a conflict. A combination of stealth features, supersonic speed, maneuvering, and standoff "noise" generation will help these assets to reach their targets. Like SDBs – if so approved by the relevant authorities – smart cruise and ballistic missiles could be outfitted for autonomous target recognition, allowing them to update target location in-flight and coordinate targeting in communications-degraded or denied environments. These missiles, whether designed for autonomous targeting or not, may be launched from the air, the sea, or undersea. They might also be launched from reloadable VLS tubes, which could give the future force a decisive mass advantage versus specific target areas in a future conflict.⁷⁶

Robotic Swarms

The future force may also use stealth aircraft to deliver robotic swarms to the target area. UAVs in robotic swarms should be designed for strike operations, with stealth, maneuverability, and munitions capacity prioritized over endurance.⁷⁷ Each UAV in a swarm would carry only a fraction of the munitions held by a single stealth bomber. However, by spreading munitions across a larger number of strike assets, the future force may be able to hedge against future reductions in the U.S. stealth advantage. It would also be able to disperse shooters – members of a swarm can be in many places at once; a single bomber can only be in one place at a time. Robotic swarms would also unlock operational concepts previously inaccessible to manned aerial formations, such as saturation attacks on particularly hard targets. UAV swarms should be networked with other airborne and space-based ISR and communications assets, to ensure efficient targeting. To capitalize fully on the potential of robotic swarms, as in the case of smart bombs and missiles, the future force will need to grapple with the question of lethal autonomy. That is, U.S. officials will need to decide whether uninhabited strike assets should be authorized to engage targets in situations where remote human controllers cannot provide timely authorization due to the speed of engagement or communications interference.



Robotic swarms, a rapidly developing set of technological capabilities, will force important and difficult debate over the proper role of autonomous weapons in conflict. (U.S. Army Research, Development, and Engineering Command)

Hypersonic Weapons

The future force will likely require hypersonic weapons to defeat A2/AD networks. Hypersonic weapons come in multiple variants, some of which are designed to fire inert rounds – or HVP – at speeds higher than Mach 5. HVPs may take the form of tungsten or other dense-metal rods. HVPs are small and inexpensive, as compared with missiles, allowing for deeper magazines and a more favorable cost-exchange ratio for U.S. forces. In the near term, HVPs will be fired from powder guns on naval ships.⁷⁸ They could also be fired by electromagnetic railguns (EMRGs), which use electromagnetic fields to hurl the inert rounds. HVPs fired by powder guns and EMRGs in the near term may dramatically enhance U.S. ships' air and missile defense capabilities. However, HVP launchers' limited range will restrict offensive applications. For instance, railguns are only expected to have a range of just over 100 nm in the near term.⁷⁹ In the medium term, however, as HVP launchers' range improves, these systems may prove to be cost-efficient standoff weapons, especially once an adversary's long-range anti-ship and surface-to-air missile systems are disabled. They could be especially useful if coupled with the introduction of sufficiently low-cost guided or retargetable HVPs.⁸⁰

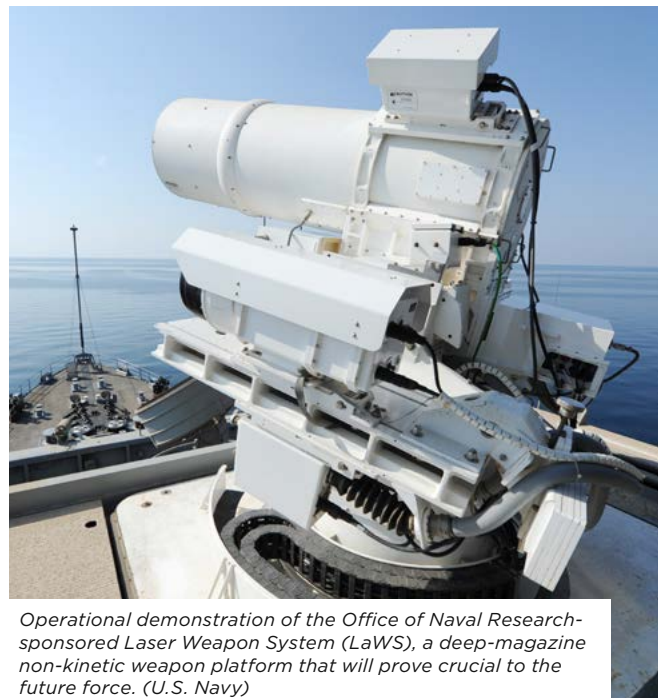
Hypersonic weapons will also play a role in the skies. A conventional variant of the air-launched Long-Range Standoff Missile (LRSO) could offer U.S. commanders one long-range, non-nuclear hypersonic strike option.⁸¹ As air-launched scramjet-powered cruise missiles such as the Hypersonic Air-Breathing Weapon Concept (HAWC) advance in range, endurance, stealth, payload, and maneuverability, they may offer even higher-speed alternatives to a conventional LRSO.⁸² Hypersonic boost-glide vehicles (HBGVs) – engineless vehicles released at high altitude before gliding downward to strike targets at potential speeds as high as Mach 20 – offer another alternative.⁸³ So too might satellite-launched HVPs, akin to the “rods from God” envisioned by science fiction writer Jerry Pournelle, which may have the added benefit of being relatively low-cost, as the cost of space launch continues to decline.⁸⁴ Hypersonic cruise missiles, HBGVs, and satellite-launched HVPs may also offer options for earth-penetration strikes.⁸⁵ This is a crucial capability gap given that many U.S. adversaries are building underground sanctuaries for vulnerable leaders and weapons platforms, as well as for command, control, and communications systems.

Lastly, it should be noted that one of the greatest benefits of hypersonic weapons is that they offer a way to keep the human in the loop, since they could allow

human operators to launch strikes from long distances against targets located within communications-degraded or -denied environments quickly enough to stay relevant. Without such a prompt strike ability, human operators may be forced to rely more heavily on UAVs, such as robotic swarms detailed above, which in turn may need to be lethally autonomous to conduct strike missions in time.

Directed-Energy Weapons

The future force will demand a robust set of nonkinetic strike options, both to complicate the adversary's defensive dilemma and for escalation management. Directed-energy weapons, inherently deep-magazine technologies, should form the core of the nonkinetic strike arsenal. These technologies have a long history of slow and unsteady progress. However, as Dr. Jason Ellis found in 2015, different types of DE weapons are on the cusp of operational utility.⁸⁶ High-power microwave technologies, for instance, may allow the future force to disable critical electronic nodes in an adversary's sea and air defense C4ISR infrastructure. In addition, high-energy lasers could be used as defensive strike weapons against soft targets such as UAVs. As HEL size and power requirements evolve, the technology may prove a crucial defensive asset for tactical and strategic aircraft operating within the enemy's threat envelope. It is not clear at this point whether or when HELs will allow the future force to engage more difficult targets, such as ballistic or supersonic cruise missiles.



Operational demonstration of the Office of Naval Research-sponsored Laser Weapon System (LaWS), a deep-magazine non-kinetic weapon platform that will prove crucial to the future force. (U.S. Navy)

Looking Ahead

The United States has made strides in the development of many of these technologies. But much work remains to be done to ensure that the future force has the mix of capabilities needed to quickly find, fix, and finish targets located within adversary A2/AD bubbles. Whether the United States will succeed in this effort – or indeed, whether it will succeed in time – hinges not on how American leaders prioritize technological investments, but how they think through the doctrinal implications thereof.

Defense Innovation

The Department of Defense has already taken steps toward developing and deploying many of these technologies. Its budget for research and development has increased dramatically since fiscal 2015.⁸⁷ These efforts focus on a range of leap-ahead technologies, including autonomous systems, artificial intelligence, and big data analytics. The Pentagon has also devoted substantial resources to fielding hypersonics, electromagnetic railguns, and directed-energy weapons, as well as novel undersea, space, cyber, and electronic warfare systems, and the advanced materials required to build them.⁸⁸

These technological investments are paralleled – and indeed, often enabled – by new initiatives and adaptations to the Defense Department’s organizational structure.⁸⁹ The Long-Range Research and Development Planning Program and the Advanced Capability and Deterrence Panel, for instance, are both tasked with identifying technological innovations that could give the United States a decisive military advantage decades in the future. The Strategic Capabilities Office, established by then-Deputy Secretary of Defense Ash Carter in 2012,

is another hub of innovation within the department. Its work has yielded progress on advanced navigation, HVPs, and robotic swarms, to name but a few achievements. Nor are DoD organizational innovations limited to the Pentagon. The department has prioritized engaging commercial actors to cooperate in developing and fielding advanced technologies, for instance, through the work of DIUx and In-Q-Tel.⁹⁰

The department’s commitment to regaining technological superiority is a critical first step toward fielding the future force that America needs. But the path forward remains difficult. The accelerated rate of technological progress, coupled with the increased role of commercial actors and the rise of foreign technology hubs, will complicate U.S. efforts to stay ahead of the curve. The constrained budget environment and DoD acquisitions timelines will compound the difficulty, as will the fact that many of the leading commercial innovators in the United States and Europe, especially, have frequently been unwilling to cooperate with the Defense Department.⁹¹ This is a challenge that other adversaries may not share.

The department’s commitment to regaining technological superiority is a critical first step toward fielding the future force that America needs.

Even so, the United States has several advantages as it plunges into this era of intensified technological competition. Perhaps most importantly, the United States is home to many of the world’s most innovative companies and minds. The American free market system, though in need of reform in many regards, has allowed it to surpass adversary innovations in the past and will be a crucial source of strength in the future. So too will America’s robust alliance networks. Many of the United States’ closest allies are leading innovators in the fields discussed in these pages. By strengthening cooperation with these actors, and in particular, by identifying ways to build or strengthen public-private partnerships within and between these nations, the United States can access a far larger network of ideas and resources than its competitors. This could be another crucial source of advantage in a period of sustained, accelerated technological innovation.



Ash Carter speaks with Will Roper, the then-director of the Strategic Capabilities Office. (Department of Defense)

The Future in the Balance

How the United States harnesses these advantages, and overcomes these hurdles, will dictate in no small measure the course of the 21st century. Whether America is still a world leader – by any measure, inasmuch as political-economic strength is rooted in military factors – at the start of the 22nd century is in the balance. So too is the more proximate risk of major war. If America fails to adapt to these changes in a sufficiently rapid, effective, and sustained manner, then its ability to deter major war will falter accordingly. So too, logically, will its ability to emerge victorious should war transpire. At the same time, even if deterrence holds, how America rebuilds its military in the face of these concerning shifts in the military-technological environment will decide the degree to which it is able to favorably shape the peace.

While many aspects of this era in American military history are unique – take, for instance, the emergence of the space, cyber, and electronic domains as primary areas

Any successful force development strategy aimed at deterring or defeating America's adversaries in this contested environment must focus first on shortening the interval from the detection and location of a target to its ultimate destruction. Moreover, especially in view of the need to strengthen U.S. force posture in multiple theaters simultaneously, America's force development strategy must shrink that interval in as cost-efficient a manner as possible. This will require pre-empting adversaries' discovery of asymmetric vulnerabilities in the U.S. force structure, for instance, by updating the U.S. military's communications, command, and control (C3) infrastructure, investing in a more resilient space architecture, and directing investment toward more survivable arrays of lower-cost sensor-and-strike platforms.

American strategists must also identify the doctrinal innovations that will make best use of new technologies, or best mitigate the vulnerabilities of older systems, inasmuch as it is not the technology that wins a war,

The pace of technological improvement, coupled with intensifying challenges to U.S. national security interests worldwide, demands that the United States dare to imagine ways of fighting that may defy conventional wisdom but that harness America's unique advantages.

of competition – the dilemmas facing U.S. strategists today are not without precedent. Arleigh Burke, Andrew Marshall, and Michael Vickers each faced variations of the same dilemmas in their time. Confronted with profound technological uncertainties, cast against a shifting and tenuous geopolitical backdrop, they were charged with imagining a way to protect or reassert America's global military pre-eminence. In each case, they succeeded by looking past the emergencies of the day and grappling directly with the trends they knew to be reshaping the character of warfare beneath the surface. Robert O. Work did similarly in his 2014 monograph, which correctly forecast the primary role of autonomous systems and artificial intelligence in the future of warfare. The pace of technological improvement, coupled with intensifying challenges to U.S. national security interests worldwide, demands that the United States dare to imagine ways of fighting that may defy conventional wisdom but that harness America's unique advantages.

but how that technology is employed. To wit, aircraft, radios, and tanks all existed in World War I, but it was not until Germany's Heinz Guderian combined them at the operational level that blitzkrieg emerged as the ultimate expression of maneuver warfare.⁹² Perhaps the most consequential doctrinal question U.S. officials will need to answer is: To what extent should the human remain in the decision loop in the future force? Offering specific doctrinal recommendations, including on this point, is beyond the scope of this report. But U.S. policymakers must not fall into the trap of developing world-class systems, only to discover that those systems lack an effective mode of employment.

The United States of America has earned its military edge these past many decades. Now that edge is under increased threat. Fortunately, the nation has the political, industrial, and military wherewithal required to reassert its military pre-eminence and, in so doing, ensure the safety and prosperity of its allies and partners around the world for decades to come.

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