U.S. Military Power

An Assessment of U.S. Military Power

D ecause America is a global power with global interests, its military is tasked first and foremost with defending the country from attack. Beyond that, it must be capable of protecting Americans abroad, America's allies, and the freedom to use international sea, air, space, and cyberspace while retaining the ability to engage in more than one major contingency at a time. America must be able not only to defend itself and its interests, but also to deter enemies and opportunists from taking action that would challenge U.S. interests-a capability that includes both preventing the destabilization of a region and guarding against threats to the peace and security of America's friends.

As noted in all preceding editions of the *Index*, however, the U.S. does not have the necessary force to meet a two-major regional contingency (two-MRC) requirement and is not ready to carry out its duties effectively. Consequently, as we have seen during the past few years, the U.S. finds itself increasingly challenged by major competitors such as China and Russia and the destabilizing effects of terrorist and insurgent elements operating in regions that are of substantial interest to the U.S.

During 2020, SARS-CoV-2, the virus that causes the COVID-19 disease, affected the military services in ways that were similar to how it affected the population generally.

• Training was curtailed in order to minimize the transmission of the virus within the force by keeping servicemembers as separated as possible;

- Exercises with allies and other security partners were canceled or reduced in scope; and
- Military resources, especially in the medical community, were redirected to support civilian efforts to deal with the spreading pandemic through the construction and staffing of field hospitals and the distribution and administering of vaccines.

This situation took a toll on some aspects of conventional readiness across the force, but it also provided an opportunity-albeit unwanted-for the military to practice existing protocols for dealing with infectious disease and develop new methods for training and education, conducting exercises under restricted conditions, and maintaining operational efforts abroad in spite of the pandemic. Similar pandemic-related problems confronted all elements of the defense industrial base and the full range of supply, maintenance, and transportation activities across the military and civilian, government, and private sectors that are essential to maintaining a viable military enterprise.

Viewed through the lenses of readiness, the potential requirement to surge operations in war, or the need to adjust practices to counter an enemy attack, responding to the COVID-19 challenge served as an important learning opportunity. Whether the military services, the Department of Defense (DOD), the Administration and Congress, and civilian firms supporting defense programs internalize such lessons remains to be seen. For 2021, it is reasonable to assume that the U.S. military gained as much as, if not more than, it lost with regard to wartime readiness.

How to Think About Sizing Military Power

Military power consists of many things and is the result of how all of its constituent pieces are brought together to create an effective warfighting force, but it begins with the people and equipment used to conduct war: the weapons, tanks, ships, airplanes, and supporting tools such as communications systems that make it possible for one group either to impose its will on another or to prevent such an outcome from happening, which is the point of deterrence.

However, simply counting the number of people, tanks, or combat aircraft that the U.S. possesses would be insufficient because it would lack context. For example, the U.S. Army might have 100 tanks, but to accomplish a specific military task, 1,000 or more might be needed or none at all. It might be that the terrain on which a battle is fought is especially ill-suited to tanks or that the tanks one has are inferior to the enemy's. The enemy could be quite adept at using tanks, or his tank operations might be integrated into a larger employment concept that leverages the supporting fires of infantry and airpower, whereas one's own tanks are poorly maintained, the crews are not well prepared, or one's doctrine is irrelevant.

Success in war is partly a function of matching the tools of warfare to a specific task and employing those tools effectively in battle. Get these wrong—tools, objective, competence, or context—and you lose.

Another key element is the military's capacity to conduct operations: how many of the right tools—people, tanks, planes, or ships—it has. One might have the right tools and know how to use them effectively but not have enough to win. Because one cannot know with certainty beforehand just when, where, against whom, and for what reason a battle might be fought, determining how much capability is needed is an exercise that requires informed but not certain judgment.

Further, two different combatants can use the same set of tools in radically different ways to quite different effects. The concept of employment matters. Concepts are developed to account for numbers, capabilities, material readiness. and all sorts of other factors that enable or constrain one's actions, such as whether one fights alone or alongside allies, on familiar or strange terrain, or with a large, well-equipped force or a small, poorly equipped force. A thinking adversary will analyze his opponent for weaknesses or patterns of behavior and seek to develop techniques, approaches, and tools that exploit such shortfalls or predictable patterns-the asymmetries of war. One need not try to match an enemy tank for tank: In many cases, not trying is more effective.

All of these factors and a multitude of others affect the outcome of any military contest. Military planners attempt to account for them when devising requirements, developing training and exercise plans, formulating war plans, and advising the President in his role as Commander in Chief of U.S. military forces.

Measuring hard combat power in terms of its capability, capacity, and readiness to defend U.S. vital interests is difficult, especially in such a limited space as this *Index*, but it is not impossible. However difficult determining the adequacy of one's military forces may be, the Secretary of Defense and the military services have to make such decisions every year when the annual defense budget request is submitted to Congress.

The adequacy of hard power is affected most directly by the resources the nation is willing to apply. Although that decision is informed to a significant degree by an appreciation of threats to U.S. interests and the ability of a given defense portfolio to protect U.S. interests against such threats, it is not informed solely by such considerations; hence the importance of clarity and honesty in determining exactly what is needed in terms of hard power and the status of such power from year to year.

Administrations take various approaches in determining the type and amount of military power needed and, by extension, the amount of money and other resources that will be necessary to support that power. After defining the national interests to be protected, the DOD can use worst-case scenarios to determine the maximum challenges the U.S. military might have to overcome. Another way is to redefine what constitutes a threat. By taking a different view of whether major actors pose a meaningful threat and of the extent to which friends and allies have the ability to assist the U.S. in meeting security objectives, one can arrive at different conclusions about the necessary level of military strength.

For example, one Administration might view China as a rising belligerent power bent on dominating the Asia–Pacific region. Another Administration might view China as an inherently peaceful rising economic power and the expansion of its military capabilities as a natural occurrence commensurate with its strengthening status. There can be dramatically different perspectives with respect to how China might use its military power and what would constitute an effective U.S. response. The difference between these views can have a dramatic impact on how one thinks about U.S. defense requirements. So, too, can policymakers amplify or downplay risk to justify defense budget decisions.

There also can be strongly differing views on requirements for operational capacity.

- Does the country need enough for two major combat operations (MCOs) at roughly the same time or just enough for a single major operation and some number of lesser cases?
- To what extent should "presence" tasks the use of forces for routine engagement with partner countries or simply to be on hand in a region for crisis response—be in addition to or a subset of a military force sized to handle two major regional conflicts?
- How much value should be assigned to advanced technologies as they are incorporated into the force?

• What is the likelihood of conventional war and, if one thinks it unlikely, what level of risk is one willing to accept that sufficient warning will allow for rearming?

Where to Start

There are two major references that one can use to help sort through the variables and arrive at a starting point for assessing the adequacy of today's military posture: government studies and historical experience. The government occasionally conducts formal reviews that are meant to inform decisions on capabilities and capacities across the Joint Force relative to the threat environment (current and projected) and evolutions in operating conditions, the advancement of technologies, and aspects of U.S. interests that may call for one type of military response over another.

The 1993 Bottom-Up Review (BUR) conducted by then-Secretary of Defense Les Aspin is one example frequently cited by analysts. Secretary Aspin recognized that "the dramatic changes that [had] occurred in the world as a result of the end of the Cold War and the dissolution of the Soviet Union" had "fundamentally altered America's security needs" and were driving an imperative "to reassess all of our defense concepts, plans, and programs from the ground up."¹

The BUR formally established the requirement that U.S. forces should be able "to achieve decisive victory in two nearly simultaneous major regional conflicts and to conduct combat operations characterized by rapid response and a high probability of success, while minimizing the risk of significant American casualties."² Thus was formalized the two-MRC standard.

Since that study, the government has undertaken others as Administrations, national conditions, and world events have changed the context of national security. Quadrennial Defense Reviews (QDRs) were conducted in 1997, 2010, and 2014, accompanied by independent National Defense Panel (NDP) reports that reviewed and commented on them. Both sets of documents purported to serve as key assessments, but analysts came to minimize their value, regarding them as justifications for executive branch policy preferences (the QDR reports) or overly broad generalized commentaries (the NDP reports) that lack substantive discussion about threats to U.S. interests, a credible strategy for dealing with them, and the actual ability of the U.S. military to meet national security requirements.

The QDR was replaced by the National Defense Strategy (NDS), released in 2018, and the independent perspectives of the formal DOD review by the National Defense Strategy Commission, which released its view of the NDS in November 2018. Departing from their predecessors, neither document proposed specific force structures or end strength goals for the services,³ but both were very clear in arguing the need to be able to address more than one major security challenge at a time. The commission's report went so far as to criticize the NDS for not making a stronger case for a larger military that would be capable of meeting the challenges posed by four named competitors-China, Russia, Iran, and North Korea-while also possessing the capacity to address lesser, though still important, military tasks that included presence, crisis response, and assistance missions.

Though the Biden Administration has not yet produced a national defense strategy to replace the one issued by the Trump Administration in 2018, its Interim National Security Strategic Guidance (INNSG) echoes the general goal for the U.S. military to "deter and prevent adversaries from directly threatening the United States and our allies, inhibiting access to the global commons, or dominating key regions,"4 themes that have remained remarkably consistent from one Administration to the next for several decades. Taken at face value and considering the challenges posed simultaneously by a multitude of competitors in several regions, the INSSG seems to imply that the military should have the capability and capacity to meet this objective.

Correlation of Forces as a Factor in Force Sizing

During the Cold War, the U.S. used the Soviet threat as its primary reference in determining its hard-power needs. At that time, the correlation of forces—a comparison of one force against another to determine strengths and weaknesses—was highly symmetrical. U.S. planners compared tanks, aircraft, and ships against their direct counterparts in the opposing force. These comparative assessments drove the sizing, characteristics, and capabilities of fleets, armies, and air forces.

The evolution of guided, precision munitions and the rapid technological advancements in surveillance and targeting systems since the late 1980s have made comparing combat power more difficult. What was largely a platform-versus-platform model has shifted somewhat to a munitions-versus-target model.

The proliferation of precise weaponry means increasingly that each round, bomb, rocket, missile, and even (in some instances) individual bullet can hit its intended target, thus decreasing the number of munitions needed to prosecute an operation. It also means that the lethality of an operating environment increases significantly for the people and platforms involved. We have reached the point at which, instead of focusing primarily on how many ships or airplanes the enemy can bring to bear against one's own force, one must consider how many "smart munitions" the enemy has when thinking about how many platforms and people are needed to win a combat engagement.⁵ The increasing presence of unmanned systems that can deliver precision-guided munitions against targets adds complexity and danger to the modern battlefield.

In one sense, increased precision and the technological advances now being incorporated into U.S. weapons, platforms, and operating concepts make it possible to do far more than ever before with fewer assets.

• Platform signature reduction (stealth) makes it harder for the enemy to find and target them, and the increased precision of weapons makes it possible for fewer platforms to hit many more targets.

- The ability of the U.S. military to harness computers, modern telecommunications, space-based platforms—such as for surveillance, communications, and positioning-navigation-timing (PNT) support from GPS satellites—and networked operations potentially means that in certain situations, smaller forces can have far greater effect in battle than at any other time in history (although these same advances also enable enemy forces).
- Some military functions—such as seizing, holding, and occupying territory—may require a certain number of soldiers no matter how state-of-the-art their equipment may be. For example, the number of infantry squads needed to secure an urban area where line of sight is constrained and precision weapons have limited utility is the same as the number needed in World War II.

Regardless of the improved capability of smaller forces, there is a downside to fewer numbers. With smaller forces, each element of the force represents a greater percentage of its combat power. Each casualty or equipment loss therefore takes a larger toll on the ability of the force to sustain high-tempo, highintensity combat operations over time, especially if the force is dispersed across a wide theater or multiple theaters of operation.

As advanced technology has become more affordable, it has become more accessible for nearly any actor, whether state or non-state.⁶ Consequently, it may well be that the outcomes of future wars will depend far more on the skill of the forces and their capacity to sustain operations over time than they will on some great disparity in technology. If so, readiness and capacity will become more important than absolute advances in capability.

All of this illustrates the difficulties of and need for exercising judgment in assessing the

adequacy of America's military power. Yet without such an assessment, all that remains are the defense strategy reviews, which are subject to filtering and manipulation to suit policy interests; annual budget submissions, which typically favor desired military programs at presumed levels of affordability and are therefore necessarily budget-constrained; and leadership posture statements, which often simply align with executive branch policy priorities.

The U.S. Joint Force and the Art of War

This section of the Index assesses the adequacy of America's defense posture as it pertains to a conventional understanding of hard power, defined as the ability of American military forces to engage and defeat an enemy's forces in battle at a scale commensurate with the vital national interests of the U.S. While some hard truths in military affairs are appropriately addressed by mathematics and science, others are not. Speed, range, probability of detection, and radar cross-section are examples of quantifiable characteristics that can be measured. Specific future instances in which U.S. military power will be needed, the competence of the enemy, the political will to sustain operations in the face of mounting deaths and destruction, and the absolute amount of strength needed to win are matters of judgment and experience, but they nevertheless affect how large and capable a force one might need.

In conducting the assessment, we accounted for both quantitative and qualitative aspects of military forces, informed by an experience-based understanding of military operations and the expertise of external reviewers. The authors of these military sections bring a combined total of more than a hundred years of uniformed military experience to their analysis.

Military effectiveness is as much an art as it is a science. Specific military capabilities represented in weapons, platforms, and military units can be used individually to some effect. Practitioners of war, however, have learned that combining the tools of war in various ways and orchestrating their tactical employment in series or simultaneously can dramatically amplify the effectiveness of the force that is committed to battle.

Employment concepts are exceedingly hard to measure in any quantitative way, but their value as critical contributors in the conduct of war is undeniable. How they are used is very much an art-of-war matter that is learned through experience over time.

What Is Not Being Assessed

In assessing the current status of the military forces, this *Index* uses the primary measures used by the military services themselves when they discuss their ability to employ hard combat power.

- The Army's unit of measure is the brigade combat team (BCT);
- The Marine Corps structures itself by battalions;
- For the Navy, it is the number of ships in its combat fleet; and
- The most consistent measure for the Air Force is total number of aircraft, sometimes broken down into the two primary subtypes of fighters and bombers.

Obviously, this is not the totality of service capabilities, and it certainly is not everything needed for war, but these measures can be viewed as surrogates that subsume or represent the vast number of other things that make these units of measure possible and effective in battle. For example, combat forces depend on a vast logistics system that supplies everything from food and water to fuel, ammunition, and repair parts. Military operations require engineer support, and the force needs medical, dental, and administrative capabilities. The military also fields units that transport combat power and its sustainment to wherever they may be needed around the world.

The point is that the military spear has a great deal of shaft that makes it possible for

the tip to locate, close with, and destroy its target, and there is a rough proportionality between shaft and tip. Thus, in assessing the basic units of measure for combat power, one can get a sense of what is probably needed in the combat support, combat service support, and supporting establishment echelons.

The scope of this Index does not extend to analysis of everything that makes hard power possible; it focuses on the status of the hard power itself. It also does not assess the services' Reserve and National Guard components, although they account for roughly one-third of the U.S. military force and have been essential to the conduct of operations since September 2001.7 Consistent assessment of their capability, readiness, and operational role is challenging because each service determines the balance among its Active, Reserve, and National Guard elements differently: Only the Army and Air Force have Guard elements; the Navy and Marine Corps do not. This balance can change from year to year and is based on factors that include cost of the respective elements, availability for operational employment, time needed to respond to an emergent crisis, allocation of roles among the elements, and political considerations.8

As with other elements essential to the effective employment of combat powerlogistics, medical support, strategic lift, training, etc.-the U.S. military could not handle a major conflict without the Reserve and Guard forces. Nevertheless, to make the challenge of annually assessing the status of U.S. military strength using consistent metrics over time more manageable, this Index looks at something that is usually associated with the Active component of each service: the baseline requirement for a given amount of combat power that is readily available for use in a major combat operation. There are exceptions, however. For example, in the 2020 Index, four Army National Guard BCTs were counted as "available" for use because of the significant amounts of additional resources that had been dedicated specifically to these formations to raise their readiness levels.9

The Defense Budget and Strategic Guidance

When it comes to the defense budget, how much we spend does not automatically determine the U.S. military's posture or capacity. As a matter of fact, simply looking at how much is allocated to defense does not tell us much about the capacity, modernity, or readiness of the forces. Proper funding is a necessary condition for a capable, modern, and ready force, but it is not sufficient by itself. A larger defense budget, for example, could be associated with less military capability if the money were allocated inappropriately or spent wastefully. Nevertheless, the budget does reflect the importance assigned to defending the nation and its interests in prioritizing federal spending.

Absent a significant threat to the country's survival, the U.S. government will always balance spending on defense against spending in all of the other areas of government activity that are deemed necessary or desirable. Ideally, defense requirements are determined by identifying national interests that might need to be protected with military power; assessing the nature of threats to those interests, what would be needed to defeat those threats, and the costs associated with that capability; and then determining what the country can afford or is willing to spend. Any difference between assessed requirements and affordable levels of spending on defense would constitute a risk to U.S. security interests.

This *Index* enthusiastically adopts this approach: interests, threats, requirements, resulting force, and associated budget. Spending less than the amount needed to maintain a two-MRC force results in policy debates about where to accept risk: force modernization, the capacity to conduct large-scale or multiple simultaneous operations, or force readiness. The composition of the force and the understanding of military risk have become more salient issues with the shift toward competition with China and Russia. Both the 2017 National Security Strategy¹⁰ and the 2021 Interim National Security Guidance¹¹ recognize that meeting the challenges posed by these two large,

well-equipped, and well-resourced countries requires a U.S. force that is modern, ready, and effective in all domains of warfare.

The decision to fund national defense at a level that is commensurate with interests and prevailing threats reflects our national priorities and risk tolerance. This *Index* assesses the ability of the nation's military forces to protect vital national security interests within the world *as it is* so that the debate about the level of funding for hard power is better informed.

The fiscal year (FY) 2021 base discretionary budget for the Department of Defense was \$703.7 billion.¹² This represents the resources allocated to pay for the forces (manpower, equipment, and training); enabling capabilities (things like transportation, satellites, defense intelligence, and research and development); and institutional support (bases and stations, facilities, recruiting, and the like). The base budget has not paid for the cost of major ongoing overseas operations, which are captured in supplemental funding known as OCO (overseas contingency operations).

FY 2021 was the last year that was heavily shaped by two budgetary instruments: OCO and the Budget Control Act (BCA) of 2011.¹³ The OCO account was created in the immediate aftermath of the September 11, 2001, terrorist attacks to provide the resources needed to prosecute the war on terrorism.¹⁴ Since then, the account has ebbed and flowed depending on political and fiscal concerns in Congress and operational realities on the battlefields. The account is set to be merged into the base budget by the Biden Administration starting in FY 2022.¹⁵

Passage of the BCA established legal limits on the funds dedicated to the budget, including defense. That prompted Congress to use OCO as an escape valve for artificially low defense budgets.¹⁶ In this regard, for the past decade, the level of funding for defense has been determined by the politics surrounding the BCA. Despite repeated emphasis on the importance of investing more to fix obvious readiness, capacity, and modernization problems, the debate has been determined by larger



Changes in Defense Spending Since 2011

SOURCE: U.S. Department of Defense, Office of the Under Secretary of Defense (Comptroller), *National Defense Budget Estimates for FY 2021*, April 2020, https://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2021/FY21_Green_Book.pdf (accessed July 23, 2021).

political dynamics that pit those who want to see an overall reduction in federal spending against those who advocate higher levels of defense spending and those who want to see any increase in defense spending matched by commensurate increases in domestic spending.

This dynamic shaped the defense spending debate until FY 2021, the last year within the BCA framework. As Congress and the DOD move into a new budgetary reality, there will be an opportunity to explain the challenges that lie ahead both for the U.S. military and for America's national interests.

Senior DOD leaders have expressed the need for more funding to meet the challenge of a more capable and aggressive China and Russia since well before the release of the 2018 NDS. Testifying before the House Armed Services Committee in 2017, both then-Secretary of Defense James N. Mattis and then-Chairman of the Joint Chiefs of Staff General Joseph Dunford emphasized the need for sustained budget growth so that U.S. forces can maintain a competitive advantage over likely adversaries. Secretary Mattis said that "he expect[ed] to ask for base budget growth 'along the lines of close to 5 percent growth, 3 to 5 percent growth for 2019 to '23," and General Dunford stated that "[w]e know now that continued growth in the base budget of at least 3 percent *above inflation* is the floor necessary to preserve just the competitive advantage we have today, and we can't assume our adversaries will remain still."¹⁷

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The bipartisan commission that assessed the National Defense Strategy also assessed the need for budgetary growth of between 3 percent and 5 percent above inflation,¹⁸ and this recommendation was sustained by former Secretary of Defense Mark Esper.¹⁹

Unfortunately, over the past five fiscal years, the DOD has seen a swing when it comes to real

growth in its budget authority (i.e., budgets that account for the effect of inflation). From 2017 to 2019, there was significant real growth of 3 percent followed by 8.4 percent and 0.3 percent. However, that was followed by two years of real decline of 1 percent in 2020 and then 2.8 percent in 2021. Further, the latest projection of defense budgets anticipates negative growth of 0.1 percent in the coming years.²⁰ That is a far cry from the steady above-inflation increase that was seen as necessary by bipartisan leaders.

Adding to future challenges, the federal government's response to the coronavirus pandemic could influence how the defense budget is discussed and appropriated in future fiscal years. The Congressional Budget Office highlighted a \$3 trillion deficit for FY 2020 and a second \$3 trillion deficit for FY 2021 in its most recent outlook on the budget and the economy.²¹ This extremely high level of budgetary deficit will undoubtedly shape how the country assesses the federal government's budgetary priorities, especially when added to the already massive national debt that approached \$27 trillion by the end of 2020,²² and demand adjustments in the federal government's allocations of taxpayers' dollars.

Purpose as a Driver in Force Sizing

The Joint Force is used for a wide range of purposes, only one of which is major combat operations. Fortunately, such events have been relatively rare, although they have occurred every 15 years on average.²³ In between (and even during) such occurrences, the military is used to support regional engagement, crisis response, strategic deterrence, and humanitarian assistance as well as to support civil authorities and U.S. diplomacy.

All of the U.S. Unified Geographic Combatant Commands, or COCOMS²⁴—Northern Command (NORTHCOM); European Command (EUCOM); Central Command (CENTCOM); Indo-Pacific Command (INDOPACOM); Southern Command (SOUTHCOM); and Africa Command (AFRICOM)—have annual and long-term plans through which they engage with countries in their assigned regions. Engagements range from very small unit training events with the forces of a single partner country to larger bilateral and sometimes multilateral military exercises. Such events help to foster working relationships with other countries, acquire a more detailed understanding of regional political-military dynamics and on-the-ground conditions in areas of interest, and signal U.S. security interests to friends and competitors.

To support such COCOM efforts, the services provide forces that are based permanently in their respective regions or that operate in them temporarily on a rotational basis. To make these regional rotations possible, the services must maintain base forces that are large enough to train, deploy, support, receive back, and again make ready a stream of units that ideally is enough to meet validated COCOM demand.

The ratio between time spent at home and time spent away on deployment for any given unit is known as OPTEMPO (operational tempo), and each service attempts to maintain a ratio that both gives units enough time to educate, train, and prepare their forces and allows the individuals in a unit to maintain some semblance of a healthy home and family life. This ensures that units are fully prepared for the next deployment cycle and that servicemembers do not become "burned out" or suffer adverse consequences in their personal lives because of excessive deployment time.

Experience has shown that a ratio of at least 3:1 (three periods of time at home for every period deployed) is sustainable. If a unit is to be out for six months, for example, it will be home for 18 months before deploying again. Obviously, a service needs enough people, units, ships, and planes to support such a ratio. If peacetime engagement were the primary focus for the Joint Force, the services could size their forces to support these forward-based and forwarddeployed demands.

Thus, the size of the total force must necessarily be much larger than any sampling of its use at any point in time. In contrast, sizing a force for major combat operations is an exercise informed by history how much force was needed in previous wars and then shaped and refined by analysis of current threats, a range of plausible scenarios, and expectations about what the U.S. can do given training, equipment, employment concept, and other factors. The defense establishment must then balance "force sizing" between COCOM requirements for presence and engagement and the amount of military power (typically measured in terms of combat units and major combat platforms, which inform total end strength) that is thought necessary to win in likely war scenarios.

Inevitably, compromises are made that account for how much military the country is willing to buy. Generally speaking:

- **The Army** sizes to major warfighting requirements;
- **The Marine Corps** focuses on crisis response demands and the ability to contribute to one major war;
- The Air Force attempts to strike a balance that accounts for historically based demand across the spectrum because air assets are shifted fairly easily from one theater of operations to another ("easily" being a relative term when compared to the challenge of shifting large land forces), and any peacetime engagement typically requires some level of air support; and
- **The Navy** is driven by global presence requirements. To meet COCOM requirements for a continuous fleet presence at sea, the Navy must have three to four ships in order to have one on station. A commander who wants one U.S. warship stationed off the coast of a hostile country, for example, needs the use of four ships from the fleet: one on station, one that left station and is traveling home, one that just left home and is traveling to station, and one that is otherwise unavailable because of major maintenance or modernization work.

This *Index* focuses on the forces required to win two major wars as the baseline force-sizing metric for the Army, Navy, and Air Force and the one-war-plus-crisisresponse paradigm for the Marine Corps. The three large services are sized for global action in more than one theater at a time; the Marines, by virtue of overall size and most recently by direction of the Commandant, focus on one major conflict while ensuring that all Fleet Marine Forces are globally deployable for short-notice, smaller-scale actions.²⁵ The military's effectiveness, both as a deterrent against opportunistic competitor states and as a valued training partner in the eyes of other countries, derives from its effectiveness (proven or presumed) in winning wars.

Our Approach

With this in mind, we assessed the state of America's military forces as it pertains to their ability to deliver hard power against an enemy in three areas:

- Capability,
- Capacity, and
- Readiness.

Capability. Examining the capability of a military force requires consideration of:

- The proper tools (material and conceptual) with the design, performance characteristics, technological advancement, and suitability that the force needs to perform its function against an enemy successfully;
- The sufficiency of armored vehicles, ships, airplanes, and other equipment and weap-ons to win against the enemy;
- The appropriate variety of options to preclude strategic vulnerabilities in the force and give flexibilities to battlefield commanders; and

• The degree to which elements of the force reinforce each other in covering potential vulnerabilities, maximizing strengths, and gaining greater effectiveness through synergies that are not possible in narrowly stovepiped, linear approaches to war.

The capability of the U.S. Joint Force was on ample display in its decisive conventional war victory over Iraq in liberating Kuwait in 1991 and later in the conventional military operation in Iraq to depose Saddam Hussein in 2003. Aspects of its capability have also been seen in numerous other operations undertaken since the end of the Cold War. While the conventional combat aspect of power projection has been more moderate in places like Yugoslavia, Somalia, Bosnia and Serbia, and Kosovo, and even against the Taliban in Afghanistan in 2001, the fact that the U.S. military was able to conduct highly complex operations thousands of miles away in austere, hostile environments and sustain those operations as long as required is testament to the ability of U.S. forces to do things that the armed forces of few if any other countries can do.

A modern "major combat operation"²⁶ along the lines of those upon which Pentagon planners base their requirements would feature a major opponent possessing modern integrated air defenses; naval power (surface and undersea); advanced combat aircraft (to include bombers); a substantial inventory of short-range, medium-range, and long-range missiles; current-generation ground forces (tanks, armored vehicles, artillery, rockets, and anti-armor weaponry); cruise missiles; and (in some cases) nuclear weapons. Such a situation involving an actor capable of threatening vital national interests would present a challenge that is comprehensively different from the challenges that the U.S. Joint Force has faced in past decades.

Since 2018, given its focus on counterinsurgency, stability, and advise-and-assist operations since 2004 and the 2018 NDS directive to prepare for conflict in an era of great-power competition, the military community has focused on its suitability and readiness for major conventional warfare.²⁷ The Army in particular has noted the need to reengage in training and exercises that feature larger-scale combined arms maneuver operations, especially to ensure that its higher headquarters elements are up to the task.

This *Index* ascertains the relevance and health of military service capabilities by looking at such factors as average age of equipment, generation of equipment relative to the current state of competitor efforts as reported by the services, and the status of replacement programs that are meant to introduce more updated systems as older equipment reaches the end of its programmed service life. While some of the information is quite quantitative, other factors could be considered judgment calls made by acknowledged experts in the relevant areas of interest or addressed by senior service officials when providing testimony to Congress or examining specific areas in other official statements.

It must be determined whether the services possess capabilities that are relevant to the modern combat environment.

Capacity. The U.S. military must have a sufficient quantity of the right capability or capabilities. When speaking of platforms such as planes and ships, a troubling and fairly consistent trend within U.S. military acquisition characterizes the path from requirement to fielded capability. Along the way to acquiring the capability, several linked things happen that result in far less of a presumed "critical capability" than was supposedly required.

- The military articulates a requirement that the manufacturing sector attempts to satisfy.
- "Unexpected" technological hurdles arise that take longer and much more money to solve than anyone envisioned.
- Programs are lengthened, and cost overruns are addressed, usually with more money.

Historical U.S. Force Allocation

Troop figures are in thousands.

	Korean War	Vietnam War	Persian Gulf War	Operation Iraqi Freedom
ARMY				
Total Troop Deployment During Engagement	206.3	219.3	267.0	99.7
Divisions*	6	7	4	1
Reserve Component Divisions Total for Strategic Documents	n/a	n/a	n/a	n/a
Total Army End Strength During Engagement, During Year of Strategy Document Active	1,313.8	1,113.3	738.0	499.0
Total Active End Strength Recommendations	n/a	n/a	n/a	n/a
NAVY				
Total Fleet During Engagement	904	770	529	297
Aircraft Carriers	6	5	6	5
Carrier Air Wings	6	5	6	5
Large Surface Combatants	37	14	30	23
Small Surface Combatants	16	47	16	9
Attack Submarines	4	0	12	12
Amphibious Vessels	34	26	21	7
Combat Logistics and Support Ships	28	29	45	42
Fighter/Attack Squadrons	21	43	22	24
MARINE CORPS				
Total Troop Deployment During Engagement	33.5	44.7	90.0	66.2
Active Divisions*	1	2	2	1
Reserve Divisions	n/a	n/a	n/a	n/a
Marine Expeditionary Force	1	1	1	2
Air Wings Active/Reserve	1	1	1	1
Total Marine Corps End Strength During Engagement by Year of Strategy Document	187.0	289.0	196.3	178.0
Total Recommended End Strength	n/a	n/a	n/a	n/a
AIR FORCE				
Bombers or Bomber	01		-	
Squadrons**	21	23	3	4
Fighter Squadrons	26		30	30
Active Fighter Wings	7	8	10	10
Reserve Fighter Wings				
Airiitt/ Iankers	239	167	388	293

* Figures for engagements are numbers deployed; figures for documents are totals.

** Figures for Air Force bombers for Korean War, Vietnam War, Persian Gulf War, and Iraq are bomber squadrons.

All other figures are bombers.

*** 2014 QDR prescribed nine heavy bomber squadrons, equaling 96 aircraft.

	1993 BUR	1997 QDR	2001 QDR	2006 QDR	2010 QDR	2010 Indep. Panel	2-MRC Paper	2014 QDR	2014 NDP
ARMY									
Total Troop Deployment During Engagement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Divisions*	10	10	10	11		11	10	10	n/a
Reserve Component Divisions Total for Strategic Documents	n/a	5	8	8	18	7	8	8	n/a
Total Army End Strength During Engagement, During Year of Strategy Document Active	572.0	492.0	481.0	505.0	566.0	566.0	550.0	490.0	490.0
Total Active End Strength Recommendations	n/a	n/a	n/a	482.4	n/a	1,106.0	600.0	450.0	490.0
NI A V/V									
NAVY Total Float During									
Engagement	346	310	n/a	n/a	n/a	346	350	n/a	346
Aircraft Carriers	12	12	12	11	11	11	11	11	n/a
Carrier Air Wings	12	11	11	n/a	10	10	10	10	n/a
Large Surface Combatants	124	116	116	n/a	84-88	n/a	120	92	n/a
Small Surface Combatants	127	110	110	n/a	14-28	n/a	n/a	43	n/a
Attack Submarines	55	50	55	n/a	53-55	55	50	51	n/a
Amphibious Vessels	41	36	36	n/a	29-31	n/a	38	33	n/a
Support Ships	65	n/a	n/a	n/a	58	n/a	75	n/a	n/a
Fighter/Attack Squadrons	33	30	30	n/a	30	30	30	30	n/a
Total Troop Deployment									
During Engagement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Active Divisions*	4	3	3	n/a	3	n/a	n/a	3	n/a
Reserve Divisions	1	1	1	n/a	1	n/a	n/a	1	n/a
Marine Expeditionary Force	3	3	3	n/a	3	3	3	2	n/a
Air Wings Active/Reserve	n/a	4	4	n/a	4	n/a	n/a	4	n/a
Total Marine Corps End Strength During Engagement by Year of Strategy Document	174.0	174.0	173.0	180.0	202.0	202.0	196.0	182.0	182.0
Total Recommended End Strength	n/a	n/a	n/a	175.0	n/a	243.0	202.0	182.0	182.0
AIR FORCE									
Bombers or Bomber Squadrons**	200	187	112	n/a	96	180	200	96***	n/a
Fighter Squadrons	54	54	46	n/a	42	66	54	48	n/a
Active Fighter Wings	13	12+	15	n/a	n/a	20	20	9	n/a
Reserve Fighter Wings	7	8	12	n/a	n/a	n/a	20	7	n/a
Airlift/Tankers	n/a	n/a	n/a	n/a	1023	1023	1,000	954	n/a

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ed to be successful in combat. cred

As deliberations proceed toward a decision on whether to reduce planned procurement, they rarely focus on and quantify the increase in risk that accompanies the decrease in procurement.

Something similar happens with force structure size: the number of units and total number of personnel the services say they need to meet the objectives established by the Commander in Chief and the Secretary of Defense in their strategic guidance.

- The Marine Corps has stated that it needs 27 infantry battalions to fully satisfy the validated requirements of the regional Combatant Commanders, yet it currently fields only 24 and has stated that it plans to drop to 21 in order to make resources available for experimentation and modernization.²⁸
- In 2012, the Army was building toward 48 brigade combat teams, but incremental budget cuts reduced that number over time to 31—less than two-thirds the number that the Army originally thought was necessary.
- The Navy has produced various assessments of fleet size since the end of the Cold War, from 313 ships to 372 ships, with some working estimates as high as 500 manned ships.

Older equipment can be updated with new components to keep it relevant, and commanders can employ fewer units more expertly for longer periods of time in an operational theater to accomplish an objective. At some point, however, sheer numbers of updated, modern equipment and trained, fully manned units are going to be needed to win in battle against a credible opponent when the crisis is profound enough to threaten a vital national interest.

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Capacity (numbers) can be viewed in at least three ways: compared to a stated objective for each category by each service, compared to amounts required to complete various types of operations across a wide range of potential missions as measured against a potential adversary, and as measured against a set benchmark for total national capability. This *Index* employs the two-MRC metric as a benchmark for most of the force.

The two-MRC benchmark for force sizing is the *minimum* standard for U.S. hard-power capacity because one will never be able to employ 100 percent of the force at any given time. Some percentage of the force will always be unavailable because of long-term maintenance overhaul, especially for Navy ships; unit training cycles; employment in myriad engagement and small-crisis response tasks that continue even during major conflicts; a standing commitment with allies to maintain U.S. forces in a given country or region; and the need to keep some portion of the force uncommitted to serve as a strategic reserve.

The historical record shows that, on average, the U.S. Army commits 21 BCTs to a major conflict; thus, a two-MRC standard would require that 42 BCTs be available for actual use. But an Army built to field only 42 BCTs would also be an Army that could find itself entirely committed to war, leaving nothing back as a strategic reserve to replace combat losses or to handle other U.S. security interests. Although new

Then the realization sets in that the coun-

try either cannot afford or is unwilling to

pay the cost of acquiring the total number

acquisition goal is adjusted downward, if

not canceled altogether, and the military finally fields fewer platforms at a higher

cost per unit than it originally said it need-

of platforms originally advocated. The

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technologies and additional capabilities have made current BCTs more capable than those they replaced, one thing remains the same: Today's BCT, like its predecessors, can be committed to only one place at a time and must be able to account for combat losses, especially if it engages a similarly modernized enemy force. Thus, numbers still matter regardless of modernity.

Again, this *Index* assesses only the Active component of the service, albeit with full awareness that the Army also has Reserve and National Guard components that together account for half of the total Army. The additional capacity needed to meet these "above two-MRC requirements" could be handled by these other components or mobilized to supplement Active-component commitments. In fact, this is how the Army thinks about meeting operational demands and is at the heart of the long-running debate within the total Army about the roles and contributions of the various Army components. A similar situation exists with the Air Force and Marine Corps.

The balance among Active, Reserve, and Guard elements is beyond the scope of this study. Our focus is on establishing a minimum benchmark for the capacity needed to handle a two-MRC requirement.

We conducted a review of the major defense studies (1993 BUR, QDR reports, and independent panel critiques) that are publicly available,²⁹ as well as modern historical instances of major wars (Korea, Vietnam, Gulf War, Operation Iraqi Freedom), to see whether there was any consistent trend in U.S. force allocation. The results of our review are presented in Table 5. To this we added 20 percent, both to account for forces and platforms that are likely to be unavailable and to provide a strategic reserve to guard against unforeseen demands.

Summarizing the totals, this *Index* concluded that a Joint Force capable of dealing with two MRCs simultaneously or nearly simultaneously would consist of:

- **Navy:** at least 400 ships and 624 strike aircraft.
- Air Force: 1,200 fighter/attack aircraft.
- Marine Corps: 30 battalions.

America's security interests require that the services have the capacity to handle two major regional conflicts successfully.

Readiness. The consequences of the sharp reductions in funding mandated by sequestration over the past decade have caused military service officials, senior DOD officials, and even Members of Congress to warn of the dangers of re-creating the "hollow force" of the 1970s when units existed on paper but were staffed at reduced levels, minimally trained, and woefully ill-equipped.³⁰ To avoid this, the services have traded quantity/capacity and modernization to ensure that what they do have is "ready" for employment.

Supplemental funding in FY 2017, a higher topline in FY 2018, and sustained increases in funding in FY 2019 and through FY 2020 have helped to stop the bleeding and have enabled the services to plan and implement readiness recovery efforts. Massive federal spending in response to the COVID-19 pandemic in calendar year 2020 led to fiscal pressure on defense accounts in future years, but gains in readiness were preserved during FY 2020. Ensuring adequate readiness in FY 2021 has been difficult given the challenges created by COVID-19 during the preceding year.

It is one thing to have the right capabilities to defeat the enemy in battle. It is another thing to have enough of those capabilities to sustain operations and many battles against an enemy over time, especially when attrition or dispersed operations are significant factors. But sufficient numbers of the right capabilities are rather meaningless if the force is not ready to engage in the task.

Scoring. In our final assessments, we tried very hard not to convey a higher level of precision than we think is achievable using unclassified, open-source, publicly available

• Army: 50 BCTs.

documents; not to reach conclusions that could be viewed as based solely on assertions or opinion; and not to rely solely on data and information that can be highly quantified. Simple numbers, while important, do not tell the whole story.

We believe that the logic underlying our methodology is sound. This *Index* drew from a wealth of public testimony from senior government officials, from the work of recognized experts in the defense and national security analytic community, and from historical instances of conflict that seemed most appropriate to this project. It then considered several questions, including:

- How does one place a value on the combat effectiveness of such concepts as Air-Sea Battle, Multi-Domain Operations, Littoral Operations in a Contested Environment, Distributed Maritime Operations, Network-centric Operations, or Joint Operational Access?
- Is it entirely possible to assess accurately (1) how well a small number of newestgeneration ships or aircraft will fare against a much larger number of currently modern counterparts when (2) U.S. forces are operating thousands of miles from home, (3) orchestrated with a particular operational concept, and (4) the enemy is leveraging a "home field advantage" that includes strategic depth and much shorter and perhaps better protected lines of communication and (5) might be pursuing much dearer national objectives than the U.S. is pursuing so that the political will to conduct sustained operations in the face of mounting losses might differ dramatically?

How does one neatly quantify the element of combat experience, the erosion of experience as combat operation events recede in time and those who participated in them leave the force, the health of a supporting workforce, the value of "presence and engagement operations," and the related force structures and patterns of deployment and employment that presumably deter war or mitigate its effects if it does occur?

New capabilities such as unmanned systems, cyber tools, hypervelocity platforms and weapons, and the use of artificial intelligence to achieve a better understanding of operations and orchestrate them more effectively have the potential to change military force posture calculations in the future. At the present time, however, they are not realized in any practical sense.

This *Index* focused on the primary purpose of military power—to defeat an enemy in combat—and the historical record of major U.S. engagements for evidence of what the U.S. defense establishment has thought was necessary to execute a major conventional war successfully. To this we added the two-MRC benchmark; on-the-record assessments of what the services themselves are saying about their status relative to validated requirements; and the analysis and opinions of various experts, both in and out of government, who have covered these issues for many years.

Taking it all together, we rejected scales that would imply extraordinary precision and settled on a scale that conveys broader characterizations of status that range from very weak to very strong. Ultimately, any such assessment is a judgment call informed by quantifiable data, qualitative assessments, thoughtful deliberation, and experience. We trust that our approach makes sense, is defensible, and is repeatable.

Endnotes

- 1. Les Aspin, Secretary of Defense, *Report on the Bottom-Up Review*, U.S. Department of Defense, October 1993, p. iii, https://www. hsdl.org/?view&did=448259 (accessed July 8, 2021).
- 2. Ibid., p. 8.
- 3. Commission on the National Defense Strategy, Providing for the Common Defense: The Assessment and Recommendations of the National Defense Strategy Commission, https://www.usip.org/sites/default/files/2018-11/providing-for-the-common-defense. pdf (accessed July 8, 2021), and press release, "National Defense Strategy Commission Releases Its Review of 2018 National Defense Strategy," United States Institute of Peace, November 13, 2018, https://www.usip.org/press/2018/11/national-defensestrategy-commission-releases-its-review-2018-national-defense (accessed July 8, 2021).
- 4. President Joseph R. Biden, Jr., Interim National Security Strategic Guidance, The White House, March 2021, p. 9, https://www. whitehouse.gov/wp-content/uploads/2021/03/NSC-1v2.pdf (accessed July 8, 2021).
- 5. The United States has not had to contend in combat with any credible air force since the Vietnam War, but U.S. Air Force planners are increasingly concerned about an enemy's ground-based, anti-air missile capability. Naval planners are much more concerned about ship-based, air-based, and shore-based anti-ship cruise missiles than they are about the number of conventional surface combatants armed with large-caliber guns that an enemy navy has. Likewise, ground force planners have to consider the numbers and types of guided anti-armor weapons that an enemy possesses and whether an opposing force has guided artillery, mortar, or rocket capabilities. Guided/precision weapons are typically less expensive (by orders of magnitude) than the platforms they target, which means that countries can produce far more guided munitions than primary weapons platforms. Adding this to the rise of unmanned platforms capable of carrying anti-platform weapons makes the threat environment even more complicated. Some examples: Harpoon ASCM (\$2 million)/DDG-51 *Arleigh Burke*-Class destroyer (\$2 billion); AT4 anti-armor weapon (\$1,500)/M1A1 Abrams main battle tank (\$9 million); 120mm guided mortar round (\$100,000) or 155mm guided artillery round (\$100,000)/M198 155mm howitzer (\$500,000); S-300 anti-air missile (\$1 million)/F/A-18 Hornet (\$70 million) or F-35A Lightning II (\$78 million).
- 6. The use of low-cost drones to attack tanks and other armored vehicles during the 2020 war between Armenia and Azerbaijan proved devastatingly effective. See Benjamin Brimelow, "A Brief, Bloody War in a Corner of Asia Is a Warning About Why the Tank's Days of Dominance May Be Over," *Business Insider*, November 24, 2020, https://www.businessinsider.com/drones-in-armenia-azerbaijan-war-raises-doubt-about-tanks-future-2020-11 (accessed July 8, 2021). In late June 2021, U.S. forces conducted air strikes against Iranian-backed militia groups in Syria that had been using drones to attack U.S. forces in the region—further evidence of the proliferation of these unmanned systems that enable non-state groups to attack state forces with some level of effectiveness. See Eric Schmitt, "U.S. Carries out Air Strikes in Iraq and Syria," *The New York Times*, June 27, 2021, https://www.nytimes.com/2021/06/27/us/politics/us-airstrikes-iraq-syria.html (accessed July 8, 2021).
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- 8. One example of force balancing was the Army's Aviation Restructuring Initiative, in which the active-duty force sought to redistribute certain rotorcraft platforms among units of the active-duty Army and the National Guard. The Guard has contended that this plan would reduce the capabilities it has gained during recent combat engagements, such as its pilots' proficiency in flying Apache helicopters. For more on this issue, see U.S. Government Accountability Office, *Force Structure: Army's Analyses of Aviation Alternatives*, GAO-15-430R, April 27, 2015, http://www.gao.gov/assets/670/669857.pdf (accessed July 8, 2021), and Enclosure 1, "Force Structure: Army's Analysis of Aviation Alternatives, Briefing for Congressional Defense Committees," updated April 27, 2015, in ibid., pp. 8-44.
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- 13. S. 365, Budget Control Act of 2011, Public Law 112-25, 112th Cong., August 2, 2011, https://www.congress.gov/112/plaws/publ25/ PLAW-112publ25.pdf (accessed July 12, 2021).
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- 16. Emil Maine and Diem Salmon, "The Future of Overseas Contingency Operations: Due Diligence Required," Heritage Foundation *Issue Brief* No. 4294, November 4, 2014, https://www.heritage.org/defense/report/the-future-overseas-contingency-operations-due-diligence-required.
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- 23. Since World War II, the U.S. has fought four major wars: the Korean War (1950–1953); the Vietnam War (1965–1973); the Gulf War/Operation Desert Shield/Desert Storm (1990–1991); and the Iraq War/Operation Iraqi Freedom (2003–2011).
- 24. U.S. Space Command (USSPACECOM) is also considered a geographic command, but within the context of this discussion, SPACECOM's interactions with other countries and the extent to which it must deal with units and peoples operating on its terrain is much different from those of terrestrial commands.
- 25. In previous editions of the *Index*, the capacity of the Marine Corps was assessed against a two-war requirement of 36 battalions: a historical average of 15 battalions for a major conflict (twice that for two) and a 20 percent buffer, bringing the total to 36. The Corps has consistently maintained that it is a one-war force and has no intention of growing to the size needed to fight two wars. Its annual budget requests and top-level planning documents reflect this position. Having assessed that the Indo-Pacific region will continue to be of central importance to the U.S., noting that China is a more worrisome "pacing threat" than any other competitor, and that the Joint Force lacks the ability to operate within the range of intensely weaponized, layered defenses featuring large numbers of precision-guided munitions, the Corps is reshaping itself to optimize its capabilities and organizational structures for this challenge. This *Index* concurs with this effort but assesses that the Corps will still need greater capacity to succeed in war in the very circumstances for which the Marines believe they must prepare. For a detailed examination of the current state of the Corps, see Dakota Wood, "The U.S. Marine Corps: A Service in Transition," Heritage Foundation *Backgrounder* No. 3501, June 16, 2020, https://www.heritage.org/sites/default/files/2020-06/BG3501_0.pdf.
- 26. Defense references to war have varied over the past few decades from "major combat operation" (MCO) and "major theater war" (MTW) to the current "major regional contingency" (MRC). Arguably, there is a supporting rationale for such shifts as planners attempt to find the best words to describe the scope and scale of significant military efforts, but the terms are basically interchangeable.

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- 28. General David H. Berger, Commandant of the Marine Corps, "Force Design 2030," March 2020, pp. 7–8, https://www. hqmc.marines.mil/Portals/142/Docs/CMC38%20Force%20Design%202030%20Report%20Phase%20I%20and%20II. pdf?ver=2020-03-26-121328-460 (accessed July 9, 2021).
- 29. The Department of Defense, through the Joint Staff and Geographic Combatant Commanders, manages a relatively small set of real-world operational plans (OPLANS) that are focused on specific situations in which the U.S. feels it is most likely to go to war. These plans are reviewed and updated regularly to account for changes in the Joint Force or with the presumed enemy. They are highly detailed and account not only for the amount of force the U.S. expects that it will need to defeat the enemy, but also for which specific units would deploy; how the force would actually flow into the theater (the sequencing of units); what ports and airfields it would use; how much ammunition, fuel, and other supplies it would need at the start; how much transportation or "lift" would be needed to get the force there (by air, sea, trucks, or rail); and the basic plan of attack. The Pentagon also routinely develops, explores, and refines various notional planning scenarios so that it can better understand the implications of different sorts of contingencies, which approaches might be more effective, how much of what type of force might be needed, and the regional issue or issues for which there would have to be an accounting. These types of planning events inform service efforts to develop, equip, train, and field military forces that are up to the task of defending national security interests. All of these efforts and their products are classified national security information and therefore not available to the public.
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U.S. Army

Thomas W. Spoehr

The U.S. Army is America's primary agent for the conduct of land warfare. Although it is capable of all types of operations across the range of military operations and support to civil authorities, its chief value to the nation is its ability to defeat and destroy enemy land forces in battle.

The Army is engaged throughout the world in protecting and advancing U.S. interests. Operationally, as of May 20, 2021, the Army had 167,370 soldiers forward located in 142 countries.¹ On May 5, 2021, the Acting Secretary of the Army and the Army Chief of Staff testified that:

Over 69,000 Soldiers are in the Indo-Pacific, including over 25,000 forward deployed on the Korean peninsula. Over 30,000 Soldiers are in Europe supporting NATO and the European Deterrence Initiative, including the forward command post of our newly reactivated V Corps. We remain dedicated to our counterterrorism and train, advise, assist missions, providing over 21,000 Soldiers in support of the U.S. Central Command theater.²

The Army, like the other military services, finds itself at a strategic inflection point. That it needs to evolve and transform is unquestioned. Advances in firepower like ballistic missiles and kamikaze drones fielded by adversaries like China have outpaced the U.S. Army's capabilities. Information-age warfare requires new levels of speed and precision in Army sensor-to-shooter chains. Autonomy is changing the character of warfare, and the Army has bold ideas about how to take advantage of this technology.

However, whether the necessary resources will be available to enable such change is open to question. Since fiscal year (FY) 2019, the Army's budget has decreased, and the Administration's FY 2022 budget request for the Army takes a sharp downward drop from \$177 billion in FY 2021 to \$173 billion requested for FY 2022. If this requested amount is approved, the Army may not be able to achieve its vision of modernizing and regaining its technological advantage while preserving readiness and sufficient end strength. The FY 2022 proposed Army budget sharply reduces training programs and exercises and drastically curtails many equipment programs.³

Enduring Relevance of Land Power. Arguments that America no longer needs a strong modern Army because, for example, China is largely a maritime threat ignore history and ignore what it means to be engaged in global competition with a near peer. America has a horrible record of predicting where it will fight its next war. As former Secretary of Defense Robert Gates famously said:

When it comes to predicting the nature and location of our next military engagements, since Vietnam, our record has been perfect. We have never once gotten it right, from the Mayaguez to Grenada, Panama, Somalia, the Balkans, Haiti, Kuwait, Iraq, and more—we had no idea a year before any of these missions that we would be so engaged.⁴

Many also seem to overlook the fact that great-power competition with China and Russia is a global contest, which means that we face the enduring need to counter aggression wherever it may occur, not just within the territory or waters of China or Russia. All of this reinforces the reality that America has a long-term need for modernized, sufficiently sized land power.

A Difficult Year. The Army has largely surmounted the challenges posed by the COVID-19 pandemic. The virus affected Army recruiting efforts in 2020, but in the end, the Army achieved its desired overall end strength, albeit by relying more on reenlistments.⁵ The magnitude of Army support for the fight against the pandemic stands in sharp contrast to the views of those who opine that our national security infrastructure is not designed to counter threats like novel coronaviruses.⁶

The Army's contributions to this fight were both multiple and noteworthy. Operation Warp Speed, the prior Administration's herculean effort to jump-start the production of COVID-19 vaccines, was a Department of Defense (DOD)–Department of Health and Human Services operation that included multiple senior Army officers and was co-led by Army General Gus Perna.⁷ During the height of the pandemic, the Army Corps of Engineers built dozens of treatment centers, and Army soldiers were deployed throughout the country to help administer vaccines. More than 47,000 National Guard personnel were deployed to help states combat the pandemic.⁸

Although the Army was forced to scale back its Defender-Europe 20 exercise, which was planned to be the Army's largest exercise in Europe in 25 years, DEFENDER 21 was executed in 2021 from March to June and was more extensive than the prior year's planned event.⁹

A Strong Force Showing Its Age. The U.S. Army is currently the world's most powerful army, but it is also too small to meet even the

modest requirements of the 2018 National Defense Strategy (NDS), much less the standard of being able to handle two major regional contingencies simultaneously, which most experts believe is necessary. It also is not sufficiently modern.

Even though the conflict in Iraq has largely ended and the military is withdrawing from Afghanistan, the 15 years from 2001 to 2016, when the Army was focused single-mindedly on counterinsurgency and winning those conflicts, completely distracted the service from focusing on modernizing the key combat capabilities that it will need for near-peer competition. As a consequence, the Army's last major modernization occurred in the 1980s. As Army Chief of Staff General James McConville stated in March 2021, "[W]e must modernize the Army. Every 40 years the Army needs to transform. It did in 1940, it did in 1980 and we're in 2020 right now."¹⁰

The Army's ability to recover was further constrained by a period of fiscal austerity that began with the Budget Control Act (BCA) of 2011.¹¹ The inability to fund everything that was needed led to difficult across-the-board tradeoffs in equipment, manpower, and operations accounts. Budget pressure drove DOD in January 2014 to shrink the Army's Active component end strength from more than 500,000 to 420,000—the smallest Army in modern U.S. history.¹² Multiple equipment programs were cancelled.

The change in Administrations in 2017 forestalled those cuts in end strength. However, the addition of billions of dollars by Congress and the Trump Administration, although it served to arrest the decline of the Army and significantly improved unit readiness, was not sufficient to modernize or significantly increase the size of the force.¹³

A Change in Strategic Direction? It is unclear what direction the Biden Administration's National Security or National Defense strategies will take. The Administration's Interim National Security Guidance provides little insight into its thinking with respect to national defense and does not even mention

Army Budget Hit by Inflation and Cuts

The Army's total obligation authority (TOA) is declining in actual dollars, but because of inflation, those declines also result in an additional loss in buying power. From 2018 to 2022, those losses have totaled \$39 billion.



SOURCE: Major General Paul A. Chamberlain, Director, Army Budget, "Army Fiscal Year 2022 Budget Overview," May 28, 2021, p. 4, https://www.asafm.army.mil/Portals/72/Documents/BudgetMaterial/2022/pbr/FY22_PB_brief_28MAY21.pdf (accessed July 23, 2021).



the Army or any other service.¹⁴ The Trump Administration's NDS made "long-term strategic competitions" with China and Russia the "principal priorities" but also stated that DOD would "sustain its efforts" to counter the challenges posed by Iran, North Korea, and terrorism—threats where land power has great or even predominant utility.¹⁵

The 2018 NDS included the relatively modest goal of "defeating aggression by a major power; deterring opportunistic aggression elsewhere; and disrupting imminent terrorist and WMD threats."¹⁶ Some, however, question whether even that goal is achievable. According to Representative Adam Smith (D–WA), the influential chairman of the House Armed Services Committee, for example, "We should get off of this idea that we have to win a war in Asia, with China, what we have to do from a national security perspective, from a military perspective, is we have to be strong enough to deter the worst of China's behavior."¹⁷ Exactly what the "worst" of China's behavior would be and what it would take to deter it remained undefined, but a change in U.S. strategy is clearly possible. **Consequences of the Loss in Buying Power.** Despite relatively broad agreement that the DOD budget needed real growth of 3 percent through 5 percent to avoid a strategybudget mismatch,¹⁸ the defense budget topline did not meet that target in FY 2019 and still has not done so.

Of all the services, the Army has fared the worst in terms of resources. Its funding levels plateaued with the FY 2018 budget and since then have declined. The Army received \$179 billion in FY 2018, \$181 billion in FY 2019, \$186 billion in FY 2020, and \$177 billion in FY 2021 and requested \$173 billion for FY 2022. Because of the inexorable annual bite of inflation and the decline in budget authority, the Army budget for FY 2022 represents a net loss of about 9 percent in buying power, or \$16 billion, since FY 2018.¹⁹

Summarizing the Army budget at a recent hearing, Acting Secretary of the Army John Whitley stated, "I think there is a lot of risk in the budget, congressman.... The Army's budget has actually been flat for the last two to three years."²⁰ General McConville's assessment is somewhat more colorful: In the past two years, the Army has "picked the fruit" from the tree trying to find ways to make tough budget choices. Now, as the service approaches FY 2022, "[t]here's no more fruit in that tree."²¹

Capacity

Capacity refers to the sufficiency of forces and equipment needed to execute the National Defense Strategy. One of the ways the Army quantifies its warfighting capacity is numbers of Brigade Combat Teams (BCTs).

Brigade Combat Teams. BCTs are the Army's primary combined arms, close combat force. They often operate as part of a division or joint task force, both of which are the basic building blocks for employment of Army combat forces. BCTs are usually employed within a larger framework of U.S. land operations but are equipped and organized so that they can conduct limited independent operations as circumstances demand.²² BCTs range between 4,400 and 4,700 soldiers in size.²³ There are three types of BCTs: Infantry, Armored, and Stryker. Each of these formations at its core has three maneuver battalions enabled by multiple other units such as artillery, engineers, reconnaissance, logistics, and signal units.²⁴

The best way to understand the status of hard Army combat power is to know the readiness, quantity, and modernization level of BCTs. This section deals with the number of BCTs in the force.

In January 2012, "DOD announced [that] the Army would reduce the size of the Active Army starting in 2012 from a post-9/11 peak in 2010 of about 570,000 soldiers to 490,000 soldiers by the end of 2017." Later guidance revised that figure downward "to a range of 440–450,000 soldiers."²⁵ In 2013, the Army announced that because of those end strength reductions and the priorities of the prior Administration, the number of Regular Army BCTs would be reduced from 45 to 33.²⁶ Subsequent reductions reduced the number of Regular Army BCTs from 33 to 31, where they remain today.

When President Trump and Congress reversed the drawdown in end strength and authorized growth starting in 2017, instead of "re-growing" the numbers of BCTs, the Army chose to "thicken" the force and raise the manning levels within the individual BCTs to increase unit readiness. The Army's goal is to fill operational units to 105 percent of their authorized manning.²⁷

Combat Aviation Brigades. The Regular Army also has a separate air component organized into Combat Aviation Brigades (CABs), which can operate independently. CABs are made up of Army rotorcraft, such as the AH-64 Apache, and perform various roles including attack, reconnaissance, and lift. The number of Army aviation units has also been reduced. In May 2015, the Army deactivated one of its 12 CABs, leaving only 11 in the Regular Army.²⁸

Generating Force. CABs and Stryker, Infantry, and Armored BCTs make up the Army's main combat forces, but they obviously

Major Army Combat Formations

Brigade Combat Teams	Regular Army	Guard	Total
Infantry Brigade Combat Teams	13	20	33
Stryker Brigade Combat Teams	7	2	9
Armored Brigade Combat Teams	11	5	16
Total	31	27	58

		Army National		
Aviation Brigades	Regular Army	Guard	Total	
Combat Aviation Brigades	11	_	11	
Expeditionary Combat Aviation Brigades	-	8	8	
Theater Aviation Brigades	-	2	2	
Total	11	10	21	

SOURCES:

 U.S. Department of the Army, *Department of the Army Fiscal Year (FY) 2022 Budget Estimates, Volume 1, Operation and Maintenance, Army, Justification of Estimates*, May 2021, pp. 65 and 128, https://www.asafm.army.mil/Portals/72/Documents/BudgetMaterial/2022/ Base%20Budget/Operation%20and%20Maintenance/OMA_VOL_1_FY_2022_PB.pdf (accessed July 23, 2021).

 U.S. Department of the Army, Department of the Army Fiscal Year (FY) 2022 Budget Estimates, Volume 1, Operation and Maintenance, Army National Guard, Justification Book, May 2021, pp. 44 and 101, https://www.asafm.army.mil/Portals/72/Documents/ BudgetMaterial/2022/ Base%20Budget/Operation%20and%20Maintenance/OMNG_VOL_1_FY_2022_PB.pdf (accessed July 23, 2021).

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do not make up the entirety of the Army. A so-called Generating Force of 87,015 Regular Army troops provides such types of support as preparing and training troops for deployments, carrying out key logistics tasks, staffing headquarters, and overseeing military schools and Army educational institutions.²⁹ The troops in this Generating Force are the seed corn of the Army, which therefore endeavors to insulate them from drawdown and restructuring proposals in order to "retain a slightly more senior force in the Active Army to allow growth if needed."³⁰

Functional or Multifunctional Support Brigades. In addition to the institutional Army, a great number of functional or multifunctional support brigades, amounting to approximately 46 percent of the force,³¹ provide air defense; engineering; explosive ordnance disposal (EOD); chemical, biological, radiological, and nuclear protection; military police; military intelligence; and medical support among other types of battlefield support. Special operations forces such as the 75th Ranger Regiment, six Special Forces Groups, and the 160th Special Operations Aviation Regiment are also included in this category.

New Concepts and Supporting Force Structure. The Army is trying to adapt its force structure to meet the anticipated new demands of near-peer competition. The foundations for these changes are contained in the Army's multi-domain operations (MDO) concept, which outlines how the Army views the future.³²

In April 2020, the Army announced that it planned to modify its force structure for MDO under the designation AimPoint Force Structure Initiative. Its objective is to produce an "MDO-capable force" by 2028 and an "MDOready force" by 2035.33 As part of this initiative, the Army reactivated V Corps Headquarters on October 16, 2020, to provide operational planning, mission command, and oversight of rotational forces in Europe.34 The Army has also announced plans to create five Multi-Domain Task Forces (MDTFs). One MDTF is currently stationed at Joint Base Lewis-McChord in Washington State. Another will be located in Germany. Of the remaining three MDTFs, one will be in the Indo-Pacific, one will be in the Arctic, and the fifth will likely be maintained in the U.S. to be available for global response. These task forces contain rockets, missiles, military intelligence, and other capabilities that will allow Army forces to operate seamlessly with joint partners and conduct multi domain operations.35

To relieve the stress on the use of BCTs for advisory missions, the Army has activated six Security Force Assistance Brigades (SFABs). These units, composed of about 800 soldiers each, are designed specifically to train, advise, and mentor other partner-nation military units. The Army had been using BCTs for this mission, but because train-and-assist missions typically require senior officers and noncommissioned officers, a BCT comprised predominantly of junior soldiers was a poor fit. The SFABs will be regionally aligned to combatant commands. Of the six SFABs, one is in the National Guard, and the other five are in the Regular Army.³⁶

Force Too Small to Execute the NDS. Army leaders have consistently stated that the Army is too small to execute the National Defense Strategy at less than significant risk. As of September 30, 2021, the Army had an authorized total end strength of 1,012,200 soldiers:

- 485,900 in the Regular Army,
- 189,800 in the Army Reserve, and
- 336,500 in the Army National Guard (ARNG).³⁷

In May 2021, Army Chief of Staff McConville testified that "[w]hen we take a look at end-strength, I would like to grow the Army. We've done analysis like the previous chief [General Mark Milley] talked about. 540 to 550 [thousand] is about the right size of the Army."³⁸ In an earlier discussion with reporters, Mc-Conville stated, "I would have a bigger...sized Army if I thought we could afford it, I think we need it, I really do.... I think the regular Army should be somewhere around 540–550 [thousand].... So, we're sitting right now at 485,000."³⁹

The Army's plan to increase the size of the Regular Army force has recently been put on hold because of budget cuts. The Army had planned to raise the Regular Army incrementally to above 500,000 by adding approximately 2,000 soldiers per year.⁴⁰ At that rate, it would have reached 500,000 by around 2028. Now even that modest plan is off the table. As a result of bleak defense budget forecasts, McConville has reported that the Army will have to hold its end strength constant to save money.⁴¹

Overall end strength dictates how many BCTs the Army can form, and by holding end strength constant, it is very unlikely that the service will be able to add any new maneuver formations to the mix. This will drive a higher operational tempo (OPTEMPO) for Army units and increase risk both for the force and for the ability of the Army to carry out its mission.

Many outside experts agree that the U.S. Army is too small. In 2017, Congress established the National Defense Strategy Commission to provide an "independent, non-partisan review of the 2018 National Defense Strategy." Two of the commissioners, Dr. Kathleen Hicks and Michael McCord, are now senior DOD officials. Among its findings, the commission unanimously reported that the NDS

Army Formations: Time Deployed vs. Time at Home Station

Even with a reduced presence in Iraq and Afghanistan, certain Army formations continue to deploy globally at a high tempo. The table below shows the ratio of time deployed to time at home station for three select Army formations. Typically, if the ratio drops below 1-to-2, a formation is spending more time deployed than is recommended, and this pace will cause long-term challenges.

	Unit Type	Ratio of Time Deployed to Time at Home Station	
	Patriot Battalions	1 to 1.23	
	IBCTs (Regular Army)	1 to 1.86	
	Division Headquarters (Regular Army)	1 to 2.25	
NOTE: Data ai SOURCE: Ema	re current as of May 20, 2021. ail from Headquarters, Department of the Army, G-3/5/7 Office to t	he author, May 25, 2021. 🛛 🕿 her	itage.org

now charges the military with facing "five credible challengers, including two major-power competitors, and three distinctly different geographic and operational environments." The commission assessed that "[t]his being the case, a two-war force sizing construct makes more strategic sense today than at any previous point in the post-Cold War era." In other words, "[s]imply put, the United States needs a larger force than it has today if it is to meet the objectives of the strategy."⁴²

In addition to the increased strategic risk of not being able to execute the NDS within the desired time frame, the combination of an insufficient number of BCTs and a lower-thanrequired Army end strength has resulted in a higher-than-desired level of OPTEMPO. As of May 2021, despite a reduction in unit deployments to Iraq and Afghanistan, Army units continued to experience sustained demand. Some of the units with the highest OPTEMPOs (measured in boots on the ground/dwell ratios) are shown in Table 3.⁴³

Army Force Posture. The Army also has transitioned from a force with a third of its strength typically stationed overseas, as it was during the Cold War, to a force that is mostly based in the continental United States. In 1985, 31 percent of the active-duty Army was stationed overseas; by 2015, that figure had declined to 9 percent.⁴⁴ The desire to find a peace dividend following the dissolution of the Soviet Union, combined with a reluctance to close bases in the United States, led to large-scale base closures and force reductions overseas. Even though the 2018 NDS placed a high premium on how the joint force is postured, achieving that goal will be very difficult with the vast bulk of the Army now in the United States.

Among Army units that deploy periodically are Armored Brigade Combat Teams (ABCTs) that rotate to and from Europe and Korea. Rather than relying on forward-stationed BCTs, the Army rotates ABCTs to Europe and Korea on a "heel-to-toe" basis so that there is never a gap. There is disagreement as to which represents the better option: rotated forces or forward-stationed forces. Proponents of rotational BCTs argue that they arrive fully trained and remain at a high state of readiness throughout their typically nine-month overseas rotation. Those who favor forward-stationed forces point to a lower cost, forces that typically are more familiar with the operating environment, and a more reassuring presence for our allies.⁴⁵ In reality, both types of force postures are needed, not only for the reasons mentioned, but also because the mechanisms by which a unit is deployed, received into theater, and integrated with the force stationed abroad must be practiced on a regular basis.

To mitigate risk and add to the number of ready BCTs, the Army has initiated a program, ARNG 4.0, to resource select Army National Guard BCTs with additional training days, moving from the standard number of 39 to as many as 63 per year to increase readiness levels. To apply these resources, the National Guard has implemented a multi-year training cycle to build readiness over time. As part of this concept, the Army increased the number of National Guard BCTs participating in a Combat Training Center (CTC) rotation from two to four starting in FY 2019. Because of budget cuts, however, the FY 2022 budget reduces National Guard CTC rotations back down to two.46

Despite the increase in the number of training days, the training goal for National Guard BCTs is to achieve a company level rather than a brigade level of proficiency, which means that additional training time would be required before the unit could be deployed.

Capability

Capability in this context refers to the quality, performance, suitability, and age of the Army's various types of combat equipment. In general, the Army is using equipment developed in the 1970s, fielded in the 1980s, and incrementally upgraded since then. This "modernization gap" was caused by several factors: the predominant focus on the wars in Iraq and Afghanistan since 9/11; pressures caused by budget cuts, especially those associated with the BCA; and failures in major modernization programs like the Future Combat System, Ground Combat Vehicle, and Crusader artillery system. Army leaders today clearly view this situation as a serious challenge. General McConville believes that modernization cannot be deferred any longer:

[E]veryone believes, and I believe strongly—that we must transform and modernize the Army now. So we've got to do that. We're three years into it, [and] I think we've got some really good programs going. We probably need about two or three more years of good solid budgets. And I think that's something we have to do.⁴⁷

Emphasizing the point, McConville also said recently that "we must transform the Army, now. Every 40 years, I would argue or suggest the Army transforms. It did it in 1940, it did it when I came in, in the Army in 1980. Now, we're in 2020, and we must transform the Army."⁴⁸

Equipment Losing Its Competitive Advantage. As an example of how Army equipment is falling behind that of our competitors, the Army Tactical Missile System (ATACMS), first introduced in 1991, is the Army's only ground-launched precision missile. Due to the restrictions of the Intermediate Range Nuclear Forces Treaty and other factors, it had a maximum range of 300 kilometers. Meanwhile, both China and Russia have much more substantial inventories of conventional, precision, groundlaunched missiles and rockets. China has nine major ground-launched missile systems and more than 425 launchers. These capable systems can range from 600 km (DF-11A and DF-15) to 4,000 km (DF-26).49 Russia, on the other hand, has the widest inventory of missiles in the world: at least four conventional ground-launched missile systems that can range from 120 km (SS-21) to 2,500 km (SSC-8).50 The U.S. hopes to field a new precision strike missile by 2023, but for now, that system remains a plan, not a capability.

Another example is the main battle tank. When the M-1 Abrams was introduced in 1980, it was indisputably the world's best tank. Now, in 2021, Russia is reportedly beginning to

U.S. Lags Behind China, Russia in Land-Based Missiles

GROUND-LAUNCHED CONVENTIONAL-CAPABLE PRECISION MISSILE SYSTEMS



SOURCES:

- Center for Strategic and International Studies, China Power Project, "How Are China's Land-based Conventional Missile Forces Evolving?" updated May 12, 2021, https://chinapower.csis.org/conventional-missiles/ (accessed July 23, 2021).
- Center for Strategic and International Studies, Missile Defense Project, "Missiles of Russia," *Missile Threat*, last modified February 11, 2021, https://missilethreat.csis.org/country/russia/ (accessed July 23, 2021).
- U.S. Army, Acquisition Support Center, "Army Tactical Missile System (ATACMS)," https://asc.army.mil/web/portfolio-item/atacms/ (accessed July 23, 2021).

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export versions of its T-14 Armata tank, which has an unmanned turret, reinforced frontal armor, an information management system that controls all elements of the tank, a circular Doppler radar, an option for a 155 mm gun, and 360-degree ultraviolet high-definition cameras. The M-1 is a great tank, but the decisive advantage that the U.S. once enjoyed in tank warfare is disappearing.⁵¹

Similarly the U.S. Army's Patriot Missile System is an excellent system, but countries

such as Saudi Arabia, Turkey, and India have either purchased or recently expressed interest in buying the Russian competitor system, the S-400.⁵² The question has to be asked: Why?

Within the Army's inventory of equipment are thousands of combat systems, including small arms, trucks, aircraft, soldier-carried weapons, radios, tracked vehicles, artillery systems, missiles, and drones. The following updates with respect to some of the major systems as they pertain to Armored, Stryker, and Infantry BCTs and Combat Aviation Brigades are by no means exhaustive.

Armored Brigade Combat Team (ABCT). The Armored BCT's role is to "close with the enemy by means of fire and movement to destroy or capture enemy forces, or to repel enemy attacks by fire, close combat, and counterattack to control land areas, including populations and resources."⁵³ The Abrams Main Battle Tank (most recent version in production: M1A2 SEPv3, first unit equipped in FY 2020)⁵⁴ and Bradley Fighting Vehicle (most recent version: M2A4, first unit equipped in FY 2020) are the primary combat platforms in Armored BCTs. There are two modernization levels of these two armored combat vehicles within the Army. (See Chart 6).

The M-1 tank and Bradley first entered service in 1980 and 1981, respectively. There are 87 M-1 Abrams tanks and 152 Bradley Fighting Vehicle variants in an ABCT.⁵⁵ Despite upgrades, the M-1 tank and the Bradley are now at least 40 years old, and their replacements will likely not arrive until the platforms are at least 50 years old.

Optionally Manned Fighting Vehicle (OMFV). The Army's replacement program for the Bradley, the Optionally Manned Fighting Vehicle, was on an aggressive timeline, but the Army cancelled the request for proposals in January 2020 and re-released a new RFP for what it calls a "concept design" in December 2020. As many as five proposals were scheduled to be awarded in June 2021 to companies to refine their designs,⁵⁶ and "[t]he Army now plans for the first unit to be equipped [with the OMFV] in the fourth quarter of FY2028."⁵⁷

New Tank? A potential replacement for the M-1 tank is even further down the road. The Army does not intend to decide "what direction we want to go for decisive lethality and survivability on the battlefield" until at least 2023.⁵⁸

Armored Multi-Purpose Vehicle (AMPV). Also part of an ABCT, the venerable M113 multi-purpose personnel carrier fills multiple roles like mortar carrier and ambulance. It entered service in 1960 and was scheduled to be replaced by the new Armored Multi-Purpose Vehicle (AMPV), which after delays has begun product qualification testing. As of May 20, 2021, BAE had delivered 31 AMPVs to the Army.⁵⁹ First fieldings for this system are now expected during the second quarter of FY 2023.⁶⁰ Apparently because of budget cuts, no procurement of the AMPV is proposed in the Army's FY 2022 budget request. It is unclear what the Army plans for this platform or whether its stated objective of 2,897 AMPVs will ever be reached.⁶¹

Stryker Brigade Combat Team (SBCT). The Stryker BCT "is an expeditionary combined arms force organized around mounted infantry" and is able to "operate effectively in most terrain and weather conditions" because of their rapid strategic deployment and mobility.62 Stryker BCTs are equipped with approximately 321 eight-wheeled Stryker vehicles.63 Relatively speaking, these vehicles are among the Army's newest combat platforms, having entered service in 2001. In response to an Operational Needs Statement, the Stryker BCT in Europe received Strykers fitted with a 30 mm cannon to provide an improved anti-armor capability.64 Based on the success of that effort, the Army decided to outfit at least three of its SBCTs equipped with the Double V-hull, which affords better underbody protection against such threats as improvised explosive devices (IEDs), with the 30 mm autocannon.65 The Army is also integrating Javelin anti-tank missiles on the Stryker platform.⁶⁶

Infantry Brigade Combat Team (IBCT). The Infantry BCT "is an expeditionary, combined arms formation optimized for dismounted operations in *complex terrain*—a geographical area consisting of an urban center larger than a village and/or of two or more types of restrictive terrain or environmental conditions occupying the same space."⁶⁷ Infantry BCTs have fewer vehicles and rely on lighter platforms such as trucks, High Mobility Multipurpose Wheeled Vehicles (HMMWVs), and Joint Light Tactical Vehicles (JLTVs) for mobility.



Army Armored Combat Vehicle Modernization

Joint Light Tactical Vehicle (JLTV). The Joint Light Tactical Vehicle (JLTV) combines the protection offered by Mine Resistant Ambush Protected Vehicles (MRAPs) with the mobility of the original unarmored HMMWV. The vehicle features design improvements that increase its survivability against anti-armor weapons and IEDs. The Army plans to procure 49,099 JLTVs over the life of the program, replacing about 50 percent of the current HMMWV fleet. As of May 20, 2021, the Army had fielded 4,543 JLTVs.⁶⁸

Requested FY 2022 funding of \$574.5 million would support procurement of 1,203 JLT-Vs and 1,541 trailers. This reflects a continued reduction in funding for this program (\$884 million was enacted for FY 2021) and illustrates the extreme budget pressures the Army is facing. Considering the 8,621 JLTVs the Army has already procured⁶⁹ and procurement at a rate of 1,203 vehicles per year starting in FY 2022, the Army will not reach its acquisition objective for the JLTV until 2055, forcing continued reliance on aging HMMWVs, which began fielding in 1983.⁷⁰

Mobile Protected Firepower (MPF). The Army is developing an armored gun system called Mobile Protected Firepower (MPF) to provide IBCTs with the firepower to engage enemy armored vehicles and fortifications. In 2020, the Army received 24 prototypes (12 each from General Dynamics Land Systems and BAE) for testing and evaluation, which will continue through June 2021. The first units are expected to receive MPF in FY 2025.⁷¹

Ground Mobility Vehicle (GMV). Airborne BCTs are the first IBCTs to receive a new platform to increase their speed and mobility. The Ground Mobility Vehicle (GMV) provides enhanced tactical mobility for an IBCT nine-soldier infantry squad with their associated equipment. GM Defense was selected for the production contract in June 2020. The Army has approved a procurement objective of 11 IBCT sets at 59 vehicles per IBCT (649 vehicles in total), to be completed by FY 2028. Ultimately, the Army will buy as many as 2,065 of these vehicles.⁷² As of May 20, 2021, 168 GMVs had been fielded to Army units.⁷³

Combat Aviation Brigade. Combat Aviation Brigades are composed of AH-64 Apache attack, UH-60 Black Hawk medium-lift, and CH-47 heavy-lift Chinook helicopters. The Army has been methodically upgrading these fleets for decades, but the FY 2022 budget request dramatically curtails the number of aircraft to be procured. This cutback in helicopter modernization, if enacted, would extend the

amount of time necessary to put aircraft crews in the latest version of these critical platforms. This is a continued reflection of downward budget pressure and incurs additional risk for the Army.

UH/HH-60. The acquisition objective for the H-60 medium-lift helicopter is 1,375 H-60Ms and 760 recapitalized 60-A/L/Vs for a total of 2,135 aircraft. The FY 2022 procurement request for the UH-60M is \$630.2 million, which would support the procurement of 24 aircraft (18 less than the 42 requested in FY 2021).⁷⁴ The most modernized variant, the UH/HH-60M, accounts for approximately 50 percent of the Army's H-60 medium helicopter fleet.⁷⁵

CH-47. The CH-47F Chinook, a rebuilt variant of the Army's CH-47D heavy-lift helicopter, has an acquisition objective of 550 aircraft and, with no replacement on the horizon, is expected to remain the Army's heavy-lift helicopter for the next several decades. The FY 2022 budget request of \$145.2 million would support the procurement of six aircraft, all of which would be the MH-47G special operations model.⁷⁶ The most recent model, the CH-47F, accounts for 89 percent of the 518 CH-47 helicopters currently in service.⁷⁷

AH-64. The AH-64E heavy attack helicopter has an acquisition objective of 791 aircraft, which is being met by the building of new aircraft and remanufacturing of older AH-64 models. The FY 2022 procurement request of \$504.1 million would support the purchase of 30 AH-64E aircraft,⁷⁸ 22 less than the 52 produced in FY 2021. This would likely terminate the AH-64E new-build line. Of the 740 AH-64 helicopters in service, 53 percent are the most recent variant, the AH-64E.⁷⁹

Overall, the Army's equipment inventory, while increasingly dated, is maintained well. Despite high usage in Afghanistan and Iraq, most Army vehicles are relatively "young" because the Army deliberately undertook and Congress funded a "reset" plan that includes "[r]epairing and reconditioning systems to bring them back to a satisfactory operating condition." Under its current modernization plans, for example, "the Army envisions [the M-1 Abrams Tank, the M-2/M-3 Bradley Fighting Vehicle (BFV), and the M-1126 Stryker Combat Vehicle] in service with Active and National Guard forces beyond FY 2028.⁷⁸⁰

In addition to seeing to the viability of today's equipment, the military must look to the health of future equipment programs. Although future modernization programs are not current hard-power capabilities that can be applied against an enemy force today, they are a leading indicator of a service's overall fitness for future sustained combat operations. In future years, the service could be forced to engage an enemy with aging equipment and no program in place to maintain viability or endurance in sustained operations.

The U.S. military services are continually assessing how best to stay a step ahead of competitors: whether to modernize the force today with currently available technology or wait to see what investments in research and development produce years down the road. Technologies mature and proliferate, becoming more accessible to a wider array of actors over time.

After years of a singular focus on counterinsurgency followed by concentration on the current readiness of the force, the Army is now playing catch-up in equipment modernization. Chairman of the Joint Chiefs of Staff General Mark Milley, for example, has said that China is "on a path...to be on par with the U.S. at some point in the future...."⁸¹ While his statement is intentionally ambiguous, General Milley was clearly conveying his concern about the pace of China's modernization and the very real danger that the U.S. military could lose its current advantages.

New Organizations and Emphasis on Modernization. The Army established a new four-star headquarters, Army Futures Command, to manage modernization and eight cross-functional teams (CFTs) to improve the management of its top modernization priorities.⁸² Army leadership—in particular the Under Secretary of the Army and the Vice Chief of Staff of the Army—devote an extraordinary amount of time to equipment modernization issues, but only time will tell whether the new structures, commands, and emphasis result in long-term improvement in modernization posture. The Army aspires to develop and procure an entire new generation of equipment based on its six modernization priorities: "Long Range Precision Fires, Next Generation Combat Vehicle, Future Vertical Lift, the Army Network, Air and Missile Defense, and Soldier Lethality."⁸³

Although the Army has put in place new organizations, plans, and strategies to manage modernization, the future is uncertain, and Army programs are in a fragile state, with only a few in an active procurement status. The Army has shown great willingness to make tough choices and reallocate funding toward its modernization programs, but usually at the expense of end strength or reduction in the total quantity of new items purchased. "There has been real progress in [modernization] over the last three or four years, but that progress is fragile," Lieutenant General James Pasquarette, a senior Army budget official, has warned. "We continue to fund [the top] priority programs at the cost of the other programs in the equipping portfolio."84

As DOD budget challenges for nuclear deterrence programs, rising personnel costs, health care, and the need to invest in programs to respond to China's increasingly aggressive activities present themselves, the Army desperately needs time and funding to modernize its inventory of equipment. Recent modernization programs seem to be on track except for the OMFV program, which needed a reboot. Limited numbers of Stryker vehicle-mounted Maneuver Short Range Air Defense (M-SHORAD) systems have been delivered to Europe.85 Army officials are currently optimistic about future fielding dates for equipment like the Extended Range Cannon Artillery, a hypersonic weapon firing battery, and the Precision Strike Missile, all of which are scheduled for delivery in FY 2023, but their success will depend on sustained funding.86

Readiness

BCT Readiness Reduced. Over the past four years, the Army has made progress in

increasing the readiness of its forces. Its goal is to have 66 percent of the Regular Army and 33 percent of National Guard BCTs at the highest levels of readiness. In FY 2021, however, BCT readiness declined, and if enacted, the FY 2022 budget's dramatic cuts in funding for Army training could lead to even bigger declines in the future.

As of May 20, 2021, the Army reported that "58 percent of Active Component Brigade Combat Teams are at the highest levels of tactical readiness," eight percentage points below their goal and 16 percentage points below last year's reported level. This means that 18 of the Army's 31 active BCTs were at either C1 or C2, the two highest levels of tactical readiness, and ready to perform all or most of their wartime missions immediately.⁸⁷ Last year's *Index* reported that 21 Regular Army BCTs were at the highest levels of readiness.

There has also been an apparent drop in readiness among National Guard BCTs from FY 2020 to FY 2021. Last year's *Index* estimated that four to five National Guard BCTs were at the highest levels of readiness. Now the Army reports that *no* National Guard BCTs are at the highest levels of readiness.⁸⁸

Of the Army's 11 Combat Aviation Brigades, eight (73 percent) are at the highest levels of readiness. This is relatively healthy.⁸⁹

Training Resources Slashed. In the FY 2022 budget request, funding for training activities has been reduced significantly. When measuring training resourcing, the Army uses full-spectrum training miles (FSTMs) for Brigade Combat Teams, representing the number of miles that formations are resourced to drive their primary vehicles on an annual basis. For Combat Aviation Brigades, the Army uses hours per crew per month ((H/C/M), reflecting the number of hours that aviation crews can fly their helicopters per month.

According to the Army's budget justification exhibits, "[t]he FY 2022 budget funds 1,109 Operating Tempo Full Spectrum Training Miles and 10.2 flying hours per crew, per month" to meet "required training readiness levels."⁹⁰ The FY 2022 proposed FSTM is significantly

Army Readiness: Brigade Combat Teams

Based on historical force requirements, The Heritage Foundation assesses that the Army needs a total of 50 Brigade Combat Teams (BCTs). Although the Army currently has 58 BCTs, only the 31 Regular Army BCTs have the necessary readiness to meet near-term and mid-term operation plan requirements.



* Includes four Army National Guard BCTs. **SOURCE:** Email from Headquarters, Department of the Army, G-3/5/7 Office to the author, May 25, 2021.

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lower (30 percent) than resourced levels of 1,598 miles and lower (5 percent) than the 10.8 flying hours enacted in the FY 2021 budget.

Training Level Goals Reduced. The Army is trying to cope with these reduced training resources by shifting training to lower echelons, which is less expensive. Its new strategy "focuses resources on squad, platoon and company level training to achieve highly trained companies."⁹¹ The FY 2022 budget justification books omit the Unit Proficiency Level Goal, which for years has been BCT; it is likely now battalion or company. In addition, the Army's major exercise, the DEFENDER series, is being cut back dramatically by \$339 million in FY 2022, shifting to an exercise in Europe in even years and an exercise in the Pacific in odd years.⁹²

CTC Rotations Chopped. The Army uses Combat Training Centers (CTCs) to train its forces to desired levels of proficiency. Specifically, this important program "provide[s] realistic joint and combined arms training... approximating actual combat" and increases
"unit readiness for deployment and warfighting."⁹³ The FY 2022 budget request reduces CTC rotations by 34 percent: For FY 2022, the Army requested resources for 17 CTC rotations (15 Regular Army and two National Guard); in FY 2021, the Army was resourced for 26 rotations (21 Regular Army and five National Guard).⁹⁴

New Readiness Model. The Army is transitioning from one readiness model to another. Its Sustainable Readiness Model, implementation of which began in 2017, was intended to give units more predictability. Its new Regionally Aligned Readiness and Modernization Model (ReARMM) is designed to "better balance operational tempo (OPTEMPO) with dedicated periods for conducting missions, training, and modernization."⁹⁵ ReARMM reportedly will feature six-month cycles to field new equipment and allocate units to specific theaters. The Army intends to shift to this new model on October 1, 2021.⁹⁶

In general, the Army continues to be challenged by structural readiness problems as evidenced by too small a force attempting to satisfy too many global presence requirements and Operations Plan (OPLAN) warfighting requirements. If demand is not reduced, funding cuts in the FY 2022 budget can be expected to result in a continued decline in readiness.

Scoring the U.S. Army

Capacity Score: Weak

Historical evidence shows that, on average, the Army needs 21 Brigade Combat Teams to fight one major regional conflict (MRC). Based on a conversion of roughly 3.5 BCTs per division, the Army deployed 21 BCTs in Korea, 25 in Vietnam, 14 in the Persian Gulf War, and approximately four in Operation Iraqi Freedoman average of 16 BCTs (or 21 if the much smaller Operation Iraqi Freedom initial invasion operation is excluded). In the 2010 Quadrennial Defense Review, the Obama Administration recommended a force capable of deploying 45 Active BCTs. Previous government force-sizing documents discuss Army force structure in terms of divisions and consistently advocate for 10-11 divisions, which equates to roughly 37 Active BCTs.

Considering the varying recommendations of 35–45 BCTs and the actual experience of nearly 21 BCTs deployed per major engagement, our assessment is that 42 BCTs would be needed to fight two MRCs.⁹⁷ Taking into account the need for a strategic reserve, the Army force should also include an additional 20 percent of the 42 BCTs, resulting in an overall requirement of 50 BCTs.

Previous editions of the *Index* had counted four Army National Guard BCTs in the overall

count of available BCTs. Because the Army reports that no Army National Guard BCTs are at the highest state of readiness, they are no longer counted in this edition of the *Index*. The Army has 31 Regular Army BCTs compared to a two-MRC construct requirement of 50. The Army's overall capacity score therefore remains unchanged from 2020.

- **Two-MRC Benchmark:** 50 Brigade Combat Teams.
- Actual FY2021 Level: 31 Regular Army Brigade Combat Teams.

The Army's current BCT capacity equals 62 percent of the two-MRC benchmark and thus is scored as "weak."

Capability Score: Marginal

The Army's aggregate capability score remains "marginal." This aggregate score is a result of "marginal" scores for "Age of Equipment," "Size of Modernization Programs," and "Health of Modernization Programs." More detail on these programs can be found in the equipment appendix following this section. The Army scored "weak" for "Capability of Equipment." Despite modest progress with the JLTV and AMPV, and in spite of such promising developments as creation of Army Futures Command, CFTs, and the initiation of new Research, Development, Testing and Evaluation (RDTE) funded programs, new Army equipment programs remain in the development phase and in most cases are two to three years from entering procurement phases. FY 2022 requested funding levels would lead to reductions in numerous equipping programs: helicopter modernization, AMPV, JLTV, HEMMT, and others. The result would be an Army that is aging faster than it is modernizing.

Readiness Score: Very Strong

The Army reports that 58 percent (18) of its 31 Regular Army BCTs are at the highest state of readiness.⁹⁸ No National Guard BCTs are at

those levels of readiness. The Army's internal requirement for Regular Army BCT readiness is 66 percent, or 20.5 BCTs.⁹⁹ Using the assessment methods of this *Index*, this results in a percentage of service requirement of 87 percent, or "very strong."

Overall U.S. Army Score: Marginal

The Army's overall score is calculated based on an unweighted average of its capacity, capability, and readiness scores. The unweighted average is 3.33; thus, the overall Army score is "marginal." This was derived from the aggregate score for capacity ("weak"); capability ("marginal"); and readiness ("very strong"). This score is the same as the assessment of the 2021 *Index*, which also rated the Army as "marginal" overall.

U.S.	Military	Power:	Army	

	VERY WEAK	WEAK	MARGINAL	STRONG	VERY STRONG
Capacity		×			
Capability			 Image: A second s		
Readiness					 ✓
OVERALL			 Image: A second s		



Main Battle Tank

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
M1A1/2 Abrams			Decisive Lethality Platform (DLP)		
Inventory: 678/1619 Fleet age: 30.5/13.5 Date: 1980/1993			The DPL program is intended to replace the tank. This program is part of the Next Gene	Abrams ration Cor	nbat
The Abrams is the main battle tank used by the Army in its armored brigade combat teams (BCTs). Its main benefits are lethality, protection, and mobility. The Abrams went through a remanufacture program to extend its life to 2045.	3	4	Vehicle (NGCV) program, which is number Army's "Big Six" modernization priorities. replacement for the Abrams tank could be 2030.	two amon The soone introduced	g the st a d is

Infantry Fighting Vehicle

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
M2 Bradley			Optionally Manned Fighting Vehicle (OMFV)		
Inventory: 4,006 Fleet age: 20 Date: 1981 The Bradley is a tracked vehicle meant to transport infantry and provide covering fire. The Bradley complements the Abrams tank in armored BCTs. The Bradley underwent a remanufacture program to extend its life to 2045.	3	3	In March 2019, the Army issued a request fo build prototypes of the OMFV, but it then di and cancelled the solicitation in January 20 now redefining the requirements and intend designs from companies in mid to late 2020 has likely slipped to first fieldings in 2028. T is part of the Next Generation Combat Vehic program, which is number two among the A modernization priorities	r proposal d an abou 20. The Ar Is to seek). The prog his progra cle (NGCV Army's "Big	ls to t-face my is digital gram m) g Six"

Armored Fighting Vehicle

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
Stryker			None		
Inventory: 4,859 Fleet age: 10 Date: 2001					
The Stryker is a wheeled vehicle that is the main platform in Stryker BCTs. The program was considered an interim vehicle to serve until the arrival of the Future Combat System (FCS), but that program was cancelled because of technology and cost hurdles. The original Stryker is being replaced with a double-v hull (DVH) configuration to increase survivability and a 30mm gun to increase lethality. Its components allow for rapid acquisition and fielding. The Stryker is expected to remain in service for 30 years.	4	4			

NOTE: See page 379 for details on fleet ages, dates, and procurement spending.

Armored Personnel Carrier

PLATFORM	Age Score	Capability Score	REPLACE	Size Score	Health Score		
M113 Armored Personnel Carrier			Armored	Multi-Purpose Ve	hicle (AMPV)		
Inventory: 4,339 Fleet age: 36 Date: 1960			Timeline:	2018-TBD		2	3
The tracked M113 serves in a supporting role for armored BCTs and in units above brigade level. The APC is being replaced by the Armored Multi Purpose Vehicle (AMPV). Plans are to use the	0	2	The AMPV has been adapted from the Brac Vehicle which largely allowed the program technology development phase. The fleet v variants. The first unit is set to be equipped		lley Fighti to bypass vill consist at the end	ng the of five d of 2021.	
platform until 2045.			PROCURE	MENT	SPENDING (\$ millions)	
			474	2,391	\$2,666	\$11,126	

Light Wheeled Vehicle

PLATFORM	Age Score	Capability Score	REPLACEM	Size Score	Health Score		
HMMWV			Joint Light	Tactical Vehicle	e (JLTV)		
Inventory: 99,800 Fleet age: 18 Date: 1985			Timeline: 20	Timeline: 2015–2036			
The HMMWV is used to transport troops and for a variety of other purposes (for example, as ambulances). Its expected life span is 15 years. A portion of the HMMWV fleet will be replaced by the Joint Light Tactical Vehicle (JLTV).	2	0	The JLTV vehicle program replaces some HMMWVs and provides improved protect survivability of vehicles. This is a joint proy USMC. In June 2019, the Army approved t production. Production is underway. Curre have forced the Army to reduce procuren		replaces some of proved protectio is is a joint progra my approved the nderway. Curren duce procureme	the Army n, reliabilit am with the JLTV for t budget nt quantit	r's ty, and he full-rate shortfalls ies.
			PROCOREP		SPENDING (p IIIIIIOIIS)	
			13,438	35,661	\$6,492	\$19,219	





Attack Helicopter

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
AH-64 D Apache Inventory: 381 Fleet age: 14.5 Date: 1997			AH-64E Reman Timeline: 2010-TBD	3	5
The Apache is found in Combat Aviation Brigades and is the Army's attack helicopter. It can destroy armor, personnel, and material targets. Its expected life cycle is approximately 20 years.	2	3	The AH-64E Reman (short for remanufact program to remanufacture older Apache h the more advanced AH-64E version. The A more modern and interoperable systems a to carry modern munitions, including the PROCUREMENT* 431 189 SPENDING*	ured) is a helicopters AH-64E w and will be IAGM miss (<i>\$ millions</i> , 9 \$3	s into ill have a able sile.)
AH-64E Inventory: 351 Fleet age: 4 Date: 2012			AH-64E New Build Timeline: 2010-2027	3	6
The AH-64E variant is a remanufactured version with substantial upgrades in power plant, avionics, communications, and weapons capabilities. Its expected life cycle is approximately 20 years.	6	6	The AH-64E New Build program produces n not rebuilt, Apaches. The program is meant and sustain the current Apache inventory. Th has more modern and interoperable system to carry modern munitions, including the JA PROCUREMENT* SPENDING* 79 2 \$	ew-build, to modern ne AH-64E s and is ab GM missile (\$ millions, 2,404	iize le 2.

* Additional procurement expected.





Medium Lift

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
UH-60A Black Hawk Inventory: 157 Fleet age: 36.5 Date: 1978			UH-60M Black Hawk Timeline: 2004-TBD	3	5
The UH-60A is a utility helicopter that provides air assault and aeromedical evacuation and supports special operations. Its expected life span is approximately 25 years. This variant of the Black Hawk is now being replaced by the newer UH-60M variant.	0	2	The UH-60M, currently in production, is inimodernize and replace current Black Haw newer M-variant will improve the Black Ha lift by upgrading its rotor blades, engine, a PROCUREMENT* SPENDING*	tended to k inventor wk's rang ind compu- (\$ millions) 5 \$6	ries. The e and uters.)
UH-60L Black Hawk			UH-60V Black Hawk		
Inventory: 958 Fleet age: 14.5 Date: 1989 The UH-60L is the follow-on to the UH-60A helicopter. As the UH-60A is retired, the M-variant will be the main medium-lift rotorcraft used by the Army. They are expected to remain in service at least until 2030.	3	3	Timeline: 2021–TBD The Army plans to upgrade the older mod UH-60V configuration, which incorporates like the one on the UH-60M. This is an Arm measure because it is cheaper to make a U 60L than it is to buy a new UH-60M. PROCUREMENT* SPENDING* 3	el UH-60I ; a digital ny cost-sa JH-60V fro (<i>\$ millions</i> N/A	4 L to the cockpit ving om a UH-
UH-60M Black Hawk					
Inventory: 1,070 Fleet age: 7.5 Date: 2005					
The UH-60M is the follow-on to the UH- 60A helicopter. As the UH-60A is retired, the M-variant will be the main medium- lift rotorcraft used by the Army. They are expected to remain in service at least until 2030.	5	4			





Heavy Lift

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
CH-47F Chinook Inventory: 439 Fleet age: 9 Date: 2002			CH-47F Timeline: 2001-TBD	3	5
The F-variant includes a new digital cockpit and monolithic airframe to reduce vibrations. It transports forces and equipment while providing other functions such as parachute drops and aircraft recovery. Its expected life span is 35 years. The Army plans to use the CH-47F until the late 2030s.	6	6	Currently in production, the CH-47F progr to keep the fleet of heavy-lift rotorcraft he variants of the CH-47, notably the CH-47D The program includes both remanufacture builds of CH-47s. The F-variant has engine upgrades to lower its maintenance require Total procurement numbers include the M configuration for U.S. Special Operations (am is inte althy as o , are retire ed and nev and airfra ments. H-47G Command	nded Ider 2d. N ame
MH-47G			PROCUREMENT* SPENDING	* (\$ millior	ıs)
Inventory: 67 Fleet age: 9 Date: 2014 The MH-47G is a special operations variant of the CH-47 Chinook multi-role helicopter used in heavy-lift missions such as the transportation of troops, ammunition, vehicles, equipment, fuel, and supplies, as well as civil and humanitarian relief missions. The helicopter can conduct long-range missions at low levels and in adverse weather conditions, both during the day and at night.	6	6	1,183 172 \$1,369	\$25,517	

Intelligence, Surveillance, and Reconnaissance (ISR)

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
MQ-1C Gray Eagle			MQ-1C Gray Eagle		
Inventory: 158 Fleet age: 4.5 Date: 2011			Timeline: 2010–2022	3	5
The Gray Eagle is a medium-altitude long-endurance (MALE) unmanned aerial vehicle (UAV) used to conduct ISR missions. The use of MALE UAVs is a new capability for the Army. The Gray Eagle is currently in production.	4	4	The MQ-1C UAV provides Army reconnaissa surveillance, and target acquisition capabili is continuing to procure MQ-1Cs to replace PROCUREMENT SPENDING (277	ance, ties. The A combat lo (\$ <i>millions</i>) 66,140	Army sses.) \$1

* Additional procurement expected.

NOTES: See Methodology for descriptions of scores. Fleet age is the average between the first and last years of delivery. The date is the year of first delivery. The timeline is from the first year of procurement to the last year of delivery/procurement. Spending does not include advanced procurement or research, development, test, and evaluation (RDT&E).

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U.S. Navy Brent Sadler

The Navy's enacted budget for fiscal year (FY) 2021 was \$162.9 billion. The goal was to balance readiness, lethality, and capacity so that the Navy could be "agile and ready to fight today while also committing to the training, maintenance, and modernization to ensure [that it] can fight and win tomorrow."¹ The proposed FY 2022 Navy budget is \$163.9 billion for an overall increase of 1 percent.²

The budget themes for the Department of the Navy (which includes both the U.S. Navy and the U.S. Marine Corps) under the Biden Administration are "Defend the Nation" (to include "rapid innovation"); "Take Care of Our People" (to include "building resilience and readiness"); and "Succeed through Teamwork."³ Unfortunately, the Navy is under immense strain to maintain readiness for combat while also conducting the daily operations necessary in peacetime to compete with the activities of China and Russia.

In the year since publication of the 2021 Index of U.S. Military Strength, there have been several significant developments that are important to the Navy.

- COVID-19 vaccines have been approved, enabling officers and sailors to be vaccinated at higher rates relative to the national average.
- In late April 2021, the Navy conducted its first multi-platform manned-unmanned fleet experiment, Integrated Battle Problem 21 (UxS IBP21).

- Highlighting the importance of maritime choke points to national security, on March 23, 2021, container ship *Ever Given* ran aground in the Suez Canal and stopped the flow of maritime traffic through the canal for 11 days, delaying transit of the *Eisenhower* Carrier Strike Group.⁴
- Because of a catastrophic fire in mid-July 2020, USS *Bonhomme Richard* (LHA-6) was decommissioned just halfway through its planned service life.

Strategic Framework. The Navy, Marine Corps, and Coast Guard (known collectively as the sea services) have enabled the U.S. to project power across the oceans, controlling activities on the seas when and where needed. To address today's maritime competition more effectively, the sea services have released a new naval strategy, *Advantage at Sea*. If the new strategy is executed, the Navy will be conducting more assertive forward presence operations to challenge Chinese and Russian maritime coercion.⁵

As the U.S. military's primary maritime arm, the Navy will provide the enduring forward global presence required of this strategy while retaining war-winning forces. The Navy therefore continues to focus its investments in several functional areas: power projection, control of the seas, maritime security, strategic deterrence, and domain access. This approach is informed by several key documents:

- The 2021 Interim National Security Strategic Guidance;⁶
- The December 2020 Advantage at Sea naval strategy;⁷
- The 2018 National Defense Strategy (NDS);⁸ and
- The Global Force Management Allocation Plan (GFMAP).⁹

U.S. official strategic guidance increasingly requires the Navy to act beyond the demands of conventional warfighting. China and Russia use their fleets to establish a physical presence in regions that are important to their economic and security interests in order to influence the policies of other countries. To counter their influence, the U.S. Navy similarly sails ships in these waters to reassure allies of U.S. commitments and to signal to competitors that they do not have a free hand to impose their will. This means that the Navy must balance two key missions: ensuring that it has a fleet ready for war while also using that fleet for peacetime "presence" operations. Both missions require crews and ships that are materially ready for action and a fleet that is large enough to maintain presence and marshal enough combat power to win in battle.

This *Index* focuses on the following elements as the primary criteria by which to measure U.S. naval strength:

- Sufficient **capacity** to defeat enemies in major combat operations and provide a credible peacetime forward presence to maintain freedom of shipping lanes and deter aggression;
- Sufficient technical **capability** to ensure that the Navy is able to defeat potential adversaries; and
- Sufficient **readiness** to ensure that the fleet can "fight tonight" given proper material maintenance, personnel training, and physical well-being.

Capacity

Force Structure. The Navy is unique relative to the other services in that its capacity requirements must meet two separate objectives:

- 1. During peacetime, the Navy must maintain a global presence in distant regions both to deter potential aggressors and to assure allies and security partners.
- 2. The Navy must be able to win wars. To this end, the Navy measures capacity by the size of its battle force, which is composed of ships it considers directly connected to combat missions.¹⁰

This *Index* continues the benchmark set in the *2019 Index*: 400 ships to ensure the capability to fight two major regional contingencies (MRCs) simultaneously or nearly simultaneously, plus a 20 percent strategic reserve, and historical levels of 100 ships forward deployed in peacetime.¹¹ This 400-ship fleet is centered on providing:

- 13 Carrier Strike Groups (CSGs);
- 13 carrier air wings with a minimum of 624 strike fighter aircraft;¹² and
- 15 Expeditionary Strike Groups (ESGs).¹³

Unmanned platforms are not included because they have not matured as a practical asset. They hold great potential and will likely be a significant capability, but until they are developed and fielded in larger numbers, their impact on the Navy's warfighting potential remains speculative. The same holds true across the fleet when it comes to new classes of ships. The Navy is investing in research, modeling, war gaming, and intellectual exercises to improve its understanding of the potential utility of new ship and fleet designs. Consequently, this Index measures what is known and can be known in naval affairs, assessing the current Navy's size, modernity, and readiness to perform its most important missions today.



Key U.S. Naval Installations

- **Joint Base Pearl Harbor-Hickham, HI** U.S. Pacific Fleet headquarters
- 2 Naval Base Kitsap, WA
- **3** Naval Station Everett, WA
- A Naval Base San Diego and Naval Base Coronado, CA U.S. Third Fleet headquarters
- 5 Naval Station Mayport, FL U.S. Fourth Fleet headquarters
- 6 Naval Submarine Base King's Bay, GA
- Naval Base Norfolk and Joint Expeditionary Base Little Creek, VA U.S. Fleet Forces Command and U.S. Second Fleet headquarters
 Naval Submarine Base New London, CT
- 8 Naval Submarine Base New London, CT
- 9 Keflavik, Iceland—Expeditionary Maritime Operations Center
- 10 Naval Station Rota, Spain
- 11 Naval Support Activity Gaeta, Italy U.S. Sixth Fleet headquarters

NOTE: Fleet boundaries are approximate. **SOURCE:** Heritage Foundation research.

- 12 Naval Support Activity, Bahrain U.S. Fifth Fleet headquarters
- 13 Lemonnier, Djibouti—Camp Lemonnier
- 14 Diego Garcia—Navy Support Facility Diego Garcia
- 5 Singapore—Commander Logistics Group Western Pacific
- Buson, South Korea—Fleet Activities Chinhae Navy Base
- U.S. Fleet Activity Yokosuka, Japan U.S. Seventh Fleet headquarters
- 18 U.S. Fleet Activity Sasebo, Japan
- 19 Okinawa, Japan—Naval Base White Beach
- 20 Naval Base Guam—Navy Expeditionary Force Command Pacific headquarters
- 21 Darwin, Australia—Marine Rotational Force Darwin

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MAP 17

Steaming Times to Areas of Vital U.S. National Interest

Steam times are approximate based on an average speed of 15 knots.



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* Assumes no delay in passage through the Panama Canal. SOURCE: Heritage Foundation research. Relative to the above metric, the Navy's current fleet of 297 warships is inadequate and places greater strain on the ability of ships and crews to meet existing operational requirements. To alleviate the operational stress on an undersized fleet, the Navy has attempted since 2016 to build a larger fleet. However, for myriad reasons, it has been unable to achieve sustained growth. In the past, the Navy has had some success in meeting operational requirements with fewer ships by posturing ships forward as it has done in Rota, Spain, and Guam.

Posture/Presence. Although the Navy remains committed to sustaining forward presence, it has struggled to meet the requests of regional Combatant Commanders. The result has been longer and more frequent deployments to meet a historical steady-state forward presence of 100 warships.14 At the height of the Cold War in 1985, the percentage of the 571-ship fleet deployed was less than 15 percent, and throughout the 1990s, deployments seldom exceeded the six-month norm: Only 4 percent to 7 percent of the fleet exceeded six-month deployments on an annual basis.¹⁵ Using the Navy's aircraft carrier fleet-the most taxed platform-as a sample set, for 20 years, approximately 25 percent of the aircraft carrier fleet has been deployed. Following the 2017 deadly collisions involving USS McCain and USS Fitzgerald, this dropped temporarily to less than 20 percent, but it surged again to almost 30 percent in 2020.16

The numbers as of July 12, 2021, are fairly typical for a total battle force of 297 deployable ships with 83 warships at sea: 58 deployed and underway and 25 underway on local operations for an operational tempo (OPTEMPO) of 28 percent, nearly double the OPTEMPO that characterized the Cold War.¹⁷ Given Combatant Commanders' requirements for naval presence, there is impetus to have as many ships forward deployed as possible by:

• **Homeporting.** The ships, crew, and their families are stationed at the port or based abroad (e.g., a CSG in Yokosuka, Japan).

Forward Stationing. Only the ships are based abroad while crews are rotated out to the ship.¹⁸ This deployment model is currently used for Littoral Combat Ships (LCS) and *Ohio*-class guided missile submarines (SSGNs) manned with rotating blue and gold crews, effectively doubling the normal forward deployment time (e.g., LCS in Singapore).

These options allow one forward-based ship to provide a greater level of presence than four ships based in the continental United States (CONUS) can provide by offsetting the time needed to transit ships to and familiarize their crews with distant theaters.¹⁹ This is captured in the Navy's GFM planning assumptions: a forward-deployed presence rate of 19 percent for a CONUS-based ship compared to a 67 percent presence rate for an overseashomeported ship.²⁰ To date, the Navy's use of homeporting and forward stationing has not mitigated the reduction in overall fleet size on forward presence.

Shipbuilding Capacity. To meet stated fleet-size goals, the Navy must build and maintain ships. Significant shortfalls in shipyards, both government and commercial, make both of these tasks hard to accomplish, and underfunded defense budgets make accomplishing them even more difficult. Given the limited ability to build ships, the Navy will struggle to meet the congressionally mandated 355ship goal,²¹ much less the 400 ships called for in this *Index*.

A bright spot in FY 2020 was the Navy's procurement of 12 ships, which marked a high point in shipbuilding over the past 20 years.²² However, subsequent procurement has not kept pace. The Navy purchased 10 new warships in FY 2021 and will purchase another eight in FY 2022,²³ but it will not meet congressional mandates for a fleet of 12 aircraft carriers.²⁴ Instead, the aircraft carrier fleet could shrink to nine (possibly augmented by a light carrier yet to be defined).²⁵

Meanwhile, diminished demand for ships has led shipbuilders to divest workforce and

delay capital investments. From 2005 to 2020, the Navy's procurement of new warships increased the size of the fleet from 291 to 296 warships; at the same time, China's navy grew from 216 to 360 warships.26 If the Navy is to build a larger fleet, more shipbuilders will have to be hired and trained-a lengthy process that precedes any expansion of the fleet. Sadly, labor statistics from 2017 to 2020 show trends in the opposite direction with total shipbuilding labor involved in production, like welders and pipefitters, shrinking 3 percent for a loss of 1,950 workers and wages falling relative to inflation.²⁷ The consequence is a reduction in the shipbuilding sector's capacity to meet emergent demands from the Navy.

Of particular concern is the increased production of nuclear-powered warships, most notably nuclear-powered submarines that would be vital in any conflict with China. Limited nuclear shipbuilding capacity28 may constrain the Navy's plans to increase the build rate from two attack submarines to three while concurrently building one ballistic missile submarine.²⁹ To support a larger nuclear-powered fleet, the relevant public shipyards have increased their workforce by 16 percent since 2013.30 However, as demand increases for nuclear-powered warships to pace the threat from China and Russia into the foreseeable future, it remains to be seen whether the public shipyards will be able to sustain the recruitment of skilled labor in the numbers needed.

As it stands today, the most senior naval officer, the Chief of Naval Operations (CNO), has admitted that current funding will not build or maintain the larger fleet that both the Navy and this *Index* say is needed and Congress has mandated. At best, the Navy has assessed that it will only be able to maintain a fleet of "about 300 to 305 ships."³¹

Manpower. In 2018, the Navy assessed that its manpower would need to grow by approximately 35,000 to achieve an end strength of 360,395 sailors to support a 355-ship Navy;³² for comparison, the last time the Navy had a similar number of ships was in 1997, when it had 359 ships and 398,847 officers and sailors.³³ As of June 10, 2021, the Navy consisted of 342,911 officers and sailors, 17,484 short of the number needed by 2034.³⁴ To improve personnel readiness and meet the demands of a growing fleet, the Navy added 5,100 sailors in FY 2020.³⁵ The FY 2021 budget continued these increases in active-duty manning end strength by an additional 7,300 sailors.³⁶ The Navy recently exceeded retention and recruitment goals for FY 2020 and appears to be on track to meet its FY 2021 recruitment goals. It remains to be seen, however, whether high retention and recruitment rates can be sustained to meet long-range manning needs.

Despite the acknowledged need to increase the Navy's cadre of officers and enlisted sailors, the President's FY 2022 budget goes in the opposite direction for the first time in years. This proposed budget reduces the Navy's end strength by 1,600 officers and sailors in the Active component and 200 in the reserves while increasing the civilian workforce by 1,141 fulltime employees.³⁷ Moreover, under the theme of "Take Care of Our People," it shrinks higher education funding by \$117 million and other "key educational programs" such as the Reserve Officer Training Corps (ROTC) by another \$4 million.³⁸ Such reductions are surprising in view of the Government Accountability Office's recent findings that persistent crew manning shortfalls on ships are as high as 15 percent and compound crew fatigue, which was a contributing factor in several fatal collisions in 2017.39

Finally, the effort to attract people to join the Navy is made more difficult by wages that are not keeping up with civilian wages. It is therefore not helpful that a 2.7 percent pay raise is planned in FY 2022 at a time when inflation continues to increase: On August 11, 2021, the U.S. Bureau of Labor Statistics reported that "[t]he all items index rose 5.4 percent for the 12 months ending July, the same increase as the period ending July."⁴⁰

Capability

A complete measure of naval capabilities requires an assessment of U.S. platforms against enemy weapons in plausible scenarios. The

Navy Fleet Design

	Starting Point	Reco	mmenda	Navy (Dec.	Plan 2020)	Range per Future Naval	
	Jan. 2021	2023	2028	2035	2023	2035	Force Study
Unmanned (LUSV, MUSV, XLUUV)	0	9	48	136	2	110	143 to 242
Aircraft Carriers (CVN, CVNE, CVS)	11	11	12	15	11	11	8 to 17
Large Surface Combatant	91	103	111	94	92	86	73 to 88
Small Surface Combatant	30	32	38	56	37	58	60 to 67
Logistics and Support Vessels	63	71	98	135	70	96	96 to 117
Submarines (SSBN, SSGN, SSN)	68	78	77	82	72	74	84 to 90
Amphibious Warships	33	34	42	57	28	52	61 to 67
Total Without Unmanned	296	329	378	439	310	377	382 to 446
Total	296	338	426	575	312	487	525 to 688

SOURCES: U.S. Navy, Office of the Chief of Naval Operations, Deputy Chief of Naval Operations (Warfighting Requirements and Capabilities–OPNAV N9), *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels*, December 9, 2020, https://media.defense.gov/2020/Dec/10/2002549918/-1/-1/1/SHIPBUILDING%20PLAN%20DEC%20 20_NAVY_OSD_OMB_FINAL.PDF (accessed August 19, 2021), and Heritage Foundation research.

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Navy routinely conducts war games, exercises, and simulations to assess this, but insight into its assessments is limited by their classified nature. This *Index* therefore assesses capability based on remaining hull life, mission effectiveness, payloads, and the feasibility of maintaining the platform's technological edge.

Most of the Navy's fleet consists of older platforms; of the Navy's 20 classes of ships, only eight are in production. However, across the Department of the Navy's \$211.7 billion FY 2022 budget,⁴¹ investment in future capability will see the largest real dollar increase (\$2.5 billion) and relative increase (12.4 percent) over the previous year.⁴² The following are highlights by platform.

Ballistic Missile Submarines (SSBN). The *Columbia*-class will relieve the aging *Ohio*-class SSBN fleet. Because of the implications of this for the nation's strategic nuclear deterrence, the *Columbia*-class SSBN remains the Navy's top acquisition priority. To ensure the continuity of this leg of the U.S. nuclear triad, the first *Columbia*-class SSBN must be delivered on time for its first deterrent patrol in 2031.⁴³ To achieve this goal, the Navy signed a \$9.47 billion contract in November 2020 with General Dynamics Electric Boat for the first inclass boat and advanced procurement for longlead-time components of the second hull.⁴⁴

Nuclear Attack Submarines (SSN). SSNs are multi-mission platforms whose stealth enables clandestine intelligence collection; surveillance; anti-submarine warfare (ASW); anti-surface warfare (ASuW); special operations forces insertion and extraction; land attack strikes; and offensive mine warfare. The newest class of SSN, the Block V *Virginia* with the Virginia Payload Module (VPM) enhancement, is important to the Navy's overall strike



U.S. vs. China and Russia Navies: Fleet Expansion Trends

NOTE: U.S. figures are actual through 2020. Figures for 2025 and 2030 are from the Navy's December 2020 30-year shipbuilding plan. See U.S. Navy, Office of the Chief of Naval Operations, Deputy Chief of Naval Operations (Warfighting Requirements and Capabilities–OPNAV N9), *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels*, December 9, 2020, https://media.defense.gov/2020/Dec/10/2002549918/-1/-1/1/SHIPBUILDING%20PLAN%20DEC%2020_NAVY_OSD_OMB_FINAL.PDF (accessed September 3, 2021).

SOURCES:

- Figure 1, "Growth of China's Maritime Forces Since 2000," in U.S. Department of the Navy, U.S. Marine Corps, and U.S. Coast Guard, *Advantage at Sea: Prevailing with Integrated All-Domain Naval Power*, December 2020, p. 4, https://media.defense.gov/2020/ Dec/16/2002553074/-1/-1/0/TRISERVICESTRATEGY.PDF (accessed September 2, 2021).
- Table 2, "Numbers of Chinese and U.S. Navy Battle Force Ships, 2000–2030," in Ronald O'Rourke, "China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress," Congressional Research Service *Report for Members and Committees of Congress* No. RL33153, updated January 27, 2021, p. 32, https://crsreports.congress.gov/product/pdf/ RL/RL33153/248 (accessed September 2, 2021).
- U.S. Navy, Office of Naval Intelligence, *The Russian Navy: A Historic Transition*, December 2015, https://nuke.fas.org/guide/russia/ historic.pdf (accessed September 2, 2021).
- Michael A. McDevitt, Rear Admiral, U.S. Navy (Ret.), prepared statement in hearing, *Department of Defense's Role in Competing with China*, Committee of Armed Services, U.S. House of Representatives, 116th Cong. 2nd Sess., January 15, 2020, pp. 76–88, https://www.govinfo.gov/content/pkg/CHRG-116hhrg40508/pdf/CHRG-116hhrg40508.pdf (accessed September 2, 2021).

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capacity, enabling the employment of an additional 28 Tomahawk cruise missiles over earlier SSN variants.⁴⁵

The FY 2021 National Defense Authorization Act included additional funds for advanced procurement that preserves a future option to buy as many as 10 *Virginia*-class submarines through FY 2023. As indicated previously, increasing *Virginia*-class production has raised concerns regarding strain on the industrial base. Complicating matters is the recently revealed premature replacement



U.S. vs. China and Russia Navies: Hull Classes

* USN ballistic missile submarines are not included because their mission is strategic deterrence, which makes it unlikely that they will be employed in a combat zone.

SOURCES:

- Michael A. McDevitt, Rear Admiral, U.S. Navy (Ret.), prepared statement in hearing, *Department of Defense's Role in Competing with China*, Committee of Armed Services, U.S. House of Representatives, 116th Cong. 2nd Sess., January 15, 2020, pp. 76–88, https://www.govinfo.gov/content/pkg/CHRG-116hhrg40508/pdf/CHRG-116hhrg40508.pdf (accessed September 2, 2021).
- Graphic, "Major Naval Units," in U.S. Department of Defense, Office of the Secretary of Defense, Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2020, p. 49, https://media.defense.gov/2020/Sep/01/ 2002488689/-1/-1/1/2020-DOD-CHINA-MILITARY-POWER-REPORT-FINAL.PDF (accessed September 3, 2021).
- International Institute for Strategic Studies, *The Military Balance 2021: The Annual Assessment of Global Military Capabilities and Defence Economics* (London: Routledge, 2021), pp. 196–199, 235–237, and 261–263, https://www.iiss.org/publications/the-military-balance (accessed September 3, 2021).

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of parts that were intended to last for the life of the boat. That such life-of-ship parts had to be replaced further taxes the ability of suppliers to meet the demand for new SSNs.⁴⁶

Aircraft Carriers (CVN). The Navy has 11 nuclear-powered aircraft carriers: 10 *Nimitz*class and one *Ford*-class. The Navy has been making progress in overcoming nagging issues with several advanced systems, notably the advanced weapons elevators, but has not announced any delay in USS *Ford*'s first operational deployment in FY 2022.⁴⁷ The second ship in the class, USS *John F. Kennedy* (CVN 79), christened on December 7, 2019, is more than 76 percent complete. Given recent shifts in shipyard workloads due to later than anticipated *Kennedy* construction and planned *Nimitz* overhaul, the Navy recently renegotiated the *Kennedy* to single-phase contracting, which is intended to ensure that the ship is ready to support F-35C fighters before its anticipated delivery to the fleet on June 30, 2024.⁴⁸

Large Surface Combatants. The Navy's large surface combatants consist of the *Ticonderoga*-class cruiser, the *Zumwalt*-class destroyer, and the *Arleigh Burke*-class destroyer. If

U.S. vs. China and Russia Navies: Missile Density



NOTES: Numbers of launchers do not include reloads. Launchers include torpedo tubes, vertical launch tubes (submarine and surface ships), and mounted canister launchers.

SOURCES: U.S. Navy, Office of Information, "Fact Files," https://www.navy.mil/Resources/Fact-Files/ (accessed September 3, 2021), and Naval Sea Systems Command, Naval Vessel Register, "Ship Battle Forces," https://www.nvr.navy.mil/NVRSHIPS/SHIPBATTLEFORCE.HTML (accessed September 3, 2021).

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the Navy executes the President's FY 2022 budget, it will decommission "15 Battle Force Ships" including seven cruisers.⁴⁹ The effect is a measurable reduction of the fleet's aggregate firepower of 854 vertical launch tubes for launching strike and defensive weapons—a 9 percent reduction of overall surface fleet firepower. Attempts to extend the life of the aging *Ticonderoga*-class cruisers have yielded mixed results as deferred upgrades and past incomplete maintenance are now driving up operating costs.⁵⁰

In FY 2022, the Navy intends to procure one *Arleigh Burke*–class DDG 51 destroyer; there is no intention of resuming construction of *Zumwalt* destroyers beyond the three previously purchased and being built out. The first *Zumwalt* destroyer (DDG-1000) was delivered on April 24, 2020; the second, USS *Michael Monsoor* (DDG-1001), was commissioned on January 26, 2019; and the third, USS *Lyndon B. Johnson* (DDG-1002), should complete construction in November 2021.⁵¹ The *Zumwalt* was to achieve initial operational capability (IOC) by September, but it is more likely that IOC will be achieved in December 2021.⁵²

To reach 355 ships by 2034, the Navy plans several class-wide service life extensions, notably the extension of DDG-51-class service life from 35 to 40 years and modernization of older hulls. The FY 2020 budget included \$4 billion for modernization of 19 destroyers from FY 2021 through FY 2024.⁵³ The previously noted decommissioning of seven cruisers in FY 2022 makes this more critical. **Small Surface Combatants.** The Navy's small surface combatants consist principally of the *Avenger*-class mine countermeasures (MCM) ship; the Littoral Combat Ship (LCS); and the *Constellation*-class frigate (FFG), which has just begun production in 2021. In January 2021, the Navy halted production of the mono-hull *Freedom*-variant of LCS until issues involving the design of its propulsion system are resolved. In the meantime, the top speed of affected ships (currently 40-plus knots) is reportedly limited to 34 knots.⁵⁴ To-day's fleet of 23 LCS (10 *Freedom*-variant and 13 *Independence*-variant) is expected to grow to 34 hulls, to be joined by 18 frigates by FY 2034.⁵⁵

On August 20, 2020, the Navy decommissioned three of its aging *Avenger*-class MCM ships, leaving eight in service overseas in Sasebo, Japan, and Manama, Bahrain. These represent the only dedicated ships countering the mine threat.⁵⁶ The FY 2020 budget accelerated retirement of all *Avenger*-class MCMs by FY 2023.⁵⁷ In what could be a reversal of that decision, the current long-range shipbuilding plan will retain the last four ships of the class in Sasebo, Japan, through 2024.⁵⁸

As these ships reach the end of their service life, the Navy is relying on the development of mine countermeasure mission packages (MPs) for the LCS to provide this capability, which will not reach IOC until FY 2022 at the earliest. In an unanticipated move, the Navy announced plans, supported in the FY 2022 budget, to begin arming LCS ships with the naval strike missile, giving these ships a longrange anti-ship capability that they had lacked despite notable operations by the class in the South China Sea.⁵⁹

Instead of requesting additional LCS, the Navy has focused on a new frigate. On April 30, 2020, the Navy awarded Fincantieri \$795 million to build the lead ship at its Marinette Marine shipyard in Wisconsin based on a proven design currently in service with the French and Italian navies.⁶⁰ The FY 2021 budget supported purchase of the second ship with annual procurement beginning in FY 2023.⁶¹ The Navy intends to expand production of these frigates to four a year by FY 2025 with the addition of a second "follow yard" by FY 2023. Austal USA has broken new ground on a steel production facility in an effort to become this second yard.⁶²

Amphibious Ships. Commandant of the Marine Corps General David Berger issued the 38th Commandant's Planning Guidance in July 2019 and Force Design 2030 in March 2020. Both documents signaled a break with past Marine Corps requests for amphibious lift, specifically moving away from the requirement for 38 amphibious ships to support an amphibious force of two Marine Expeditionary Brigades (MEB).63 The Commandant envisions a larger yet affordable fleet of smaller, low-signature amphibious ships-the so-called Light Amphibious Warship (LAW)-that enable littoral maneuver and associated logistics support in a contested theater.⁶⁴ Today, the amphibious fleet remains centered on fewer large ships, but the Navy's Future Naval Force Study (FNFS)65 and December 2020 30-year shipbuilding plan acknowledged the growing importance of the LAW, which will have to be produced rapidly and in sufficient numbers in order to actualize the naval forces' distributed concepts of operations (e.g., Marine Littoral Regiments and Maritime Distributed Operations).

As of July 14, 2021, the Navy had nine amphibious assault ships in the fleet (seven *Wasp*-class LHD and two *America*-class LHA); 11 amphibious transport docks (LPD); and 11 dock landing ships (LSD).⁶⁶ USS *Tripoli* (LHA-7) was delivered on February 28, 2020, and fabrication has begun on LHA-8, supporting delivery in FY 2024.⁶⁷

The FY 2021 budget included \$250 million in additional funds to accelerate construction of LHA-9.⁶⁸ The July 2020 catastrophic fire on *Bonhomme Richard* (LHD-6) makes it important that LHA-9 be delivered early so that the Navy can sustain its amphibious capacity. The decision to decommission the damaged ship further exposed limitations in shipyard capacity, as repairs would have had a negative effect on other planned shipbuilding and maintenance.⁶⁹ The Navy's LSDs, the *Whidbey Island*-class and *Harpers Ferry*-class amphibious vessels, are currently scheduled to reach the end of their 40-year service lives in 2025. LPD-30 began construction in April 2020 and when delivered will be the first of 13 *San Antonio*-class Flight II ships to replace the legacy LSD ships. The 12th first flight *San Antonio*-class ship (LPD 28) will be delivered in September 2021,⁷⁰ and the FY 2021 budget included \$500 million "to maximize the benefit of the amphibious ship procurement authorities provided elsewhere in this Act through the procurement of long lead material for LPD-32 and LPD-33."⁷¹

Unmanned Systems. The Navy does not include unmanned ships in counting its battle force size, but the current long-range shipbuilding plan envisions purchasing 12 Large Unmanned Surface Vessels (LUSV); one Medium Unmanned Surface Vessel (MUSV); and eight Extra Large Undersea Unmanned Vessels (XLUUV) by FY 2026.⁷² This plan builds on the previous FY 2021–FY 2025 budget, which included \$12 billion for all naval unmanned air and sea platforms, an increase of 129 percent over FY 2020.⁷³ The June 2021 iteration of the Navy's long-range shipbuilding plan does not address the procurement of unmanned ships.⁷⁴

In April 2020, the Navy took delivery of its second MUSV *Sea Hunter* prototype. It will be joined in FY 2022 by two LUSV under Surface Development Squadron One (SURFDEVRON ONE), charged with developing associated operating requirements.⁷⁵ On May 18, 2021, one of these experimental LUSV vessels, the *Nomad*, was seen transiting the Panama Canal on its way to SURFDESRON ONE.⁷⁶

In a show of concern about the maturity of technologies associated with unmanned systems, both the Senate and House Armed Services Committees stipulated in the FY 2021 NDAA that the Navy qualify the reliability of engines and power generators before procuring unmanned surface vessels.⁷⁷ Those concerns remain outstanding.

Until the March 2021 release of the Department of the Navy's Unmanned Campaign Framework, there had been no overarching vision to guide the naval services' unmanned investments and operational strategies.⁷⁸ For example, in 2019, the Marine Corps' Long Range Unmanned Surface Vessel conducted autonomous navigation from Norfolk, Virginia, to Cherry Point, North Carolina. The Corps plans to procure three more of these longrange unmanned vessels for further testing.⁷⁹

As the Marine Corps' unmanned program has progressed, the Navy has also made independent progress, notably its April 2021 U.S. Pacific Fleet–led Unmanned Integrated Battle Problem 21 (IBP21) exercise. This fleet experiment brought together the Navy's *Zumwalt* destroyer and unmanned MUSVs with a range of sensitive air and undersea unmanned platforms to mature the technologies and techniques required for effective naval manned– unmanned operations.⁸⁰

Navy and Marine Corps unmanned programs also appear to be converging in the development of an expeditionary control station for the *Fire Scout* (MQ-8C) unmanned helicopter.⁸¹ If deployed, this control station would allow for flexible employment of the Fire Scout both from austere sites ashore and from a range of ships for anti-submarine as well as surface warfare missions. However, as the Navy and Marine Corps accelerate their investments in unmanned systems, future fleet experimentation will have to incorporate both services' platforms to ensure interoperability.

Logistics, Auxiliary, and Expeditionary Ships. Expeditionary support vessels are highly flexible platforms consisting of two types: Today there are two Expeditionary Transfer Dock (ESD) and three Expeditionary Sea Base (ESB) vessels, which are used for prepositioning and sustaining forward operations, and 12 shallow-draft Expeditionary Fast Transport (EPF) vessels for high-speed lift in uncontested environments. Delivery of ESB 6 is planned for FY-2022, and delivery of ESB 7 is planned for FY 2023.82 Newport (EPF-12) was delivered to the Navy on September 2, 2021, and construction of Apalachicola (EPF-13) is progressing.⁸³ In March 2021, the Navy revised its contract with Austal USA for \$235 million to

modify EPF-14 and future EPF-15 to be highspeed hospital ships with the capability of embarking a V-22 tilt-rotor aircraft.⁸⁴

The Navy's Combat Logistics Force (CLF), consisting of dry-cargo and ammunition ships (T-AKE), fast combat support ships (T-AOE), and oilers (AO), provides critical support, to include at-sea replenishment, that enables the Navy to sustain the fleet at sea for prolonged periods. The Navy's future oiler *John Lewis* (T-AO 205) was launched on January 12, 2021, with delivery expected in June 2021 and an additional five to follow.⁸⁵ To sustain the fleet's number of oilers, the Navy will have to receive T-AO 205 and T-AO 206, both currently under construction, by FY 2023.⁸⁶

Strike Platforms and Key Munitions. The FY 2021 and proposed FY 2022 budgets continued the Navy's focus on long-range, offensive strikes launched from ships, submarines, and aircraft. Notable investments include Conventional Prompt Strike (CPS); the Maritime Strike Tomahawk (MST); the Joint Standoff Weapon Extended Range (JSOW-ER); the Long-Range Anti-Ship Missile (LRASM); and the Standard Missile-6 (SM-6).

The FY 2021 budget sustained the rapid prototyping of upgraded SM-2 Block IIIC and SM-6 Block IB; procurement of Block V Tactical Tomahawk (TACTOM) cruise missiles and Navigation/Communication upgrade kits to improve performance in layered defense environments; and procurement of 48 LRASM.⁸⁷

To counter the threat posed by the Chinese PL-15 long-range air-to-air missile, which has an operational range of 186 miles, the Navy is working with the Air Force to develop the AIM-120 Advanced Medium-Range missile, the operational range of which has not been made public.⁸⁸ In March 2021, the Air Force reported a record long-range kill of a drone target by this developmental missile from one of its F-15C fighters.⁸⁹ If this report is accurate, it indicates that development is proceeding apace.

Shore-Based Anti-Ship Capabilities. Following the August 2019 U.S. withdrawal from the Intermediate-Range Nuclear Forces (INF) Treaty, new intermediate-range (500–1,000

miles) conventional ground-launched strike options became politically viable. This is especially important in Asia where such capable missiles deployed to the first island chain would have great relevance in any conflict with China.⁹⁰

The FY 2020 budget included \$76 million to develop ground-launched cruise missiles.⁹¹ The FY 2021 budget included \$59.6 million in additional funds to procure 36 ground-based anti-ship missiles.⁹² A photo of the launch of a U.S. Marine Corps truck-mounted naval strike missile—ostensibly, part of the Navy–Marine Expeditionary Ship Interdiction System (NMESIS)—was released in April 2021.⁹³

Electronic Warfare (EW). The purpose of electronic warfare is to control the electromagnetic spectrum (EMS) by exploiting, deceiving, or denying its use by an enemy while ensuring its use by friendly forces. It is therefore a critical element of successful modern warfare. The final dedicated EW aircraft, the EA-18G Growler, was delivered in July 2019, meeting the Navy's requirement to provide this capability to nine carrier air wings (CVW), five expeditionary squadrons, and one reserve squadron.⁹⁴ Anticipating the EA-18G's retirement in the 2030s, the Navy has been exploring follow-on manned and unmanned systems.

Air Early Warning. The E-2D forms the hub of the Naval Integrated Control-Counter Air system and provides critical Theater Air and Missile Defense capabilities. The Navy's FY 2021 budget supported the procurement of four aircraft with an additional 10 to be procured over the next two years.⁹⁵ The proposed FY 2022 budget conforms to this plan by including procurement of five new E-2D aircraft, thus sustaining effective air early warning and increasingly important air control of unmanned platforms.

High Energy Laser (HEL). HEL systems provide the potential to engage targets or shoot down missiles without being limited to how much ammunition can be carried onboard ship. A significant milestone was achieved when USS *Portland* (LPD-27) used its HEL Weapon System Demonstrator to shoot down an unmanned aerial vehicle (UAV) over the Pacific on May 16, 2020.⁹⁶ This was followed by the Navy's decision to begin installation of a HEL system—the HELIOS (60kw) laser—on destroyers in 2021 beginning with USS *Preble*.⁹⁷

HELIOS is a scalable laser system integrated into the ship's weapons control and radar systems that can dazzle and confuse threats, disable small boats, or shoot down smaller air threats. However, until field testing against meaningful threat platforms is conducted across a range of weather conditions, the effectiveness of such systems remains unproven.

Command and Control. Networked communications are essential to successful military operations, and the information passed over these networks includes sensitive data from targeting to logistics. Cyber security, communications, and the information systems that generate and relay this information are therefore critical elements of the DOD information enterprise.

To enhance continuity, the Navy has consolidated information management in the Office of the Chief Information Officer (CIO). The Navy plans to spend \$4.17 billion from FY 2021-FY 2026 to bolster cyber defense and resiliency to attack.98 On February 23, 2021, the Navy consolidated network and IT-related technical authorities in a newly formed office, Taskforce Overmatch.⁹⁹ At a May 10, 2021, event, the CNO described Taskforce Overmatch as a unified data construct at the operational and tactical level and part of the DOD Joint All Domain Command and Control architecture.¹⁰⁰ Such investments are meant to prevent competitors' efforts to nullify the Navy's technological advantage or interfere in its logistic infrastructure (much of it on unclassified networks).

Readiness

In the 1980s, the Navy had nearly 600 ships in the fleet and kept roughly 100 (17 percent) deployed at any one time. As of July 12, 2021, the fleet numbered 297 ships, of which 83 (28 percent) were at sea or deployed. With fewer ships carrying an unchanging operational workload, training schedules become shorter while deployments become longer. The commanding officer's discretionary time for training and crew familiarization is a precious commodity that is made ever scarcer by the increasing operational demands on fewer ships.

FY 2019 marked the first time in more than a decade that the DOD and the Navy did not have to operate under a continuing resolution for at least part of the fiscal year. Having a full fiscal year to plan and execute maintenance and operations helped the Navy to continue on its path to restoring fleet readiness. However, as CNO Admiral John Richardson explained to the Senate Armed Services Committee in April 2018, it will take until late 2021 or 2022 to restore fleet readiness to an "acceptable" level provided adequate funding is maintained, and without "stable and adequate funding," it will take longer.¹⁰¹

Unfortunately, the Navy began FY 2020 under a continuing resolution that delayed planned maintenance for USS *Bainbridge* (DDG 96) and USS *Gonzalez* (DDG 66).¹⁰² This indicates that progress on fleet material readiness remains tenuous despite the fact that current and previous CNOs have made readiness their number one priority. Admiral Michael Gilday reiterated this most recently at a May 2021 Navy Memorial SITREP speaker event.¹⁰³

Impact of COVID-19. The eruption of the COVID-19 pandemic in 2020 caused many problems for the U.S. Navy. USS Theodore Roosevelt (CVN 71), for example, was forced to quarantine for 55 days in Guam; the major biannual international Rim of the Pacific Exercise (RIMPAC) was scaled down; 1,629 reservists were called to active duty to backfill high-risk shipyard workers conducting critical maintenance; and the Navy was restricted to using "safe haven" COVID-free ports, limiting where warships could call. In May 2021, the CNO assessed that the Navy managed the pandemic with minimal operational impact but with added time at sea and delays for family reunions pending quarantines.¹⁰⁴

In fact, the Navy's response to the pandemic has been a success overall. As of June 2, 2021,

Navy Combat Ships Nearing End of Service Life



NOTE: Figures are based on calculations for August 2021.

SOURCE: Naval Sea Systems Command, Naval Vessel Register, "Fleet Size," http://www.nvr.navy.mil/NVRSHIPS/FLEETSIZE.HTML (accessed August 2, 2021).

heritage.org

total cumulative COVID cases among the Navy's active-duty uniformed personnel numbered 38,849, with six deaths since February 2020.¹⁰⁵ Of the Navy's active-duty personnel on July 16, 2021, 78 percent were fully vaccinated, and 84.4 percent of sailors had received at least one shot, with both figures above the national average at the time.¹⁰⁶

Maintenance and Repairs. Naval Sea Systems Command completed its Shipyard Optimization and Recapitalization Plan in September 2018.¹⁰⁷ Three years later, the improvement of public shipyard capacities is just beginning. The initial step of building digital models to inform future upgrades to the Navy's four public shipyards is expected to be complete

by the end of 2021, but attempts by Congress to accelerate the breaking of new ground remain stalled. $^{\rm 108}$

At a May 10, 2021 event, the Chief of Naval Operations highlighted reducing the number of days of delayed maintenance at the four public yards by 80 percent and at private yards by 60 percent, improving maintenance planning at private shipyards, and giving yards more time to plan from contract approval to starting work as positive trends.¹⁰⁹ Nevertheless, the overall capacity for maintaining today's Navy, much less a fleet that is larger than 300 ships, remains inadequate.

Moreover, a recently declassified DOD Inspector General report that assessed readiness issues with respect to the Navy's newest maritime patrol aircraft, the P-8A Poseidon, concluded that the platform's low capability rates were due to an inadequate sustainability strategy for the aircraft.¹¹⁰ A similar issue regarding spare parts for the Virginia-class nuclear submarine fleet came to light at a fall 2020 Navy League conference and in a subsequent Congressional Budget Office report.¹¹¹ Over a two-year period beginning in 2018, the cannibalization of otherwise life-of-ship parts had a marked early failure rate, reportedly because of galvanic corrosion, which occurs at the contact space of two dissimilar metals. This problem reflects either poor design decisions preceding construction of the submarine class or modification of materials used by suppliers without the Navy's knowledge. Either way, this material issue illustrates an ongoing need for better management of the transition from design to sustainment as well as better management of the Navy's supplier base.

Training, Ranges, and Live-Fire Exercises. Ship and aircraft operations and training are critical to fleet readiness. The Navy seeks to meet fleet readiness requirements by funding 58 underway days for each deployed warship and 24 underway days for each non-deployed warship per quarter. Less clear is how much of this time is spent on crew training and whether the Navy assesses this as effective in meeting needed operational proficiencies.

That said, to achieve desired days at sea, the Navy sought an increase of 6.4 percent in its FY 2022 operations budget,¹¹² slightly less than FY 2021's 6.5 percent increase to cover "ship operations funding."¹¹³ Importantly, the FY 2022 budget increases the Flying Hour program by 11.0 percent, continuing the previous year's 5.8 percent increase, to ensure that squadrons are combat-ready when deployed.¹¹⁴

To improve warfighting proficiency, the Navy is seeking to expand and update instrumentation of the training range at Naval Air Station Fallon, Nevada, to enable practice with the most advanced weapon systems.¹¹⁵ This training range fits into the larger fiveyear \$27.3 billion Pacific Deterrence Initiative (PDI), led by Indo Pacific Command, intended partly to transform the way the Navy trains for high-end conflict and improve training with U.S. allies in the Pacific.¹¹⁶ Of particular importance to the Navy are PDI investments to modernize the Pacific Missile Range Facility (PMRF); the Joint Pacific Alaska Range Complex (JPARC); and the Combined/Joint Military Training (CJMT) Commonwealth Northern Mariana Islands in order to improve training for operations across all domains: air, land, sea, space, and cyber.¹¹⁷

Not forgotten are the 2017 collisions of USS *John S. McCain* (DDG 56) and USS *Fitzgerald* (DDG 62) in which 17 sailors were lost. Findings of the subsequent investigations, which highlighted the importance of operational risk management and unit readiness, remain relevant.¹¹⁸ To ensure that these tragic events are not repeated, the following broad institutional recommendations in the Secretary of the Navy's *Strategic Readiness Review* should be implemented:

- "The creation of combat ready forces must take equal footing with meeting the immediate demands of Combatant Commanders."
- "The Navy must establish realistic limits regarding the number of ready ships and sailors and, short of combat, not acquiesce to emergent requirements with assets that are not fully ready."
- "The Navy must realign and streamline its command and control structures to tightly align responsibility, authority, and accountability."
- "Navy leadership at all levels must foster a culture of learning and create the structures and processes that fully embrace this commitment."¹¹⁹

Scoring the U.S. Navy

Capacity Score: Weak

This *Index* assesses that a battle force consisting of 400 manned ships is required for the U.S. Navy to do what is expected of it today. The Navy's current battle force fleet of 297 ships and intensified operational tempo combine to reveal a Navy that is much too small relative to its tasks. The result is a score of "weak," which is unchanged from the *2021 Index*. Depending on the Navy's ability to fund more aggressive growth options and service life extensions, its capacity score could be lower in the next edition of the *Index*.

Capability Score: Marginal Trending Toward Weak

The overall capability score for the Navy remains "marginal" with downward pressure as the Navy's technological edge narrows against peer competitors China and Russia. The combination of a fleet that is aging faster than old ships are being replaced and the rapid growth of competitor navies with modern technologies does not bode well for U.S. naval power.

Readiness Score: Marginal Trending Toward Weak

The Navy's readiness is rated "marginal" trending toward "weak" as the Navy struggles to sustain overdue readiness corrective actions, complicated by an inadequate fleet size and overwhelmed maintenance infrastructure.

Overall U.S. Navy Score: Marginal Trending Toward Weak

The Navy's overall score for the 2022 Index is "marginal" trending toward "weak." To correct this trend, the Navy will have to eliminate several readiness and capacity bottlenecks while seeing to it that America has an operational fleet with the numbers and capabilities postured to counter Russian and Chinese naval advances.

	VERY WEAK	WEAK	MARGINAL	STRONG	VERY STRONG
Capacity		 ✓ 			
Capability			 Image: A second s		
Readiness			~		
OVERALL			~		

U.S. Military Power: Navy



Aircraft Carrier

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
Nimitz-Class Aircraft Carrier (CVN-68) Inventory: 10 Fleet age: 30.4 Date: 1975			Ford-Class Aircraft Carrier (CVN-78) Timeline: 2017-2032	2	2
The <i>Nimitz</i> -class is a nuclear powered multipurpose carrier. The aircraft carrier and its embarked carrier air wing can perform a variety of missions including maritime security operations and power projection. Its planned service life is 50 years. The class will start retiring in the FY 2025 and will be replaced by the <i>Ford</i> -class carriers.	3	3	Currently in production, the Ford-class will replace Nimitz-class aircraft carriers. The Ford-class design the basic Nimitz-class hull form but incorporates s improvements to achieve a 33 percent higher sorti smaller crew with approximately 600 fewer sailors a half times greater electrical power, and more tha in life-cycle cost savings over the Nimitz-class. The completed its first Full Ship Shock Trial (FSST) on and will complete the rest by the end of summer.		the uses veral a rate, a two and 1 \$4 billion ship une 18
Ford-Class Aircraft Carrier (CVN-78) Inventory: 1 Fleet age: 4 Date: 2017			six months before operational employmer undergo modernization, maintenance, and intended life expectancy is 50 years.	t so that d repairs.	it can The ship's
The <i>Ford</i> -Class incorporates new technologies that will increase aircraft sortie rates, reduce manning, provide greater electrical power for future weapons systems, and decrease operating costs. Its planned service life is 50 years.	6	4	PROCUREMENT SPENDING (\$ millions) 13 \$15	5,558



Large Surface Combatant

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
<i>Ticonderoga</i> -Class Cruiser (CG-47) Inventory: 22 Fleet age: 31 Date: 1981			Zumwalt-Class Destroyer (DDG-1000) Timeline: 2016-2022	0	1
The <i>Ticonderoga</i> -class is a multi- mission battle force ship equipped with the Aegis Weapons System. While it can perform strike, anti-surface warfare and anti-submarine warfare, its primary focus is air and missile defense. The ship has a life expectancy of 40 years, the Navy plans to retire eight of the 22 CGs between FY 2021 and FY 2024.	2	3	The DDG-1000 was designed to be a new-generation destroyer capable of handling more advanced weapon systems for long-range strike with a hull design capable reducing aimed to reduce radar detectability for its origi primary mission of naval surface fire support (NSFS). The DDG-1000 program was intended to produce a tota of 32 ships, but this number has been reduced to three. The first DDG-1000 was commissioned in October 2016.		
Zumwalt-Class Destroyer (DDG-100)			PROCUREMENT SPENDING (\$ millions)	¢7F7
Inventory: 1 Fleet age: 3.6 Date: 2016 The <i>Zumwalt</i> -Class is a multi-mission destroyer that incorporates several technological improvements, such as a stealthy hull design and integrated electric-drive propulsion system. Although it has passed sea trials, it continues to experience problems with its combat systems. The third and final <i>Zumwalt</i> -class ship was commissioned in FY 2020.	6	2	5 24		\$733
Arleigh Burke-Class Destroyer (DDG-51) Inventory: 69			Arleigh Burke-Class Destroyer (DDG-51)	3	4
Fleet age: 18.7 Date: 1991 The Arleigh Burke-class is a multi- mission guided missile destroyer featuring the Aegis Weapons System with a primary mission of air defense. The Navy was supposed to buy two in FY 2022, but President Biden's proposed budget would provide only one. This would break multiyear contracts and has received pushback from Congress, so the decision is still being debated. The Navy plans to extend the service life of the entire class to 45 years from its original life expectancy of 35-40 years.	3	4	Timeline: 1991–2029 DDG-51 production was restarted in FY 2013 to make up for the reduction in DDG-1000 acquisitions. Beginning in FY 2017, all DDG-51s procured will be the Flight III design, which includes the more capable Advanced Missile Defense Radar (AMDR). The Navy was supposed to buy two in FY 2022, but President Biden's proposed budget would provide only one. This would break multiyear contracts and has received pushback from Congress, so the decision is still being debated. The destroyers are believed to have an extended life span of 45 years of operational service. PROCUREMENT SPENDING (\$ millions)		

Small Surface Combatant

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score	
Littoral Combat Ship (LCS) Inventory: 24 Fleet age: 4.1 Date: 2008			Littoral Combat Ship (LCS) Timeline: 1991–2030	2	2	
The Littoral Combat Ship includes two classes: the <i>Independence</i> -class and the <i>Freedom</i> -class. The modular LCS design depends on mission packages (MPs) to provide warfighting capabilities in the SUW, ASW and MCM mission areas. The ship has an expected service life of 25 years.	6		The LCS is intended to fulfill the mine cour antisubmarine warfare, and surface warfar Navy. It is designed to operate in near-sho but is also capable of open-ocean operatic with smaller ships than the DDG-51 does. I small surface combatant in the fleet once ships are retired and until the new FFG(X) The Navy will have six deployed by the end	e roles fo re enviror on. It work t will be th the Navy's enters se d of the ye	ure, r the nments ks better he only s MCM rvice. ear.	
Avenger-Class Mine Counter Measure (MCM-1)			33 \$21,6	millions) 109	\$602	
Inventory: 8 Fleet age: 28.8 Date: 1983		2	FFG Frigate			
Avenger-class ships are designed as mine sweepers/hunter-killers capable of finding, classifying, and destroying moored and bottom mines. The class has an expected 30-year service life. The remaining MCMs are expected to be decommissioned throughout the 2020s. While there is no direct replacement single-mission MCM ship in production, the Navy plans to fill its mine countermeasure role with the LCS and its MCM MP.	0		Timeline: 1991–2030 A new program called the FFG(X) will augn program to fill out the remaining 20-ship sr combatant requirement for a total of 52 Sm Combatants. The ships will be 496 feet with miles per hour and a range of 6,000 nautica is to escort carrier battle groups and high-v accommodate 32 VLS cells to handle high- and machine guns. The first ship should be and be operational by 2030. The current co provide 10 hulls by 2035.	FFG(X) will augment the LCS naining 20-ship small surface or a total of 52 Small Surface II be 496 feet with a top speed of 29 e of 6,000 nautical miles. Its purpose groups and high-value convoys. It will s to handle high-powered missiles st ship should be delivered by 2026 30. The current contract would		
			PROCUREMENT SPENDING (2 1 \$2,334	\$ millions) \$ \$1,	088	



SSGN Cruise Missile Submarine

PLATFORM	Age Score	Capability Score	MODERNIZATION PROGRAM	Size Score	Health Score
Ohio-Class (SSGN-726) Inventory: 4			None		
The SSGNs provide the Navy with a large stealthy strike and special operations mission capabilities. From 2002-2007, the four oldest <i>Ohio</i> -class ballistic missile submarines were converted to guided missile submarines. Each SSGN is capable of carrying up to 154 Tomahawk land-attack cruise missiles and up to 66 special operations forces for clandestine insertion and retrieval. All four SSGNs will be retired between FY 2026 and FY 2028. The Navy has tentative plans to replace the SSGNs with a new Large Payload Submarine beginning in FY 2036. The SSGN had a planned service life of 42 years, but this may be extended.	0	4			



Attack Submarines

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
Seawolf-Class (SSN-21) Inventory: 3 Fleet age: 21 Date: 1997			Virginia-Class (SSN-774) Timeline: 2004-2019	2	3
The Seawolf-class is exceptionally quiet, fast, well-armed, and equipped with advanced sensors. Though lacking a vertical launch system, the Seawolf- class has eight torpedo tubes and can hold up to 50 weapons in its torpedo room. Although the Navy planned to build 29 submarines, the program was cut to three. The Seawolf-class has a 33-year expected service life. They have been succeeded by the Virginia-class	3	4	The Virginia-class is in production and will Angeles-class and Seawolf-class attack su are decommissioned. The Virginia Payload will be incorporated into eight of the 11 plan V submarines beginning in FY 2019. VPM in large-diameter, vertical launch tubes that c additional Tomahawk missiles or other pay service life of the Virginia-class is 33 years. been procured so far at a rate of two per year PROCUREMENT SPENDING	nia-class is in production and will replace the Los class and Seawolf-class attack submarines as the mmissioned. The Virginia Payload Module (VPM) corporated into eight of the 11 planned Block ines beginning in FY 2019. VPM includes four neter, vertical launch tubes that can carry up to I Tomahawk missiles or other payloads. The plan e of the Virginia-class is 33 years. Thirty-four hav cured so far at a rate of two per year.	
attack submarine.			34 2 \$105,3	14 \$60),202
Inventory: 28 Fleet age: 30 Date: 1976 The <i>Los Angeles</i> -class comprises the largest portion of the Navy's attack submarine fleet. They are multi-mission submarines that can perform covert intelligence collection, surveillance, ASW, ASuW, and land attack strike. The <i>Los Angeles</i> -class has a 33-year expected service life. The last Los Angeles-class submarine is expected to be retired in the late 2020s and is being replaced by the <i>Virginia</i> -class.	0	3			
Virginia-Class (SSN-774) Inventory: 19 Fleet age: 8 Date: 2004 The Virginia-class is the U.S. Navy's next-generation attack submarine. It includes several improvements over previous attack submarine classes that provide increased acoustic stealth, improved SOF support, greater strike payload capacity and reduced operating costs. The planned service life of the Virginia-class is 33 years. The Virginia-class is in production and will replace the Los Angeles-class and Seawolf-class attack submarines as they are decommissioned. Thiry-four have been procured so far, at a rate of two per year.	4	4			
SSBN Ballistic Missile Submarine

PLATFORM	Age Score	Capability Score	Size H REPLACEMENT PROGRAM Score						
Ohio-Class (SSBN)			Columbia-Class (SSBN-826)						
Inventory: 14 Fleet age: 31 Date: 1981			Timeline: TBD						
The Ohio-class SSBN is the most survivable leg of the U.S. military's strategic nuclear triad. Its sole mission is strategic nuclear deterrence, for which it carries long-range submarine- launched ballistic missiles. The Ohio-class's expected service life is 42 years. Retirement of the class will begin in 2027 at an estimated rate of one submarine per year until 2039. The Ohio-class is being replaced by the Columbia-class SSBN.	2	4	The 12-ship <i>Columbia</i> -class will replace the <i>Ohio</i> -class nuclear ballistic missile submaries provides a credible and survivable sea-base deterrent. The Navy's FY 2021 budget estin total procurement cost for 12 ships will be \$ The first patrol of the lead ship, SSBN 826, for FY 2031. However, the pandemic, techn and potential funding issues could cause the building of the lead boat to be delayed. The ships will have a 42-year life expectancy. PROCUREMENT SPENDING (1	existing ne force, v ed strateg nates that 5109.8 billi is schedul- ical challer e designin e Columbia \$ millions) \$106,176	which ic the on. ed nges, ng and a-class				

Amphibious Warfare Ship

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
Wasp-Class Amphibious Assault Ship (LHD-1) Inventory: 7 Fleet age: 24.3 Date: 1989			<i>America</i> -Class (LHA-6) Timeline: 2004-TBD	3	3
The Wasp-class can support amphibious landing operations with Marine Corps landing craft through its well deck. It can also support Marine Air Combat Element operations with helicopters, tilt-rotor aircraft, and Vertical/Short Take-Off and Landing (V/ STOL). This ship has a planned 40-year service life.	2	3	LHA Flight 0 (LHA-6 and 7) were built with deck to provide more space for Marine Cor maintenance and storage as well as increas capacity. LHA Flight 1 (LHA-8 and beyond) a well deck for increased mission flexibility, class is in production with three LHA 6s and Advance procurement for LHA 9 will begin PROCUREMENT	out a well ps aviation ed JP-5 fu will reinco The <i>Amer</i> eady proce in FY 202	n Jel orporate <i>rica-</i> ured. 3.
America-Class Amphibious Assault Ship (LHA-6) Inventory: 2 Fleet age: 3.9 Date: 2014 This new class of large-deck amphibious assault ships is meant to replace the retiring <i>Wasp</i> -class LHD. LHAs are the largest of all amphibious warfare ships and resemble small aircraft carriers. The America-class is designed to accommodate the Marine Corps' F-35Bs.	6	4	3 \$11,89	97 \$3	8,055

NOTE: See page 412 for details on fleet ages, dates, timelines, and procurement spending.

Amphibious Warfare Ship (Cont.)

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
San Antonio-Class Amphibious Transport Dock (LPD-17) Inventory: 11 Fleet age: 9.9 Date: 2006			San Antonio-Class Amphibious Transport Dock (LPD-17) Timeline: 2006-2017	6	4
The LPDs have well decks that allow the USMC to conduct amphibious operations with its landing craft. The LPD can also carry four CH-46s or two MV- 22s. Eleven of the planned 13 Flight I LPD- 17-class ships are operational, and the remaining two are under construction. The class has a 40-year planned service life.	4		The 13 LPD-17s are replacements for the Sa class LPDs. Both Flight I and Flight II LPDs mission ships designed to embark, transpo- elements of a Marine landing force by helio rotor aircraft, landing craft, and amphibiou PROCUREMENT 13 \$PENDING \$26,44	an Antonic are multi- ort, and la copters, til is vehicles is (<i>\$ million</i> 7 \$25	0– - It s. (063
Whidbey Island-Class Dock Landing Ship (LSD-41) Inventory: 7 Fleet age: 32.2 Date: 1985 <i>LSD-41 Whidbey Island-</i> class ships were designed specifically to transport and launch four Marine Corps Landing Craft Air Cushion vehicles. They have an expected service life of 40 years. All eight ships will be retired between FY 2026 and FY 2033. LSD-41-class ships will be replaced by the LPD-17 Flight II program, which began procurement in FY 2018.	2	3	LPD-17 Flight II Timeline: 2025–TBD Previously known as LX(R), the LPD-17 Flight will procure 13 ships to replace the Navy's The Navy originally planned to procure the in FY 2020, but accelerated procurement is procurement of the first LPD-17 Flight II in delayed the second ship, planned for FY 2 PROCUREMENT SPENDING	5 ght II prog LSD-type e first Fligi unding er FY 2018. ⁻ 020, until i (<i>\$ million</i> \$2,926	4 ships. ht II ship nabled The Navy FY 2021. s)
Harpers Ferry-Class Dock Landing Ships (LSD-49) Inventory: 4 Fleet age: 25.1 Date: 1995 The Harpers Ferry-class reduced LCAC capacity to two while increasing cargo capacity. They have an expected service life of 40 years, and all ships will be retired by FY 2038. The LSD-49 will be replaced by the LPD-17 Flight II, which began procurement in FY 2018.	3				

NOTE: See page 412 for details on fleet ages, dates, timelines, and procurement spending.



Airborne Early Warning

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
E-2C Hawkeye Inventory: 49 Fleet age: 38 Date: 1973			E-2D Advanced Hawkeye Timeline: 2014–2022	4	4
The E-2C Hawkeye is a battle management and airborne early warning aircraft. The E-2C fleet received a series of upgrades to mechanical and computer systems around the year 2000. While still operational, the E-2C is nearing the end of its service life and is being replaced by the E-2D Advanced	0	3	The E-2D Advanced Hawkeye replaces the and is in production. The Navy received ap five-year multi-year procurement plan beg 2019 for 24 aircraft to complete the progra \$17.5 billion program has a goal to build 75 PROCUREMENT SPENDING (3)	e legacy E proval fo ginning in am of reco new airc <i>millions</i>)	-2C r a FY ord. The raft.
Hawkeye.			107 5 \$19,16	0 \$6	,001
Inventory: 45 Fleet age: 3.5 Date: 2014					
The E-2D program is the next- generation, carrier-based early warning, command, and control aircraft that provides improved battle space detection, supports theater air missile defense, and offers improved operational availability.	6	4			

Electronic Attack Aircraft

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
EA-18G Growler			None		
Inventory: 158 Fleet age: 8 Date: 2009					
The EA-18G Growler is the U.S. Navy's electronic attack aircraft and provides tactical jamming and suppression of enemy air defenses. The final EA-18G aircraft was delivered in FY 2018, bringing the total to 160 aircraft and fulfilling the Navy's requirement. It replaced the legacy EA-6B Prowlers.	6	4			

NOTE: See page 412 for details on fleet ages, dates, timelines, and procurement spending.



Fighter/Attack Aircraft

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score			
F/A-18E/F Super Hornet Inventory: 586 Fleet age: 17 Date: 2001 The F/A-18 E/F Super Hornet has longer range, greater weapons payload, and increased survivability than the F/A- 18A-D Legacy Hornet. The Navy plans to achieve a 50/50 mix of two F-35C squadrons and two F/A-18E/F Block III squadrons per carrier air wing by the mid-2030s. The ongoing service life extension program will extend the life of all Super Hornets to 9,000 flight hours.	3	3	F-35C Joint Strike Fighter Timeline: 2019-TBD (3) The F-35C is the Navy's variant of the Joint Strike Fighter. The Joint Strike Fighter faced many issues during its developmental stages, including engine problems, software development delays, cost overruns incurring a Nunn-McCurdy breach, and structural problems. The Navy declared initial operational capability (IOC) of the F-35C in February 2019. The planned procurement of 273 F-35Cs will replace over 500 Super Hornets. PROCUREMENT SPENDING (\$ millions)					
			144 20 \$22,7	27 \$2	2,109			
F-35C Joint Strike Fighter			F/A-18 Super Hornet					
Inventory: 30 Fleet age: 1 Date: 2019			The Navy plans to buy 108 Block III Super and modernize most of its existing Super I	Hornets by Hornets to	y 2024 Block			
The C-variant is the Navy's fifth- generation aircraft, bringing radar- evading technology to the carrier deck for the first time. The F-35C performs a variety of missions to include air-to-air combat, air-to-ground strikes, and ISR missions.	6	4	is standards. All of the Block III Super Horn span of 10,000 flight hours, which is 50 pe that of earlier F/A-18E/F aircraft. The Bider proposed budget would decrease the Nav budget, which would eliminate the planne Super Hornets.	ets will ha rcent grea 1 Administ y's aviatio d purchas	ater than tration's on e of			

NOTES: See Methodology for descriptions of scores. Fleet age is the average of platform since commissioning. The date for ships is the year of commissioning. Inventory for aircraft is estimated based on the number of squadrons. The date for aircraft is the year of initial operational capability. The timeline for ships is from the year of first commissioning to the year of last delivery. The timeline for aircraft is from the year of delivery. Spending does not include advanced procurement or research, development, test, and evaluation (RDT&E). The total program dollar value reflects the full F-35 joint program, including engine procurement. The Navy is also procuring 67 F-35Cs for the Marine Corps. Age of fleet is calculated from date of commissioning to January 2016.

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Littoral Combat Ship

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U.S. Air Force

John Venable

The U.S. Air Force (USAF), originally part I of the Army Signal Corps, became a separate service in 1947, and its mission has expanded significantly over the years. Initially, operations were divided among four major components-Strategic Air Command, Tactical Air Command, Air Defense Command, and Military Air Transport Service-that collectively reflected the Air Force's "fly, fight, and win" nature. Space's rise to prominence in the early 1950s brought a host of faculties that would expand the service's portfolio and increase its capabilities in the mission areas of intelligence, surveillance, and reconnaissance (ISR) and command and control (C2). Together, the addition of the Space Force as the fifth uniformed service within the Department of Defense (DOD) and the onset of the global SARS-CoV-2 (COVID-19) pandemic have had a notable impact on the Air Force in the year since the 2021 Index of Military Strength was published.

With the birth of the Space Force in December 2019,¹ the Air Force began to move its space portfolio of assets and personnel to the new service. This change will affect at least three mission areas: air and space superiority, ISR, and C2. Each of these mission areas was born from air-breathing assets, and while the loss of the space portfolio will reduce the service's inherent capabilities, they will remain within the Department of the Air Force (DAF) and allow the Air Force to focus the weight of its efforts on the core missions in the air and cyber domains. Today's Air Force has five principal missions:

- Air superiority (space superiority is now the responsibility of the Space Force);
- Intelligence, surveillance, and reconnaissance;
- Mobility and lift;
- Global strike; and
- Command and control.

The summer of 2021 finds the Air Force, like the rest of DOD, recovering from the effects of COVID-19. Recruiting and other training pipelines like pilot training have slowed considerably, and this has affected accessions. The service's ability to generate sorties and flying hours for training has reached near-historic lows with equally grim readiness levels. All of this comes on the heels of reductions in force size and a drought in readiness from which the Air Force has been trying to recover for the past several years.

The pandemic's impact on the economy has reduced external hiring opportunities, particularly with the airlines, and this has helped to mitigate the separation from the Air Force of the most experienced airmen in critically manned areas.² However, because the COVID-19 vaccine's distribution is now widespread and the economic recovery is underway, it could well become harder to retain trained personnel. Unlike some of the other services, the Air Force did not grow larger during the post-9/11 buildup. Instead, it grew smaller as acquisitions of new aircraft failed to offset programmed retirements of older aircraft. Following the sequestration debacle in 2012, the Air Force began to trade size for quality.³ Presidential defense budgets from 2012 through 2017 during the Obama Administration proved merely aspirational, and as the service sustained the war on terrorism, it struggled also to sustain the type of readiness required to employ in a major regional contingency (MRC) against a near-peer threat.

The Air Force was forced to make strategic trades in capability, capacity, and readiness to meet the operational demands of the war on terrorism and develop the force it needed for the future. The collective effects left the Air Force of 2016 with just 55 total force fighter squadrons, and the readiness levels within those organizations were very low. Just four of the Air Force's 32 active-duty fighter squadrons were ready for conflict with a near-peer competitor, and just 14 others were considered ready even for low-threat combat operations.⁴

Recognizing the threat from a rising China and resurgent Russia, the 2018 National Defense Strategy (NDS) directed the services to prepare for a large-scale, high-intensity conventional conflict with a peer adversary.⁵ Later that same year, the Air Force released "The Air Force We Need" (TAFWN), a study of the capacity it would need to fight and help the U.S. win such a war. Based on thousands of war-game simulations, the study found that the service needed to grow by 25 percent, from 312 to 386 squadrons, to execute that strategy. That growth included one additional airlift squadron and seven additional fighter, five additional bomber, and 14 additional tanker squadrons.6 That equates to an additional 182 fighter, 50 bomber, 210 air refueling, and 15 airlift platforms.7 During the same period, the service's most senior leaders conveyed the need for more time in the air for its aircrews,8 and these collective demands required a bigger budget.

In a series of speeches in 2018, Air Force Secretary Heather Wilson and Air Force Chief of Staff General David Goldfein highlighted the shortfall and the need for more funding to increase the service's capacity with nextgeneration platforms: in other words, to buy all-new-design aircraft rather than continuing to purchase aircraft that have been in production since the 1980s and 1990s).⁹ To meet that requirement, the Trump Administration increased DAF funding by 31 percent from 2017 to 2021.¹⁰

Considering this shortfall, one might assume that the Air Force increased its procurement budget and accelerated acquisition of fifth-generation offensive platforms and next-generation tanker aircraft during that period by a substantial margin. However, funding for aircraft procurement remained relatively flat, growing from \$22.4 billion in fiscal year (FY) 2017 to just \$25.6 billion in FY 2022—a rate of growth that did not keep up with inflation. The budget for procurement fell from \$28.4 billion in FY 2021 to \$25.6 billion in FY 2022, a straight decrease of 11 percent but, accounting for inflation, a loss of buying power that approaches 14 percent.

The budget for research, development, test and evaluation (RDT&E), on the other hand, has more than doubled since FY 2017, growing from \$20.5 billion in FY 2017 to \$40.1 billion in FY 2022, and now exceeds procurement by more than 50 percent.¹¹ Much of that funding was used to develop and field the digital backbone for the Airborne Battle Management System (ABMS) to help move information to the warfighter, process targets, and optimize their engagement.

Capacity

At the height of the Cold War buildup in 1987, the active-duty Air Force had an inventory of 3,082 fighter, 331 bomber, 576 air refueling, and 331 strategic airlift platforms. When the strategic reserve assets within the Air National Guard (Guard) and Air Force Reserve (Reserve) are added, the 1987 totals were 4,468 fighter, 331 bomber, 704 air refueling, and 362

Air Force Budgets, 2017–2022

IN BILLIONS OF U.S. DOLLARS



NOTE: FY 2022 figures are proposed.

SOURCES: Extracted from U.S. Air Force budget summaries for the years 2017 through 2021. For example: Table 1, "Air Force Budget Highlights Summary," in U.S. Department of the Air Force, *United States Air Force Fiscal Year 2018 Budget Overview*, May 2017, p. 15, http://www.saffm.hq.af.mil/LinkClick.aspx?fileticket=m3vZOmfR368%3d&portalid=84 (accessed August 17, 2021), and Table 1, "Department of the Air Force Budget Summary," in U.S. Department of the Air Force Fy 2021 Budget Overview, p. 2, https://www.saffm.hq.af.mil/Portals/84/documents/FY21/SUPPORT_/FY21%20Budget%200verview_1.pdf? ver=2020-02-10-152806-743 (accessed August 17, 2021).

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strategic airlift platforms. After the fall of the Iron Curtain, the United States shifted from a force-sizing construct centered on great-power competition to one capable of winning two simultaneous or nearly simultaneous MRCs. Those numbers for capacity have been reduced significantly over the years.

It is projected that at the end of FY 2021, the Air Force will have a total aircraft inventory (TAI) of 2,183 fighters, 140 bombers, 512 tankers, and 274 strategic airlift platforms. After just three years of adding to that inventory, the service returned to the idea of trading capacity for some future gain through RDT&E.¹² In 2021, Chief of Staff General C.Q. Brown announced plans to cut another 137 fighters and 32 tankers from the USAF's inventory by the end of FY 2022. While the service has not stated where those reductions will be made, it will reduce the TAI to 2,096 fighters, 140 bombers, 483 tankers, and 274 by the end of FY 2022.¹³ The Air Force will have a total force that equates to 47 percent of the fighter and bomber assets and 69 percent of the tanker and airlift assets that it possessed the last time the United States was prepared to fight a peer competitor.

The idea that aircraft production lines will somehow surge to come to the rescue in a peer-level crisis may seem plausible to some,¹⁴ but even if Congress were to throw an unlimited amount of funding at production lines, there would not likely be enough time to bring new fighters into the force to meet the 2018 NDS's scenario and timing requirements.¹⁵

The *Index of U.S. Military Strength* uses "combat-coded" fighter aircraft within the active component of the U.S. Air Force to assess capacity. Combat-coded aircraft and related squadrons are aircraft and units with an assigned wartime mission, which means that those numbers exclude units and aircraft assigned to training, operational test and evaluation (OT&E), and other missions.

The software and munitions carriage and delivery capability of aircraft in non-combatcoded units renders them incompatible with and/or less survivable than combat-coded versions of the same aircraft. For example, all F-35As may appear to be ready for combat, but training wings and test and evaluation jets have hardware and software limitations that would severely curtail their utility and effectiveness in combat. While those jets could be slated for upgrades, hardware updates sideline jets for several months, and training wings and certain test organizations are generally the last to receive those upgrades.

Of the 5,504 manned and unmanned aircraft projected to be in the USAF's inventory at the end of FY 2021, 1,482 are active-duty fighters, and 983 of those are combat-coded aircraft.¹⁶ It is important to separate the active-duty fighters and units from the strategic reserve because it would take several months to get elements of the latter up to manning and readiness levels that allowed their first elements to deploy. Unfortunately, there are other factors that also affect the number of fighters the service could actually employ in combat.

Most squadrons will have to pack up and deploy several thousand miles to be able to fight. Because of the additional wartime manning requirements and the fact that most squadrons have several jets that are in disrepair at any given time, it takes the resources of approximately three active-duty squadrons to deploy two combat-capable fighter units forward.¹⁷ That effectively reduces the total number of active-duty, combat-coded fighters to 649 jets.

The strategic reserve has 518 fighters, of which 419 are combat coded. Because of the additional manning requirements and the fact that Guard and Reserve units generally have just one squadron at each location, it takes two squadrons to deploy one combat-capable unit forward.¹⁸ In terms of capacity, this means that 649 active-duty and 210 strategic reserve fighters, for a total of 859 combat-coded fighters, could be deployed into combat, leaving virtually nothing in reserve.

Capacity also relies on the stockpile of available munitions and the production capacity of the munitions industry. The actual number of munitions within the U.S. stockpile is classified, but there are indicators that make it possible to assess the overall health of this vital area. The inventory for precision-guided munitions (PGM) was severely stressed by nearly 18 years of sustained combat operations and budget actions that limited the service's ability to procure replacements and increase stockpiles. From 2017 through 2021, funding for munitions was significant, and the service, believing the inventory is now sufficiently restocked, has reduced the number of PGMs it will acquire to a total of 8,365 munitions in FY 2022.

However, even though the munitions stockpile may have returned to a level capable of supporting a surge in expenditures associated with a conflict similar to the one in which the U.S. has been engaged for the past 19-plus years, it would not likely support a peer-level fight that lasts more than a few weeks. Typically, there is a delay of 24–36 months between funding and delivery of additional munitions, and while the potential exists for a rapid expansion of production, it is hard to envision how such an expansion could be rapid enough to exceed demand before the stockpile is depleted. (See Table 5).

Precision-Guided Munitions Expenditures and Programmed Acquisitions

TOTAL MUNITIONS EXPENDED

	FY 2017	FY 2018	FY 2019	FY 2020	FY2021*
JDAM	30,664	5,462	7,354	4,004	4,500
HELLFIRE	1,536	2,110	2,449	1,019	1,250
SDB-I/II	4,507	749	1,289	397	300
APKWS	Unknown	Unknown	Unknown	Unknown	Unknown
JASSM-ER	360	19	16	10	16
LGB	276	373	106	6,078	6,000
ARRW**	n/a	n/a	n/a	n/a	n/a
Total	38,092	9,462	11,963	11,508	12,066

TOTAL MUNITIONS ACQUIRED

	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022*
JDAM	35,106	36,000	25,000	16,800	1,919
HELLFIRE	3,629	3,734	3,859	4,517	1,176
SDB-I/II	7,312	6,254	8,253	3,205	1,983
APKWS	10,621	6879	15,642	3,946	2,750
JASSM-ER	360	360	390	400	525
LGB	0	0	0	0	0
ARRW**	n/a	n/a	n/a	n/a	12
Total	57,777	53,976	53,893	29,617	8,365

* Estimate based on data from President's Budget.

** Air-launched Rapid Response Weapon (ARRW) is a hypersonic, long-range, conventional air-to-surface missile with precisionguided, prompt-strike capability from stand-off ranges.

SOURCES: Headquarters U.S. Air Force, Deputy Chief of Staff for Operations, written response to Heritage Foundation request for information on Air Force munition levels, May 7, 2021; Table 2, "Department of the Air Force Budget Summary," in U.S. Department of the Air Force, *Department of the Air Force FY 2022 Budget Overview*, p. 12, https://www.saffm.hq.af.mil/Portals/84/documents/ FY22/SUPPORT_/FY22%20Budget%20Overview%20Book.pdf?ver=SMbMqD0tqIJNwq2Z0Q4yzA%3d%3d (accessed August 17, 2021); and U.S. Department of the Air Force, *Department of Defense Fiscal Year (FY) 2022 Budget Estimates, Air Force, Justification Book Volume 1 of 1, Procurement of Ammunition, Air Force*, May 2021, pp. Volume 1-7-Volume 1-76, https://www.saffm.hq.af.mil/Portals/84/documents/FY22/PROCUREMENT_/FY22%20DAF%20J-Book%20-%203011%20-%20Ammunition%20Proc.pdf?ver=PaFt7rWf7aiKYJhl-cpv9w%3d%3d (accessed August 17, 2021).

Capability

The risk assumed with capacity has placed an ever-growing burden on the capability of Air Force assets. The ensuing capability-overcapacity strategy centers on the idea of developing and maintaining a *more*-capable force that can win against the advanced fighters and surface-to-air missile systems now being developed by top-tier potential adversaries like China and Russia, which are also increasing their capacity.

Any assessment of capability includes not only the incorporation of advanced technologies, but also the overall health of the inventory. Most aircraft have programmed life spans of 20 to 30 years based on a programmed level of annual flying hours. The bending and flexing of airframes over time in the air generates predictable levels of stress and fatigue on everything from metal airframe structures to electrical wiring harnesses.

The average age of Air Force aircraft is 31 years, and some fleets, such as the B-52 bomber, average 60 years. In addition, KC-135s comprise 78 percent of the Air Force's 483 tankers and are more than 59 years old on average. By the end of FY 2022, 71 brand-new KC-46s will make up 15 percent of the tanker inventory, but they will not be capable of refueling aircraft during combat operations—the jet's primary mission—until sometime in FY 2024.¹⁹

The average age of the F-15C fleet is more than 37 years,²⁰ significantly exceeding the programmed service life of a fleet that comprises more than half of USAF air superiority platforms.²¹ The planes in the F-16C/D fleet are almost 31 years old on average,22 and the service has used up nearly 87 percent of their expected life span. In 2018, the Air Force announced its intent to extend the service lives of 300 F-16s through a major service life extension program (SLEP) that will allow those jets to continue to fly through 2050.23 SLEPs lengthen the useful life of airframes, and these F-16 modifications also include funding for the modernization of avionics within those airframes. These modifications are costly, and the added expense reduces the amount of funding the service has

to invest in modernization, which is critical to ensuring future capability. Even with a SLEP, there is a direct correlation between aircraft age and the maintainability of those platforms. (See Table 6).

The Air Force's ISR and lift capabilities face similar problems in specific areas that affect both capability and capacity. The majority of the Air Force's ISR aircraft are now unmanned aerial vehicles (UAVs). The Air Force will accept delivery of 19 MQ-9s to its inventory in FY 2022 for a total of 351 Reapers.²⁴ The service lost an RQ-4 to an Iranian missile in 2019 and intends to reduce its inventory by another 21 platforms by the end of FY 2022, leaving it with just 10 of these strategic reconnaissance platforms. These unmanned surveillance aircraft have largely replaced older manned platforms, but not entirely. With an average age of 39 years,²⁵ the U-2, a manned high-altitude reconnaissance aircraft, is still very much in demand and currently has no scheduled retirement date.26

The E-8 Joint Surveillance Target Attack Radar System (J-STARS) and RC-135 Rivet Joint are critical ISR platforms. Each was built on the Boeing 707 platform, and the last one came off the production line 42 years ago. The FY 2020 National Defense Authorization Act directed the Air Force not to retire the E-8 until a replacement system is available. However, the President's FY 2022 budget request includes the retirement of four of those platforms.²⁷

The Air Force is working on an incremental approach for a J-STARS replacement that focuses on advanced and disaggregated sensors (a system of systems) that would require enhanced and hardened communications links. Known as the Advanced Battle Management System (ABMS),²⁸ it is envisioned as an all-encompassing approach to both airborne and ground Battle Management Command and Control (BMC2) that would allow the Air Force to fight and support joint and coalition partners in high-end engagements.²⁹

With respect to air combat, the Active Air Force has just 98 F-15Cs left in its fleet,³⁰ and

Air Force Total Aircraft Inventory (Page 1 of 3)	TABLE 6
	Air Force Total Aircraft Inventory (Page 1 of 3)

			FY 2021				MISSION CA	PABLE (MC)			FY 2022	
Type	Active Duty	Air National Guard	Air Force Reserve	Total	Average Age in Years	MC Rate FY 2019	MC Rate FY 2020	Change	Average Daily MC Aircraft, FY 2021	Programmed Retirements	Programmed Acquisitions	Total
A010C	143	85	55	281	39	71%	72%	0.80%	202	-42		239
AC130J	26	0	0	26	4	86%	82%	-4.12%	21		4	30
AC130U	9	0	0	9	30	86%	88%	2.38%	£	9-		0
B-1B	61	0	0	44	33	46%	53%	6.58%	23	0		44
B-2A	20	0	0	20	26	80%	62%	1.53%	12			20
B-52H	58	0	18	76	59	66%	61%	-4.73%	46			76
C-130H	2	127	42	141	30	66%	70%	4.49%	66	-13		128
C-130J	109	16	10	146	11	77%	79%	1.98%	115		5	151
C-5M	52			52			61%		31			52
C-17A	146	50	26	222	17	82%	82%	0.07%	183			222
CV022B	52	0	0	52	ω	53%	54%	0.75%	28			52
E003B	16	0	0	16	42	74%	66%	-8.61%	11	-4		12
E003C	1	0	0	Ч	37	73%	77%	3.61%	Ч			Ч
E003G	20	0	0	20	40	74%	71%	-3.66%	14			20
E008C	0	16	0	16	20	67%	67%	-0.86%	11	-4		12
EC130H	6	0	0	6	47	73%	67%	-6.29%	9	-2		7
EC130J	0	7	0	7	20	57%	53%	-4.88%	4			7
F015C	86	123	0	209	36	70%	72%	1.85%	150	-36		173

TABLE 6

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	ed Is Total	12	218	2	736	153	186	376	39	3	82	36	71	322	54	10	16	55	351
FY 2022	Programme Acquisitior							50	4				М					11	21
	Programmed Retirements	-12			-40	9					-25	-14		-18					
	Average Daily MC Aircraft, FY 2021	17	151		573	115	97	248	28	2	74	40	45	248	39	4	12	33	300
PABLE (MC)	Change	-1.95%	-2.09%		0.93%	1.73%	1.41%	14.50%	-0.07%	6.07%	2.79%	1.50%	0.00%	0.40%	1.99%	3.42%	4.95%	-1.64%	1.45%
MISSION CA	MC Rate FY 2020	71%	%69		74%	72%	52%	76%	80%	74%	69%	81%	67%	73%	73%	44%	74%	76%	91%
	МС Rate FY 2019	72%	71%		73%	70%	51%	62%	80%	68%	86%	79%	63%	73%	71%	40%	%69	78%	89%
	Average Age in Years	36	28	0	30	30	13	5	9	26	30	36	2	59	60	35	32	9	7
	Total	24	218	2	776	159	186	326	35	З	107	50	68	340	54	10	16	44	330
FY 2021	Air Force Reserve	0	0		49	4	0	0	2	0	15	0	4	70	0	0	0	0	0
	Air National Guard	14	0		288	44	20	20	12	Ю	18	0	12	148	24	10	0	0	24
	Active Duty	10	218	2	439	111	166	306	21	0	74	50	52	122	30	0	16	44	306
	Type	F015D	F015E	F015EX	F016C	F016D	F022A	F035A	HC130J	HC130N	D090HH	KC010A	KC046A	KC135R	KC135T	LC130H	MC130H	MC130J	MQ009A

TABLE 6

Air Force Total Aircraft Inventory (Page 3 of 3)

	Total	0	м	2	œ	6	10	178	59	445	31	
FY 2022	Programmed Acquisitions											
	Programmed Retirements	-2					-20					
	Average Daily MC Aircraft, FY 2021	2	3	2	9	7	22	122	42	291	23	
PABLE (MC)	Change	4.14%	-2.79%	-4.57%	3.90%	11.51%	-2.15%	7.89%	-3.18%	2.35%	-5%	
MISSION CA	MC Rate FY 2020	87%	88%	87%	78%	81%	74%	68%	71%	65%	73%	
	MC Rate FY 2019	82%	%06	91%	74%	%69	76%	61%	74%	63%	78%	
	Average Age in Years	58	58	55	56	57	6	26	54	53	29	
	Total	2	З	2	8	6	30	178	59	445	31	
FY 2021	Air Force Reserve	0	0	0	0	0	0	0	0	0	0	
	Air National Guard	0	0	0	0	0	0	0	0	0	0	
	Active Duty	2	З	2	8	6	30	178	59	445	31	
	Type	OC135B	RC135S	RC135U	RC135V	RC135W	RQ004B	T001A	T038A	T038C	U2	

Appendix, "Department of the Air Force Total Aircraft Inventory (TAI)," in U.S. Department of the Air Force, Department of the Air Force FY 2022 Budget Overview, p. 50, https://www.saffm.hq.af.mil/ Portals/84/documents/FY22/SUPPORT_/FY22%20Budget%20Overview%20Book.pdf?ver=SMbMqD0tqJNwq2Z0Q4yzA%3d%3d (accessed August 17, 2021); and International Institute for Strategic SOURCES: Headquarters U.S. Air Force, Deputy Chief of Staff for Operations, written response to Heritage Foundation request for information on Air Force mission-capable rates, May 17, 2021; Studies, The Military Balance 2021: The Annual Assessment of Global Military Capabilities and Defence Economics (London: Routledge, 2021), pp. 56–59. Theritage.org

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concerns about what platform will fill this role when the F-15C is retired are fully justified. The Department of Defense planned to purchase 750 F-22A stealth air superiority fighters to replace the F-15C, but draconian cuts in the program of record reduced the acquisition to a total of just 186 F-22As: 166 Active Duty and 20 Air National Guard.³¹

The ability to fulfill the operational need for air superiority fighters will be further strained in the near term because of the F-22's low availability rates and a structural repair program that causes some portion of those jets to be unavailable for operational use. The program had six F-22s off the flight line at any given time³² to make alterations required to extend the airframe's service life to 8,000 hours. That program was completed in late 2020 and will now transition to a 10-year program to refurbish the low-observable coatings on the engine inlets and inspect and overhaul the aircraft's flight control system that will run through 2031.³³

The Air Force's number-one acquisition priority remains the F-35A, the next-generation fighter scheduled to replace all legacy multirole and close air support aircraft. The jet's full operating capability (FOC) was delivered in early 2018.³⁴ The rationale for the Air Force's planned acquisition of 1,763 aircraft is to replace every F-117, F-16, and A-10 aircraft on a one-for-one basis.³⁵ The F-35A's multirole design favors the air-to-ground mission, but its fifth-generation faculties will also be dominant in an air-to-air role, allowing it to augment the F-22A in many scenarios.³⁶

A second top acquisition priority is the KC-46A air refueling tanker. The KC-46 has experienced a series of problems and delays, the most recent of which involves the air refueling system that currently cannot refuel fighters in an operational environment. The Air Force will have 68 KC-46s (44 Active, 12 Guard, and 12 Reserve) by the end of FY 2021 and will receive three more for a total of 71 in FY 2022.³⁷ The program plans to acquire another 108 tankers for a total of 179 by the end of FY 2028. The KC-46 will replace less than

half of the current tanker fleet and will leave the Air Force with over 200 aging KC-135s (already averaging 59 years old) that still need to be recapitalized.³⁸

The third major USAF acquisition priority is the B-21 Raider, formerly called the Long-Range Strike Bomber (LRSB). The USAF awarded Northrop Grumman the B-21 contract to build the Engineering and Manufacturing Development (EMD) phase, which includes associated training and support systems and initial production lots. The program has completed an Integrated Baseline Review for the overall B-21 development effort as well as the jet's Preliminary Design Review. The Air Force is committed to a minimum of 100 B-21s at an average cost of \$564 million per plane.³⁹

With the budget deal that was reached for FY 2018 and FY 2019, the Secretary of the Air Force announced the service's intent to retire all B-1s and B-2s and sustain a fleet comprised of 100 B-21s and 71 B-52s.⁴⁰ The B-21 is programmed to begin replacing portions of the B-52 and B-1B fleets by the mid-2020s.⁴¹ In the interim, the Air Force continues to execute a SLEP on the remaining fleet of B-1s in the inventory to restore the bomber's engines to their original specifications. Through 2020, the Air Force sustained a fleet of 61 B-1s, but the state of repair of 17 of those jets has deteriorated to the point where the Air Force will retire them by the end of FY 2021.⁴²

The Air Force had planned to modernize the B-2's Defense Management System but cancelled the plan in 2021 because of a software coding mismatch with its legacy computer system.⁴³ Stores Management Operational Flight Program and Common Very-Low-Frequency/ Low Frequency Receiver Program elements will be fielded to ensure that this penetrating bomber remains viable in highly contested environments, keeping it fully mission capable until it is replaced by the B-21.⁴⁴

Modernization efforts for the B-52 are also underway. The jet was designed in the 1950s, and the current fleet entered service in the 1960s. The FY 2018 budget funded the re-engineering of this fleet with upgrades that will include a new Long-Range Standoff (LRSO) cruise missile, improved radar, new computers, new communication links, and a new suite of electronic warfare countermeasures. The aircraft will remain in the inventory through 2050.⁴⁵

When the Secretary of the Air Force and the Chief of Staff rolled out "The Air Force We Need" in 2018 to expand the number of squadrons from 312 to 386, one of the stated elements of that campaign was to fill the ranks of those new squadrons with only the newest generation of aircraft-F-35s, B-21s, and KC-46s-because of the capabilities that those platforms bring to bear.⁴⁶ Curiously, the Air Force is now acquiring the fourth-generation F-15EX, based primarily on the ill-perceived notion that it will be cheaper to acquire and operate than the F-35A.47 The FY 2022 budget funds 12 F-15EXs, and the Air Force has an unfunded request for 12 more. Although the service will certainly increase its numbers with that approach, the F-15EX will not be survivable in the high-threat environment in which deployed assets will be required to fight by the time fielding has been completed. The Air Force is using precious acquisition dollars to buy an aircraft that, by all indicators, will have very limited utility in a conflict with a peer competitor.

Readiness

The 2018 National Defense Strategy's focus on peer-level war was designed to facilitate a clear and rapid paradigm shift away from the tiered levels of readiness the Air Force had adopted because of years of relentless deployments and funding shortfalls. In a move that would refine the service's focus on great-power competition as spelled out by the new NDS, Secretary of Defense James Mattis directed the Air Force to increase the mission-capable rates of the F-16, F-22, and F-35 aircraft to 80 percent by the end of September 2019.48 The move was designed to make more of an all-toosmall fleet of combat aircraft available to deploy in the numbers required to deter or defeat a peer adversary.

Early in 2019, General Goldfein stated that the service would likely not meet the 80 percent mission-capable (MC) threshold directive until 2020, and in the spring of 2020, he made it clear that the threshold was no longer a focus for the Air Force. MC rates are a measure of how much of a certain fleet is "ready to go" at a given time, and the general stated in clear terms that he regarded them as an inaccurate portrayal of the service's overall health.

Instead of using that historic marker for readiness, the service moved to highlight how deployable the fleet is within a short period of time⁴⁹ and shifted its focus to the number of "force elements" (fighters, bombers, and tankers) that it has across the Air Force and how quickly those forces need to be ready. One of the examples that Goldfein used was the rapid deployment of a "task force" of four B-52s to the Middle East in May 2019.50 The bombers, from Barksdale Air Force Base, Louisiana, had two days to deploy and immediately began to fly combat missions even though the B-52 fleet had a mission-capable rate of 65.73 percent at the time. While the ability to prepare and then deploy four of 58 operational bombers rapidly is a capability, it is more in line with responding to a regional contingency than it is with the capacity requirements spelled out in the 2018 NDS.

In the USAF's FY 2020 posture statement, Secretary Wilson and Chief of Staff Goldfein said that more than 90 percent of the "lead force packages" within the service's 204 "pacing squadrons" are "ready to 'fight tonight." They went on to say that "pacing squadrons are on track to reach 80% readiness before the end of Fiscal Year 2020."51 In the FY 2021 posture statement, however, Goldfein and new Air Force Secretary Barbara Barrett were unable to declare that pacing squadrons had actually achieved that level of readiness, saying only that pacing squadron mission-capable rates had increased and that the Air Force was continuing its efforts to improve MC rates "across all fleets."52

The definitions for "pacing unit" and "pacing squadrons" are somewhat elusive. Assuming that a pacing squadron is an operational

	Combat-Coded Fighters	Average Age in Years	Mission- Capable Rate	Mission-Capable Combat-Coded Fighters
A-10C	117	39	72%	84
F-15C	98	36	72%	71
F-15E	164	28	69%	113
F-16C	336	30	74%	249
F-22A	133	13	52%	69
F-35A	136	4	76%	103
Total	983			689

Mission-Capable Combat-Coded Fighters in the Active-Duty Air Force

NOTE: Thirteen months were added because of the difference between the aircraft data capture dates for the 2021 USAF Almanac and publication of this edition of the *Index*.

SOURCES:

 "Air Force & Space Force Almanac 2021," Air Force Magazine, Vol. 104, No. 6 and 7 (June/July 2021), https://www.airforcemag.com/ article/2021-usaf-ussf-almanac-equipment/ (accessed Augsut 17, 2021).

• Headquarters U.S. Air Force, Deputy Chief of Staff for Operations, written response to Heritage Foundation request for information on Air Force mission-capable rates, May 17, 2021.

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unit that is fully qualified and ready to execute its primary wartime mission (C1), one is still left wondering what the "lead force packages" within those 204 pacing/mission-ready units are and what the limits on the remaining portions of those units might be. Taken together, these statements imply that only portions of the Air Force's combat-coded squadrons are currently qualified to execute the unit's primary wartime mission.

The FY 2022 Air Force posture statement offers no more clarity or assurances of readiness, but it has moved (again) to change the terminology. The simplified, three-phase force-generation model is designed "to more effectively articulate" otherwise undefined "readiness impacts and capacity limits."⁵³

In 2017, the Secretary of the Air Force and the Chief of Staff informed Congress that "[w]e are at our lowest state of full spectrum readiness in our history."⁵⁴ In the four years since their testimony, DOD has stifled open conversation or testimony about readiness, limiting the Air Force's ability to be forthcoming with open-source readiness indicators. While this makes any assessment of readiness difficult, there are three areas that can support an assessment: MC rates, aircrew training, and deployability.

MC rates are defined as the percentage of a unit's aircraft that are capable of executing its mission set. Several factors drive MC rates, but two are common to mature systems: manning and operations and maintenance (O&M) funding. Taken together, they dictate the number of sorties and flight hours that units have available for aircrew training. Multiplying the MC rates by the actual number of aircraft within a particular fleet yields the actual operational capacity of that capability.

There are 186 F-22As in the total aircraft inventory, but 28 are dedicated trainers, and

Skill Level	Authorized	Assigned	Manning Percentage				
3-level (Apprentice)	15,078	15,994	106%				
5-level (Journeyman)	36,704	36,151	98%				
7-level (Craftsman)	18,443	18,390	100%				
COURCE: Handquarters LLS Air Force Deputy Chief of Staff for Operations, written response to							

Air Force Maintenance Manning

SOURCE: Headquarters U.S. Air Force, Deputy Chief of Staff for Operations, written response to Heritage Foundation request for information on Air Force mission-capable rates, May 17, 2021.

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16 are primary development aircraft inventory (used for testing new equipment). In 2020, the F-22A had an MC rate of 52 percent, which means that there were just 74 F-22As that could be committed to combat at any given time.55 The last time the United States was prepared to fight a peer competitor, the Air Force had more than 700 F-15C air superiority fighters with an MC rate of more than 80 percent for that fleet. If just 500 of them were combat coded, more than 400 mission-capable jets were ready to fight the Soviet Union. Although the F-22A is an incredibly capable fighter and 74 F-22s would be a formidable capability against a regional threat, numbers are critical to winning a peer fight, particularly for offensive platforms, and 74 would not be sufficient. For a summary of the mission-capable rates for combat-coded (operational) aircraft of the five fighter weapons systems, see Table 7.

There are 33 operational B-1s in the Lancer fleet,⁵⁶ and with an MC rate of 52.78 percent, 17 are available for combat at any given time during the year. The small size of the B-2 fleet, coupled with its 62.41 percent MC rate, means that, on average, just 12 are combat capable. If the B-52 operational fleet and its missioncapable rate of 60.51 percent are added, just 64 bombers in the Air Force inventory were capable of executing combat missions on any given day in 2020.

Maintenance manning is now healthy across the board (see Table 8), but the pilot

shortage shows no signs of abating. In March 2017, Lieutenant General Gina M. Grosso, Air Force Deputy Chief of Staff for Manpower, Personnel, and Services, testified that at the end of FY 2016, the Air Force had a shortfall of 1,555 pilots across all mission areas: 608 Active, 653 Air National Guard, and 294 Reserve. Of that total, the Air Force was short 1,211 fighter pilots: 873 Active, 272 Air National Guard, and 66 Reserve.⁵⁷

The numbers continued to fall, and in the middle of FY 2020, the Air Force was short 2,100 pilots. Today, the total Air Force has a shortfall of 1,925 pilots, and while this is an improvement of 175 pilots over 2020, almost all of that improvement was due to the cessation of airline hiring caused by COVID-19.⁵⁸ The ability of the Air Force to recover from that shortfall will depend on how well the service addresses several major issues, especially the available number of pilot training slots, an area in which it appears that some progress is being made.

In FY 2018, the Air Force graduated 1,200 pilots; it added 1,279 in FY 2019 and projected that 1,480 would graduate in 2020, but the impact of COVID-19 was such that only 1,263 received their wings. The vast majority of candidates who did not graduate washed back and will graduate some time in FY 2021.

Those projected numbers rely on a very high annual graduation rate of approximately 94 percent of the candidates that enter flight school. According to the data the Air Force provided for the 2021 Index of Military Strength, the graduation rates for 2016, 2017, and 2018 were 93 percent, 98 percent, and 97 percent, respectively.⁵⁹ Those numbers, however, were incorrect, and the actual graduation rates were 96 percent for 2016, 92 percent for 2017, and 93 percent for 2018.⁶⁰

Throughout the pilot shortage, the Air Force has done an excellent job of emphasizing operational manning instead of placing experienced fighter pilots at staffs and schools, but the currency and qualifications of the pilots in operational units are at least as important as manning levels. Although the quality of sorties is admittedly subjective, a healthy rate of three sorties a week and flying hours averaging more than 200 hours a year have been established as "sufficient" over more than six decades of fighter pilot training.61 In the words of General Bill Creech, "Higher sortie rates mean increased proficiency for our combat aircrews,"62 and given the right number of sorties and quality flight time, it takes seven years beyond mission qualification in a fighter for an individual to maximize his potential as a fighter pilot.63

COVID-19's impact on flying hours hit the Air Force as it was beginning to recover from an 18-year drought in training for combat with a near-peer competitor. Flying hours and sortie rates across all fighter platforms fell to historic lows as the average line combat mission-ready fighter pilot received less than 1.5 sorties a week and 131 hours of flying time that year. That is significantly below the healthy fighter force thresholds of three sorties a week and 200 hours a year per pilot. Moreover, to the extent that the Air Force lacks available aircraft, it will remain unable to train pilots to those thresholds.

As noted, the primary drivers for missioncapable rates are maintenance manning and O&M funding. Maintenance manning has been healthy for more than four years, and FY 2022 O&M funding is 42 percent higher than the funding O&M received for FY 2017. However, flying hours across the fleet of fighters have increased by just 9 percent over that same period, and senior Air Force leaders actually decreased the flying hour budget for FY 2022 by some 80,000 hours (7 percent).⁶⁴ This calls into question how well maintenance is organized to generate those sorties.

The sortie production recovery that took place at the end of the hollow-force days of the Carter Administration happened while levels of maintenance experience and inventories of spare parts were still low and well before the Reagan Administration's increase in defense spending.65 The maintenance organization that created that turnaround was changed in 1989 to "save money by reducing maintenance staffing, equipment, and base level support,"66 which may help to explain the lackluster performance. No matter what the rationale may be, even with robust manpower and funding, flying hours and sortie rates are still short of the levels required for a rapid increase in readiness levels across the fighter force.

Five years of increases in the O&M budget have not translated into a proportionate growth in flight hours or greater readiness levels. Fighter pilots received an average of 13.0 hours per month in 2017, and an incremental O&M budget increase of 16.4 percent over the next three years delivered 12.9 hours per month in 2018 and 14.1 hours per month in 2019—only 8 percent higher than in 2017.⁶⁷ (For data related to flight hours and sorties, see Tables 9 through 14.)

Combat mission-ready pilots generally fly more than average, and those assigned to a combat-coded (operational) unit received just 14.6 hours and 7.5 sorties a month in 2019,⁶⁸ which is an average below two sorties a week when they need three per week to sustain their skills.⁶⁹ The Air Force did its best to fly through the effects of COVID-19, but the pandemic had a devastating effect on hours and sortie rates. The average fighter pilot flew just over one sortie a week for the duration of 2020, which in a high-performance jet reduces competency levels to the point where excellent pilots begin to question the execution of very basic tasks.⁷⁰

It will take several more years of robust training for fighter pilots within fighter squadrons to regain what they lost in 2020 alone.

	2017	2018	2019	2020	Percentage Change, 2019 to 2020
F-22	10.8	10.8	10.5	6.9	-34%
F-35A	10.4	10.4	14.4	10.2	-29%
F-15C	10.5	10.5	11.8	4.8	-59%
F-16C	12.2	12.2	12.1	6.7	-45%
F-15E	18.3	18.3	20.3	13.0	-36%
A-10	15.1	15.1	16.5	12.2	-26%
All Jets	13.0	12.9	14.1	8.7	-38%
Average Hours per Year	155.4	154.6	168.7	104.3	-38%

Average Hours All Fighter Pilots Received per Month

SOURCE: Headquarters U.S. Air Force, Deputy Chief of Staff for Operations, written response to Heritage Foundation request for information on Air Force mission-capable rates, May 17, 2021.

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Unfortunately, the Air Force is not moving on that path and will cut 87,479 flying hours from its budget in FY 2022—a reduction of 7 percent.⁷¹

Deployability. Because long-term inspections and depot-level work affect the

availability of support equipment and aircraft, it takes three active-duty squadrons to deploy two squadrons forward. For that reason, up until the end of the Cold War, the Air Force organizational structure was based on a three-squadron wing. On any given day, units

TABLE 10

Average Sorties All Fighter Pilots Received per Month

	2017	2018	2019	2020	Percentage Change, 2019 to 2020
F-22	6.4	6.4	7.1	5.3	-25%
F-35A	6.6	6.6	6.5	5.9	-9%
F-15C	7.0	7.0	6.6	4.5	-32%
F-16C	7.4	7.4	7.3	4.6	-37%
F-15E	7.9	7.9	7.6	6.4	-16%
A-10	7.1	7.1	7.5	5.9	-21%
All Jets	7.2	7.2	7.2	5.3	-26%
Average Sorties per Year	86.5	86.2	86.0	64.0	-26%

SOURCE: Headquarters U.S. Air Force, Deputy Chief of Staff for Operations, written response to Heritage Foundation request for information on Air Force mission-capable rates, May 17, 2021.

Average Hours Line Fighter Pilots Received per Month in Combat-Coded Squadrons

	2019	2020	Percentage Change
F-22	11.0	7.6	-31%
F-35A	15.4	14.7	-5%
F-15C	11.9	8.9	-25%
F-16C	12.7	8.5	-33%
F-15E	21.7	16.6	-24%
A-10	16.9	14.1	-17%
All Jets	14.6	10.9	-25%
Average Hours per Year	174.7	131.0	-25%
SOURCE: Headquarters U.S. Air Force, resp	heritage.org		

have several aircraft that are not flyable because of long-term inspections, deep maintenance, or the need for spare parts. By using aircraft from one of the three squadrons to "plus up" the others, the wing could immediately deploy two full-strength units into combat. The handful of fully flyable jets and pilots left at the home station were then used to train new and inbound pilots up to mission-ready status so that, among other things, they could replace pilots that were lost during combat.⁷²

Normal, active duty fighter squadron manning levels are based on a ratio of 1.25 aircrew members for every aircraft,⁷³ which means that a unit with 24 assigned aircraft should have 30 line pilots and five supervisor pilots who are

TABLE 12

Average Sorties Line Fighter Pilots Received per Month in Combat-Coded Squadrons

	2019	2020	Percentage Change
F-22	7.4	5.5	-26%
F-35A	6.7	6.8	1%
F-15C	6.8	5.0	-26%
F-16C	7.6	5.3	-30%
F-15E	8.0	7.2	-10%
A-10	7.7	6.5	-16%
All Jets	7.5	5.9	-21%
Average Sorties per Year	89.9	71.0	-21%

SOURCE: Headquarters U.S. Air Force, response to request for information, May 14, 2021.

	2017	2018	2019	2020	Percentage Change, 2019 to 2020
F-22	11.7	12.8	10.9	7.1	-35%
F-35A	10.6	12.4	15.0	10.5	-30%
F-15C	10.5	13.1	11.8	4.6	-61%
F-16C	11.9	15.5	12.5	6.9	-45%
F-15E	19.1	20.3	21.3	6.6	-69%
A-10	16.7	23.0	16.9	12.6	-25%
All Jets	13.2	16.1	14.6	8.9	-39%
Average Hours per Year	159.0	193.0	175.0	107.0	-39%
SOURCE: Headquarters U.S. Air Force. r	esponse to reques	t for information	. May 14. 2021.		🖀 heritage.org

Average Hours All Line Fighter Pilots Received per Month

combat mission ready.⁷⁴ Flight times, sortie rates, mission planning teams, and flight supervision requirements are significantly higher in combat, and to cover those requirements, the manning ratio normally increases to 1.50 pilots per aircraft, or 36 line pilots per squadron. In other words, every squadron deployed to fight requires six more pilots than it has on its roster.⁷⁵ Pilots from "donor" squadrons can fill those slots for the deploying units.

With the downsizing that has taken place since the end of the Cold War and the reduction in the number of fighter squadrons, the Active Air Force has reduced the number of fighter squadrons to two or even one in many wings. All operational Guard and Reserve

TABLE 14

	2017	2018	2019	2020	Percentage Change, 2019 to 2020
F-22	6.3	4.5	7.3	5.5	-25%
F-35A	6.5	7.5	6.6	6.0	-9%
F-15C	7.2	8.4	6.7	4.6	-31%
F-16C	7.3	9.3	7.5	4.7	-37%
F-15E	8.0	8.5	7.9	6.6	-16%
A-10	7.2	9.7	7.7	6.1	-21%
All Jets	7.2	8.3	7.4	5.4	-27%
Average Sorties per Year	86.0	100.0	89.0	65.0	-27%

Average Sorties All Line Fighter Pilots Received per Month

SOURCE: Headquarters U.S. Air Force, Deputy Chief of Staff for Operations, written response to Heritage Foundation request for information on Air Force mission-capable rates, May 17, 2021.

FIGURE 2

Air Force Active-Duty Combat-Coded Fighter Squadrons (32 Total)



wings are comprised of a single squadron, which complicates the math behind the total number of deployable fighter squadrons.

Of the 55 operational fighter squadrons on the Air Force roster, 32 are Active and 23 are Guard or Reserve Units. (See Figures 2 and 3.) Using the notion that it takes three squadrons to get two active-duty ones forward, the airframe disposition of each active-duty wing would allow just 21 active-duty fighter squadron equivalents (24 fighter aircraft each) to deploy to a fight. That equates to 480 active-duty fighters that could deploy to meet a crisis situation, which is well short of the 600 it takes to win a single MRC and means that a war with a peer competitor will draw heavily on our strategic reserve.

Guard and Reserve units face the same manning and deployment challenges that the

active-duty service faces, except that the vast majority of those units have just one fighter squadron per wing, further straining their ability to muster the airframes and manning to meet an emergency deployment.⁷⁶ Planning for low-threat, low-intensity deployments to Operation Iraqi Freedom and Operation Enduring Freedom took this into consideration by mapping deployments out months (often years) in advance of the required movement, allowing pilots to deconflict their civilian work schedules not just for the deployment, but also to get the training and time in the air that they needed to employ successfully in those low-threat combat operations.77 Nevertheless, it was common for Guard units to pull pilots from other units to fulfill manning requirements for "rainbow" fighter squadrons,78 and in a conflict where there is little time from

Air National Guard and Air Force Reserve Combat-Coded Fighter Squadrons (23 Total)



SOURCE: Headquarters U.S. Air Force, Deputy Chief of Staff for Operations, written response to Heritage Foundation request for information on Air Force mission-capable rates, May 17, 2021.

heritage.org

warning order to deployment, it would likely take two Guard and Reserve squadrons to enable one to deploy forward.⁷⁹

The average Guard and Reserve fighter squadron has one-third fewer jets than similar active-duty units have. By rainbowing units with similar aircraft, they could muster 12 squadrons as a strategic reserve of 288 fighters that could deploy sometime after the active-duty units deploy. In other words, the service could muster just 768 fighters (480 Active and 288 Guard and Reserve) for a peer-level fight. Unfortunately, the gravity of that mix is not fully understood. The Guard and Reserve numbers are based on airframes alone, but other factors such as manning levels would also limit the number of sorties and the amount of combat power that those fighters could generate continually in a high-end confrontation with a peer competitor.

The declaration in Air Force posture statements for FY 2020 and FY 2021 that lead force packages within the service's 204 pacing squadrons are ready to fight also conveys the fact that only portions of its most capable squadrons have enough mission-capable aircraft and mission-ready aircrews to respond readily to a crisis. Because of the pilot shortage, actual unit manning levels in fighter squadrons are below peacetime requirements (if only slightly), which obviously is not enough to meet the significantly increased demands and the tempo required for combat operations.

The service has already moved the majority of pilots who were in staff or other non-flying billets back to the cockpit in an effort to relieve the manning shortfall. Thus, the only way units can meet wartime manning requirements is by pulling pilots from other "donor" squadrons. The complications that this involves are significant and call into question the idea that the portions of the 55 fighter squadrons that are unable to deploy immediately in a crisis could be combined to create more combat power. The vast majority of aircraft and aircrew that are left would be used for homeland defense and to train replacement pilots or as replacement aircraft that are lost through combat attrition.

Scoring the U.S. Air Force

Capacity Score: Marginal

One of the key elements of combat power in the U.S. Air Force is its fleet of fighter aircraft. In responding to major combat engagements since World War II, the Air Force has deployed an average of 28 fighter squadrons. Based on an average of 18 aircraft per squadron, that equates to a requirement of 500 active component fighter aircraft to execute one MRC. Adding a planning factor of 20 percent for spares and attrition reserves brings the number to 600 aircraft.

As part of its overall assessment of capacity, the 2022 *Index* looks for 1,200 active-duty, combat-coded fighter aircraft to meet the baseline requirement for two MRCs.⁸⁰ That number of fighters lines up well with the fighter requirement from the 2018 TAFWN. The bomber, tanker, and strategic air requirement from that study are also used in this assessment.

- **Two-MRC Fighter—Threshold:** 1,200 combat-coded active-duty fighters / 62 squadrons.
- **Two-MRC Fighter—Actual 2021 Level:** 983 active-duty combat-coded fighters (82 percent) / 55 total force squadrons (88 percent).
- TAFWN Bomber Squadron— Threshold: 14 combat-coded bomber squadrons / 140 bombers.
- TAFWN Bomber Squadron—Actual 2021 Level: nine combat-coded bomber squadrons (64 percent) / 114 combatcoded bombers (81 percent).

- **TAFWN Tanker Squadron—Threshold:** 54 tanker squadrons / 540 combat-coded tankers.
- TAFWN Tanker Squadron—Actual 2021 Level: 39 combat-coded tanker squadrons (72 percent) / 414 combatcoded tankers (76 percent).
- TAFWN Airlift Squadron—Threshold: 54 airlift squadrons / 540 combatcoded airlifters.
- TAFWN Airlift Squadron—Actual 2021 Level: 50 combat-coded airlift squadrons (93 percent) / 538 combatcoded airlifters (99 percent).

Based on a pure count of combat-coded squadrons and platforms that have achieved initial operating capability (IOC), the USAF currently is at 86 percent of the capacity required to meet a two-MRC/TAFWN benchmark. However, the disposition of those assets limits the ability of the service to deploy them rapidly to a crisis region. While the active fighter and bomber assets that are available would likely prove adequate to fight and win a single regional conflict, when coupled with the low mission capability rates of those aircraft (see Table 7), the global sourcing needed to field the required combat fighter force assets would leave the rest of the world uncovered.

Nevertheless, the capacity level is well within the methodology's range of "marginal." With programmed retirements that will exceed acquisitions, capacity is now trending downward.

Capability Score: Marginal

The Air Force's capability score is "marginal," based on scores of "strong" for "Size of Modernization Program," "marginal" for "Age of Equipment" and "Health of Modernization Programs," but "weak" for "Capability of Equipment." These assessments are the same as those in the *2021 Index*. New F-35 and KC-46 aircraft continue to roll off their respective production lines, but these additions are more than offset by aircraft retirements. As a consequence, this score will probably not improve over the next three to five years.

Readiness Score: Weak

The Air Force scores "weak" for readiness in the *2022 Index*, one grade lower than it received in the *2021 Index*. The USAF's sustained pilot deficit and the impact of COVID-19 on already low sortie rates and flying hours certainly contribute to this assessment. The Air Force's mission-capable rates improved slightly in 2020, but the lack of a systemic effort to increase operational training reflects a service that is content with being ready to respond to a regional contingency rather than building the readiness levels required to meet the 2018 NDS.⁸¹

The Air Force should be prepared to respond quickly to an emergent crisis not with a "task force" of four bombers, but with the speed and capacity required to stop a peer competitor in its tracks. With the significant curtailment of deployments in support of the global war on terrorism, the Air Force should be much farther along in its full-spectrum readiness than we have witnessed to date.

Overall U.S. Air Force Score: Weak

This is an unweighted average of the USAF's capacity score of "marginal," capability score of "marginal," and readiness score of "weak." The shortage of pilots and flying time for those pilots degrades the ability of the Air Force to generate the quality of combat air power that would be needed to meet wartime requirements. Fighter pilots should receive an average of three or more sorties a week and 200 hours per year to develop the skill sets needed to survive in combat, and while the service cannot be blamed for the effects of COVID-19 on readiness, it elected not to surge to acquire more aircraft or significantly increase training/sortie production in the window of robust funding.

Although it would likely win a single MRC in any theater, there is little doubt the Air Force would struggle in war with a peer competitor. Both the time required to win such a conflict and the attendant rates of attrition would be much higher than they would be if the service had moved aggressively to increase high-end training and acquire the fifth-generation weapon systems required to dominate such a fight.

	VERY WEAK	WEAK	MARGINAL	STRONG	VERY STRONG
Capacity			 Image: A set of the set of the		
Capability			~		
Readiness		 ✓ 			
OVERALL		~			

U.S. Military Power: Air Force





Strategic Bomber

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
PLATFORM B-52 Stratofortress Inventory: 76 Fleet age: 60 Date: 1961 The B-52, oldest of the bombers, provides global strike capabilities with conventional or nuclear payloads. Programmed upgrades for the B-52 include new communications, avionics, and Multi-Functional Color Displays. The Air Force plans to use this aircraft through the 2050s. B-1B Lancer Inventory: 44 Fleet age: 34 Date: 1986 Nicknamed "The Bone," the B-1B Lancer is a long-range, multi-mission, supersonic conventional bomber, that has served the United States Air Force	1	2	B-21 Raider Timeline: TBD The B-21 is an advanced stealth bomber tha programmed to replace all B-1s and B-2s in bomber fleet by 2032. Flight testing is sche 2021, and procurement is expected to begi Raider is projected to enter service in the m deliver a fleet of at least 100 aircraft.	at is currer the Air Fo eduled for n in FY 20 hid-2020s	atly arce late 22. The and
since 1985. Originally designed for nuclear capabilities, the B-1 switched to an exclusively conventional combat role in the mid-1990s. In September 2020, the entire B-1B Lancer fleet completed the Integrated Battle Station upgrade to modernize the jet's datalinks, cockpit displays, and test system. The B-1B is scheduled to be phased out in 2032.	2	2			
B-2 Spirit Inventory: 20					
The B-2 bomber provides the USAF with global strike capabilities for both nuclear and conventional payloads. The stealth bomber's communication suite is currently being upgraded. At present, the plan is to begin phasing out the B-2 in 2032.	3	4			

NOTE: See page 450 for details on fleet ages, dates, timelines, and procurement spending.




Ground Attack/Multi-Role Aircraft

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
A-10 Thunderbolt II Inventory: 281 Fleet age: 41 Date: 1977			F-35A Timeline: 2016–2035	4	3
The A-10 is the only USAF platform that is designed specifically for close air support missions using both self- designated precision-guided munitions and an internal 30mm cannon. Retirement of the A-10 has been discussed for years, but it appears that it will continue flying through 2040.	2	2	The F-35A "Lightning" is a multirole stealth became IOC on August 2, 2016. In FY21, Co the procurement of 60 F-35As (including 12 adds) and in FY22, the number fell back to a single congressional add). The Block 4 ve aircraft will upgrade capabilities of early pr PROCUREMENT	fighter th ngress fun 2 congress 49 jet (inc rsion of th oduction. \$ millions)	at Ided sional Iluding Ie
F-16C Falcon			460 48 \$5	I,381 \$4	4,168
Inventory: 935 Fleet age: 31 Date: 1980					
The F-16 is a multi-role aircraft capable of tactical nuclear delivery, all-weather strike, and Suppression of Enemy Air Defenses (SEAD). An ongoing Service Life Extension Program (SLEP) will keep this jet in the inventory through the late 2040s.					
F-35A Lightning					
Inventory: 326 Fleet age: 5 Date: 2016 The F-35 is a multi-role stealth fighter that became operational in 2016. The Air Force has received more than 326 of a planned purchase of 1,763 aircraft.	6	5			
F-15E Strike Eagle					
Inventory: 218 Fleet age: 29 Date: 1989 The F-15E is a multi-role aircraft capable of all-weather, deep interdiction/attack, and tactical nuclear weapons delivery. Upgrades include an AESA radar, an EPAWSS self-defense suite, a new central computer, and cockpit displays.	2	2			

AIR FORCE SCORES



Fighter Aircraft

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
F-15C/D Eagle Inventory: 233 Fleet age: 37 Date: 1975			F-15 EX Timeline: 2020-2029	2	0
The F-15C/D is an air superiority fighter that has been in service since the late 1970s. The jet is receiving upgrades that include a new AESA radar and self- defenses needed to survive and fight in contested airspace. Discussions are underway to retire the F-15C in late 2020s.	0	2	The F-15EX, the most advanced Eagle varia on the F-15QA as a replacement for the lega The USAF awarded Boeing a \$1.2 billion cor first eight of up to 144 new-build F-15EX jet 2020. FY 2021 funds procure an additional 12 more in FY 2022. The Air Force accepted F-15EXs in FY 2021 and expects the next six	nt, is base acy F-15C/ ntract for t s on July 1 l2 aircraft the first t fighters i	d /D. the 13, and :wo in 2023.
F-22A Raptor Inventory: 186 Elect age: 15 Date: 2005			12 12 \$1,234	\$1,18	7
The F-22 is the preeminent air superiority stealth fighter aircraft, modified to enable delivery of precision- guided weapons. The jet is currently undergoing a modification called RAAMP that will improve reliability, maintainability, and performance. In FY 2022, the jet will begin fielding the Link-16, which will allow it to transmit data with legacy aircraft via the Multifunctional Information Distribution System/Joint Tactical Radio System (MIDS/JTRS).	4	5			





Tanker

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
KC-10 Extender			KC-46		
Inventory: 50 Fleet age: 36 Date: 1981			Timeline: 2019-2027	3	3
The KC-10 is multi-role tanker and airlift platform that can refuel both boom- compatible and drogue-compatible fighters on the same mission. Recent modifications have enabled a service life extension through 2045. The USAF targeted fleet reduction to 40 aircraft in FY 2021, but Congress directed the service to maintain at least 50 aircraft to provide sufficient tanker support because of shortfalls with the KC-46.	2		The KC-46 Pegasus entered low-rate proc August 2016, and the Air Force accepted l Pegasus on January 10, 2019. The tanker h several problems, the most significant of v its remote visual refueling system, which i to refuel aircraft. In spite of that challenge Force has cleared the KC-46 for limited, n operations while Boeing fixes that system is still accepting approximately 15 aircraft simultaneously retiring other refueling pla the inability of the Pegasus to perform its	luction in the first ias had which is wi s required ton-comba . The Air a year whi atforms de primary n	ith force ile spite hission.
KC-135 Stratotanker		5	PROCUREMENT SPENDING (\$	millions)	
Inventory: 340 Fleet age: 61 Date: 1957			94 14 \$15,6	i95 \$2	2,380
The KC-135 a multi-role tanker/airlift platform. The aircraft has undergone several modifications, mainly engine upgrades to improve performance and reliability. The USAF plans to modify 395 aircraft with Block 45 upgrades (an additional glass cockpit display for engine instrumentation, a radar altimeter, an advanced autopilot, and a modern flight director) at a rate of 38 aircraft per year through 2026. Part of the fleet will be replaced with the KC- 46, with the remainder scheduled to be in service through 2050.	0				
KC-46 Pegasus					
Inventory: 68 Fleet age: 1 Date: 2020 This Pegasus is a multi-role tanker/airlift platform that can refuel both boom- compatible and drogue-compatible fighters on the same mission. The Air Force accepted the first of 179 programmed aircraft in 2019. The program has significant problems that preclude use of the plane as a refueling platform in combat, but 15 of the aircraft will be delivered in 2021, bringing the total number of KC-46s in the inventory to 68.	6	1			





Heavy Lift

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
C-5M Galaxy Inventory: 52 Fleet age: 34 Date: 1970			None		
The C-5 is the USAF's largest mobility aircraft. It can transport 270,000 pounds of cargo over intercontinental ranges and can be refueled in the air. The "M" models are heavily modified C-5A/Bs that have new engines, avionics, and structural/reliability fixes. Ongoing modifications include a new weather radar, a new mission computer, and improved Large Aircraft Infrared Countermeasures (LAIRCM).	2	0			
C-17 Globemaster III Inventory: 222 Fleet age: 19 Date: 1995 The C-17 is a heavy-lift strategic transport capable of direct tactical delivery of all classes of military cargo. It is the U.S. military's core airlift asset; it can be refueled in the air and is capable of operating on small airfields (3,500 feet by 90 feet). Ongoing modifications include next-generation Large Aircraft Infrared Countermeasures (LAIRCM), structural, safety, and sustainment modifications.	4	J			

Medium Lift

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
C-130J Super Hercules Inventory: 146 Fleet age: 12 Date: 2006			C-130J Timeline: 2006–2022	5	5
The C-130J is an improved tactical airlift platform that can operate from small, austere airfields, and provide inter-theater airlift and airdrop and humanitarian support. The Air Force active component completed its transition to the C-130J in October 2017.	5	6	The C130J Super Hercules is an upgraded ta platform with a medium-lift capability with variants including the C-130J-30, AC-130J g HC-130 rescue/air refueling platform. The C carry 92 airborne troops and lift over 40,00 cargo. The Air Force currently has two mult underway with Lockheed Martin to procure per year through FY2023, and second to pr additional 24 H/MC-130 aircraft from FY 20 PROCUREMENT	actical airl multiple unship, ar -130J-30 0 pounds i-year cor 16 C-130J ocure an 21-FY 202 <i>millions</i>) 5,417	ift an of itracts ls 25.



Intelligence, Surveillance, and Reconnaissance (ISR)

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
RQ-4 Global Hawk Inventory: 30 Fleet age: 11 Date: 2011 The Global Hawk is a strategic, high- altitude, long-endurance (HALE), "deep look" ISR platform that complements satellite and manned ISR. Unlike the MQ-9, which is a medium-altitude, long- endurance unmanned aerial vehicle (UAV), the RQ-4 has a higher altitude and longer range.	4	2	None		
MQ-9 A/B Reaper Inventory: 330 Fleet age: 7 Date: 2007 The MQ-9B is a medium-altitude to high-altitude, long-endurance hunter- killer RPA (remotely piloted aircraft) tasked primarily with eliminating time-critical and high-value targets in permissive environments. The USAF is attempting to end the MQ-9 procurement and seeks to replace the Reaper with a more survivable, flexible, and advanced platform as early as 2031.	6	2	MQ-9 Timeline: 2007-2024 The MQ-9 Reaper is a hunter-killer unmann vehicle (UAV). The Air Force planned to en- of the Reaper in FY 2021, but Congress dec procure an additional 16 Reaper aircraft. Th planning to replace the Reaper with a more flexible, and advanced platform as early as PROCUREMENT 40 \$PENDING (\$	5 ed aerial d procurer ided to e Air Force survivabl 2031.	s nent e is e, \$3
RC-135 Rivet Joint Inventory: 22 Fleet age: 58 Date: 1972 The RC-135V/W is tasked with real-time electronic and signals intelligence- gathering, analysis, and dissemination in support of theater and strategic- level commanders. The RC-135, an extensively modified reconnaissance version of the C-135, detects, identifies, and geolocates signals throughout the electromagnetic spectrum.	0	4	None		

Intelligence, Surveillance, and Reconnaissance (ISR) (Cont.)

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
U-2 Dragon Lady			None		
Inventory: 31 Fleet age: 40 Date: 1956					
The U-2S is the Air Force's only manned, strategic, high-altitude, long-endurance ISR platform and is capable of SIGINT, IMINT, and MASINT collection. The aircraft's modular payload systems allow it to carry a wide variety of advanced optical, multispectral, EO/IR, SAR, SIGINT, and other payloads simultaneously. Its open system architecture also permits rapid fielding of new sensors to counter emerging threats and requirements.	0	4			

Command and Control

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
E-3 Sentry			None		
Inventory: 35 Fleet age: 41 Date: 1977					
The E-3 Airborne Warning and Control System (AWACS) is tasked with all-weather air and maritime surveillance, command and control, battle management, target, threat, and emitter detection, classification, and tracking. Ongoing upgrades include an urgent operational requirement to shorten kill-chains on time-sensitive targets, modernization of airborne moving target indication, and addition of high-speed jam-resistant Link 16. The E-3 is scheduled to stay in service through the 2040s.	0	2			
E-8 JSTARS Inventory: 16 Fleet age: 41 Date: 2010 E-8C is a ground moving target indication (GMTI), airborne battlefield management/ command and control platform. Its primary mission is providing theater commanders with ground surveillance data to support tactical operations. The Air Force planned to retire this platform in the mid-2020s, but Congress blocked this. The USAF aims to re-engine the fleet with refurbished JT8D-219 turbofans as a cost-effective interim solution to improve performance and reliability.					

NOTES: See Methodology for descriptions of scores. The date is the year the platform achieved initial operational capability. The timeline is from the year the platform achieved initial operational capability to its final procurement. Spending does not include advanced procurement or research, development, test, and evaluation (RDT&E).

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- 71. Table 2, "Department of the Air Force Budget Summary," in U.S. Department of the Air Force, *Department of the Air Force FY* 2022 Budget Overview, p. 12.
- 72. Author's experience through 26 years of Air Force operations, coupled with senior leader engagements from 2018–2019.
- 73. Albert A. Robbert, Anthony D. Rosello, Clarence R. Anderegg, John A. Ausink, James H. Bigelow, William W. Taylor, and James Pita, *Reducing Air Force Fighter Pilot Shortages* (Santa Monica, CA: RAND Corporation, 2015), p. 33, https://www.rand.org/content/dam/rand/pubs/research_reports/RR1100/RR1113/RAND_RR1113.pdf (accessed July 7, 2021).
- 74. Even though active-duty fighter squadrons have an average of 30 aircraft per squadron, that number includes maintenance, spare, and attrition reserve platforms. Manning is based on Primary Assigned Aircraft (PAA), which is 24 aircraft for active-duty fighter squadrons.
- 75. Based on a squadron with 24 Primary Assigned Aircraft. For units with 18 PAA, four additional pilots are required.
- 76. The very premise of these units is that they are manned with citizen soldiers whose main source of income is full-time civilian jobs and who are committed to travel and temporary duty locations that make them unavailable for days or weeks at a time. Those units would likely require several days to assemble the manpower required to deploy, and once an assessment of their real mission currency was made, they would need some period of intense training before a responsible senior leader could employ them in a fight with a peer competitor.
- 77. "Deployments most suited to the ARC are those in which there is long lead time (six months or more), and in which the operation is of short duration (six days or less), requiring a small force package (12 aircraft or less), and in which the scheduling is flexible." John T. Correll, "Future Total Force," *Air Force Magazine*, Vol. 82, No. 7 (July 1999), p. 32, https://www.airforcemag.com/PDF/MagazineArchive/Documents/1999/July%201999/0799total.pdf (accessed July 5, 2021).
- 78. The author commanded the 349th Expeditionary Combat Group at AI Udeid, Qatar, from 2004–2005. During that time, he flew with seven different Air National Guard F-16 squadrons. Every one of those units had some level of rainbow manning, and each performed admirably.
- 79. Interview with senior Air National Guard leader, November 20, 2019.

- 80. The number of fighters needed for a two-MRC strategy is based on a Heritage Foundation study of airpower requirements and actual fighter deployments for all major combat operations and conflicts from 1950 through 2021.
- 81. See Venable, "Independent Capability Assessment of U.S. Air Force Reveals Readiness Level Below Carter Administration Hollow Force."

U.S. Marine Corps

The U.S. Marine Corps (USMC) is the nation's expeditionary armed force, positioned and ready to respond to crises around the world. Marine units assigned aboard ships ("soldiers of the sea") or at bases abroad stand ready to project U.S. power into crisis areas. Marines also serve in a range of unique missions, from combat defense of U.S. embassies under attack abroad to operating the President's helicopter fleet.

Although Marines have a wide variety of individual assignments, the focus of every Marine is on combat: Every Marine is first a rifleman. Over the past several decades, the Marine Corps has positioned itself for crisis response, but while the Corps has maintained its historical, institutional, and much of its doctrinal focus on operations in maritime environments, the majority of its operational experience over the past 20 years has been in sustained land operations. This has led to a dramatic decline in the familiarity of most Marines with conventional amphibious operations and other types of employment within a distinctly maritime setting.¹

Recognizing this shortfall, the Corps' leadership has initiated efforts to reorient the service toward enabling and supporting the projection of naval power in heavily contested littoral environments with a particular focus on the Indo-Pacific region and China as the "pacing threat" against which Marine Corps capabilities are being assessed and modified. This reorientation is much more than a simple refocusing on amphibious operations. Following a comprehensive assessment of the operational challenges that the service's operating forces are most likely to face 10 to 15 years in the future, General David H. Berger, Commandant of the Marine Corps, issued Force Design 2030 (FD 2030), his directive to the service to reorganize, re-equip, and retrain Marines in ways that will make them relevant and effective in the presumed operating environment of the 2030s.²

As necessary an effort as FD 2030 appears to be, however, the force envisioned by the project has yet to be built (though progress is being made) and certainly has not yet been proven in battle. Consequently, this *Index* can only assess the Corps that exists today, and our assessments of capacity, capability (modernity), and readiness therefore pertain to the Marine Corps' current status, not to what it might be in the future.

As reported in 2021, the Corps had 33,500 Marines deployed, roughly one-third of its operational force.³ During the year preceding its fiscal year (FY) 2022 budget request, "[T]he Marine Corps executed 156 total operations, nine amphibious operations, [and] 36 theater security cooperation events, and participated in 36 exercises" involving numerous countries in Europe, the Middle East, and Asia including Japan, South Korea, Thailand, Malaysia, Singapore, Germany, Norway, Scotland, and Romania.⁴

The Marine Corps has always prized its crisis-response contributions to national security—a point consistently emphasized by senior service leaders over the years. Maintaining this emphasis, General Berger has made it central to the Corps' efforts to remain combat credible as adversary capabilities evolve, even at the expense of force capacity (the size of the service) and existing capabilities that, while still of value, are perceived as less relevant to the maritime environment of the Indo-Pacific. Service leadership is assuming that defense budgets will not see any appreciable growth in the next several years, so the Commandant has ordered the Corps to retire or reduce assets and capabilities such as tanks, conventional tube artillery, heavy bridging, and some aircraft and continue to reduce manpower end strength in order to make related funding available for other purposes.

In general for the Joint Force, this Index focuses on the forces required to win two major wars as the baseline force-sizing metric for the Army, Navy, and Air Force, but it adopts a different paradigm-one war plus crisis response-for the Marine Corps. The three large services are sized for global action in more than one theater at a time; the Marines, by virtue of overall size and most recently by direction of the Commandant, focus on one major conflict while ensuring that all Fleet Marine Forces are globally deployable for short-notice, smaller-scale actions. Marine Corps officials have emphasized that the results of the FD 2030 redesign will ensure that USMC forces are more capable and relevant in any fight, in any region, but the pacing challenge for Corps planners is China.

In previous editions of the *Index*, the capacity of the Marine Corps was assessed against a two-war requirement of 36 battalions: a historical average of 15 battalions for a major conflict (30 for two major conflicts) and a 20 percent buffer, bringing the total to 36. The Corps has consistently maintained that it is a one-war force and has no intention of growing to the size needed to fight two wars, and both its annual budget requests and its top-level planning documents reflect this position.

However, with China as the primary threat driving Marine Corps force planning and given

China's extraordinary investment in modernizing its forces across all capabilities, to include the expansion of various sensors, weapons, and platforms that are essential to the creation of an intensely weaponized, layered defense architecture, this *Index* cannot help but note that the Corps will need greater capacity if it is to succeed in war in the very circumstances for which the Marines believe they must prepare and with which this *Index* concurs.

Capacity

The measures of Marine Corps capacity in this *Index* are similar to those used to assess the Army's: end strength and units (battalions for the Marines and brigades for the Army). The Marine Corps' basic combat unit is the infantry battalion, which is composed of approximately 900 Marines and includes three rifle companies, a weapons company, and a headquarters and service company.⁵

Infantry. In 2011, the Marine Corps maintained 27 infantry battalions in its active component at an authorized end strength of 202,100.⁶ As budgets declined, the Corps prioritized readiness through managed reductions in capacity, including a drawdown of forces, and delays or reductions in planned procurement levels. After the Marine Corps fell to a low of 23 active component infantry battalions in FY 2015,⁷ Congress began to fund gradual increases in end strength, returning the Corps to 24 infantry battalions.

New requirements have also sapped the Corps' conventional deployable strength. In 2005, the Marines were directed to establish a special operations component to which they ultimately committed 2,700 Marines.⁸ In 2010, the Corps established a cyberspace element,⁹ redirecting more manpower to new capabilities. The point here is that new requirements arise over time. Unless the Marine Corps' end strength is increased accordingly, establishing new units and capabilities means losing capacity in other areas.

The Corps operated with 181,200 Marines in FY 2021, with plans to shrink further to 178,500 in FY 2022 to free funding so that it can be reapplied to experimentation, retooling, and reorganization as described in Force Design 2030.¹⁰ The current size allows for 24 infantry battalions, but future plans will likely see the number shrink to 21 battalions.¹¹

Infantry battalions serve as a surrogate measure for the Corps' total force. As the first to respond to many contingencies, the Marine Corps requires a large degree of flexibility and self-sufficiency, and this drives its approach to organization and deployment of operational formations that, although typically centered on infantry units, are composed of ground, air, and logistics elements. Each of these assets and capabilities is critical to effective deployment of the force, and any one of them can be a limiting factor in the conduct of training and operations.

Aviation. Despite being stressed consistently by insufficient funding, the Marine Corps has made significant progress in regaining capability and readiness in its aviation component, achieving its objective of 80 percent aviation readiness in FY 202012 and achieving 86 percent to 96 percent pilot manning in its rotary wing community, a status the Corps considers healthy.13 The Corps has not published an update to its Aviation Plan since 2019. At that time, the service stated that it possessed 16 tactical fighter squadrons,14 compared to 19 in 201715 and approximately 28 during Desert Storm.¹⁶ Service officials have stated repeatedly that the number of manned aircraft, and therefore squadrons, will likely continue to decline as the Corps divests itself of older aircraft without replacing them on a one-for-one basis, shifts investment to unmanned platforms, and retools the force for distributed operations undertaken by smaller units per Force Design 2030.

While the Corps is introducing the F-35 platform into the fleet, F/A-18 Hornets remain "the primary bridging platform to F-35B/C" and will remain in the force until 2030.¹⁷ This primary tactical air (TACAIR) capability has to be managed carefully as it is no longer in production. Through various programs, the Marines have extended the service life of their F/A-18 fleet to 10,000 flight hours, making it possible to keep them in service until FY 2030. A similar effort will keep the venerable AV-8B Harrier in use until FY 2027.¹⁸ At present, the Marines have acquired 101 F-35B—the Short Take-Off and Vertical Landing (STOVL) variant of the Joint Strike Fighter (JSF)—and nine F-35C (aircraft carrier capable) aircraft¹⁹ of a planned 353 F-35B and 67 F-35C models.²⁰ This has enabled the service to stand up 10 JSF squadrons: six operational, two fleet replacement (used to train new pilots), and one test for F-35Bs and one operational squadron of F-35C aircraft.²¹

The activation of and achievement of full operational capable status for the F-35C squadron are especially important given the end of operational service of the last squadron flying its predecessor aircraft, the F/A-18C. Marine Fighter Attack Squadron 323 (VMFA 323) returned from its final deployment aboard the USS *Nimitz* (CVN-68) with Carrier Air Wing 17 at the end of February 2021.²² The Corps' F-35Cs will eventually replace the now operationally retired F/A-18C for duty aboard the Navy's aircraft carriers.

In its heavy-lift rotary-wing fleet, the Corps began a reset of the CH-53E in 2016 to bridge the procurement gap between the CH-53E and the CH-53K King Stallion and aimed to "reset...the entire 143-aircraft fleet by FY20,"²³ but reporting in 2020 indicated that the Corps was moving rather slowly in this effort, and it was only one-third of the way through the process toward the close of the fiscal year.²⁴ Even when the reset is complete, the service will still be 57 aircraft short of the stated heavy-lift requirement of 200 airframes and will not have enough helicopters to meet its heavy-lift requirement without the transition to the CH-53K.²⁵

As for the CH-53K heavy-lift helicopter, the service has reported good news about the perunit cost, once an exorbitant \$125 million per aircraft. In testimony to the House Armed Services Committee's Subcommittee on Tactical Air and Land Forces, Lieutenant General Mark Wise said that the cost per aircraft had dropped to \$97 million and could drop further to \$94 million per plane.²⁶ The Marines have acquired four of these new helicopters for testing and hope to have the King Stallion available for deployment by 2024.²⁷

The Corps continues to search for improvements to its MV-22B Osprey, most recently by testing a version of an electronic warfare radar jamming pod that it uses on other aircraft.²⁸ In the absence of conventional pylons on which weapons and sensors can be mounted, new capabilities have to be reconfigured to fit inside the aircraft or mounted on the aircraft fuselage.

Notably, the Corps has moved aggressively to implement aviation-related actions specified or implied by FD 2030. In May, it disestablished HMLA-367, a light-attack helicopter squadron in Hawaii, sending its still relatively new attack and utility helicopters to Davis-Monthan Airbase in Arizona where they will be placed in the "bone yard" for possible use in the future. The 27 AH-1Z Viper attack helicopters and 26 UH-1Y Venom utility helicopters that were decommissioned represented approximately one-fifth of the Marine Corps' inventory of such aircraft.²⁹ The Marines have also started divestiture of three MV-22 squadrons, an additional light-attack helicopter squadron, and nearly three heavy-lift squadrons.³⁰

Amphibious Ships. Amphibious ships, although driven by the Corps' articulation of what it needs to execute its operational concepts, remain a Navy responsibility. A trio of documents describe the rationale for and nature of the Marine Corps' thinking about how it plans to contribute to the projection of naval power in highly contested environments such as that found in the Indo-Pacific region should the U.S. find itself at war with China.

- In 2017, the Corps and the U.S. Navy jointly released *Littoral Operations in a Contested Environment* (LOCE), in which the services presented general ideas about how to conduct naval operations against a very capable enemy.³¹
- Several months after taking office, General Berger published FD 2030, which set

objectives for redesigning the force so that it could do the things implied by LOCE.³²

• In February 2021, the Corps released an unclassified version of the *Tentative Manual for Expeditionary Advanced Base Operations*, in which the service provided substantial details about its evolved thinking about the tactical and organizational challenges posed by high-threat maritime environments.³³

These documents informed and reinforced Marine Corps and Navy plans to develop and acquire upwards of 35 light amphibious warships (LAWs), new amphibious vessels that would be smaller than those constituting the current fleet and optimized to support naval operations in the contested environments envisioned by LOCE and Expeditionary Advance Base Operations (EABO).³⁴ The Marine Corps held 38 amphibious ships as the minimum requirement for many years but stepped away from that as a prelude to redefining its amphibious operations capabilities.³⁵ With the evolution of FD 2030 and refinement of related supporting concepts and material requirements, the Corps is now making the case for 28 to 31 traditional amphibious ships augmented by LAWs.³⁶ Though five companies have been awarded contracts for further concept development of LAWs,37 procurement is not expected to begin until FY 2023 and will extend through FY 2026.38 Meanwhile, the number of traditional amphibious ships had dropped to 31 as of August 2021.39

The USMC continues to invest in the recapitalization of legacy platforms in order to extend platform service life and keep aircraft and amphibious vehicles in the fleet, but as these platforms age, they also become less relevant to the evolving modern operating environment. Thus, although they do help to maintain capacity, programs to extend service life do not provide the capability enhancements that modernization programs provide. The result is an older, less capable fleet of equipment that costs more to maintain.

Capability

The nature of the Marine Corps' crisisresponse role requires capabilities that span all domains. The USMC ship requirement is managed by the Navy, as indicated in the preceding section on capacity, and is covered in the Navy's section of the Index. The Marine Corps is focused on a force-wide redesign per FD 2030 with modernization and divestiture programs shaped accordingly. General Berger has emphasized that his force redesign initiatives are being self-funded, meaning that the service will get rid of some capabilities that are less relevant to expected operational demands and will reduce manpower to redirect that funding to other priorities of greater relevance. Nevertheless, defense funding has not kept pace with inflation, and there are some things for which the Corps needs additional money. According to one account:

Making his case [on June 15, 2021] before the House Armed Services Committee... for the Marine Corps' \$47.86 billion budget request, Berger said he has reduced headquarters staffing by 15%, cut legacy systems and end strength, and has nothing left to draw from to fund programs and projects.

"We have wrung just about everything we can out of the Marine Corps internally," Berger said. "We're at the limits of what I can do."

The Marine Corps' budget request represents a 6.2% increase from fiscal 2021, even as the service plans to reduce the size of the active-duty force by 2,700, to 178,500 Marines. The service ultimately wants to reach 174,000 by 2030—roughly the size it was in fiscal 2002.

Berger is using the money he has saved by reorganizing the Marine Corps and shedding capabilities such as tanks and artillery to invest in new technologies and platforms.⁴⁰ Programs such as the Amphibious Combat Vehicle (ACV), F-35, CH-53K, Naval Strike Missile,⁴¹ and Light Amphibious Warship are at the top of the list of major items of equipment and weapons, but the Corps is also pursuing a variety of unmanned systems (air, ground, and sea) and has placed great emphasis on smaller pieces of gear and individual-level weapons that will enable tactical units to be more effective.⁴² These latter items are typically small in cost when compared with aircraft and armored vehicles, but they can have a decisive effect in small-unit actions in the field.

Vehicles. Of the Marine Corps' current fleet of vehicles, its amphibious vehicles specifically, the Assault Amphibious Vehicle (AAV-7A1) and Light Armored Vehicle (LAV) are the oldest, with the AAV-7A1 averaging more than 49 years old and the LAV averaging 39 years old.⁴³ The Corps had moved to extend the service life of the AAV but abandoned that program as progress with the ACV accelerated.⁴⁴ The Corps has stated that:

[W]e continue to make strategic choices in the divestiture of certain programs to reallocate funds toward building a more lethal, modern, multi-domain, expeditionary force. This has included accepting near-term capacity risk by reducing depot level maintenance for the legacy Amphibious Assault Vehicle (AAV) as we transition to the Amphibious Combat Vehicle (ACV).⁴⁵

The Marine Corps has also been exploring the possible replacement of its aged Light Armored Vehicle (LAV) with a collection of vehicles under the Advanced Reconnaissance Vehicle (ARV) program and has requested \$48.6 million in its FY 2022 budget submission for research and design work. General Berger, however, has said that he is "unconvinced that additional wheeled, manned armored ground reconnaissance units" are needed and that the Corps' light armored reconnaissance units "must be re-evaluated in light of the emerging concept of multi-domain mobile reconnaissance," indicating that the requirement for the ARV is being reconsidered.⁴⁶

The AAV program hit rough waters on July 30, 2020, with the sinking of an AAV off the California coast near San Clemente Island. In addition to halting all AAV operations until various investigations were completed, the Corps installed supplementary emergency breathing devices in the vehicle and took other steps to improve its safety and survivability.⁴⁷ AAV operations were resumed in April 2021 following inspection and modification of vehicles and related training and certification of AAV crews on the improvements.⁴⁸

The Corps has accelerated procurement of the ACV in recognition of the problems of its AAV fleet and the urgent need to update force capabilities per FD 2030. It procured 56 ACVs in FY 2020 and 72 in FY 2021 and has requested funding sufficient to acquire 92 in FY 2022.⁴⁹ Combined with the 56 vehicles acquired in previous years, the additions in 2020 and 2021 bring the number of ACVs in the Corps' inventory to 184 out of a total program objective of 632.⁵⁰

A note about the Corps' heavy armor: The operational challenges, organizational design, and tactical capabilities addressed in FD 2030 called for the Marines to retire their inventory of M1A2 Abrams main battle tanks and associated support capabilities like heavy bridging and recovery vehicles. The Marine Corps retired its last active-duty tank unit in May 2021,⁵¹ bringing to a close nearly a century of experience with tanks. The Corps retains some tanks in various storage configurations (for example, aboard Maritime Prepositioning Squadron ships and in equipment storage caves in Norway) but will transfer them to the Army by FY 2023.⁵²

Acquisition of the Joint Light Tactical Vehicle (JLTV) continues to move apace. Since 2017, when fielding of the HMMWV replacement began, the Marines have acquired 4,531 vehicles (out of a requirement for 9,091⁵³) and have placed another 613 on order with its FY 2022 budget request.⁵⁴ Budget documents do not indicate plans for purchase beyond FY 2022,⁵⁵ most likely because decisions extending from FD 2030 initiatives have yet to be made.

Aircraft. Fixed-wing fighter-attack aircraft continue to age while the Corps pursues delivery of replacement aircraft: the F-35B STOVL variant to replace the AV-8B, in service since 1985, and the F-35C to replace its carrier-capable F/A-18s. To account for a lengthy transition period, the Corps has undertaken various efforts to extend the service life of its Hornets and Harriers to keep them in service until the end of the decade.⁵⁶

The Corps has acquired approximately onethird of the F-35B aircraft that it plans to purchase but has only started to outfit its aviation element with the F-35C, the version designed for use aboard aircraft carriers. Though the F-35 program has been the subject of vigorous criticism ever since it began, much of this criticism is misplaced today given the superior capabilities the aircraft brings to air operations in heavily contested environments featuring peer-level enemies and the steady decrease in per-unit cost.⁵⁷ The Corps' current concerns about the aircraft have less to do with its capabilities than they do with the overall cost of modern aircraft in general in the constrained budget environment within which the service is working to redesign its force.

Today, the USMC MV-22 Osprey program is operating with few problems and nearing completion of the full acquisition objective of 360 aircraft.⁵⁸ The Marine Corps now has 16 fully operational MV-22 squadrons in the active component.⁵⁹ The MV-22's capabilities are in high demand from the Combatant Commanders (COCOMS), and the Corps is adding such capabilities as fuel delivery and use of precision-guided munitions to the MV-22 to enhance its value to the COCOMs.

The Corps has struggled with sustainment challenges in the Osprey fleet. In the years since procurement of the first MV-22 in 1999, the fleet has developed more than 70 different configurations.⁶⁰ This has resulted in increased logistical requirements as maintainers have had to be trained to each configuration and not all spare parts are shared. The Marine Corps has developed its Common Configuration– Reliability and Modernization program to consolidate the inventory to a common configuration at a rate of "2–3 aircraft installs per year." The program was initiated in FY 2018.⁶¹

The USMC's heavy-lift replacement program, the CH-53K, conducted its first flight on October 27, 2015.62 The CH-53K will replace the Corps' CH-53E, which is now 30 years old. Although "unexpected redesigns to critical components" delayed a low-rate initial production decision,63 the program achieved Milestone C in April 2017. The Corps received \$1 billion in 2019 to purchase seven aircraft,64 continued this effort by purchasing six in FY 2020 for \$848 million, and bought an additional nine in FY 2021 for \$1.1 billion.65 This aircraft is of increasing importance because the Marine Corps maintains only 138 CH-53Es and will not have enough helicopters to meet its heavy-lift requirement of 200 aircraft without the transition to the CH-53K.

Readiness

Riding alongside the Corps' principal Title 10 responsibility to provide "fleet marine forces [for service] in the seizure or defense of advanced naval bases and for the conduct of such land operations as may be essential to the prosecution of a naval campaign"66 is its contribution as the crisis-response force for the military. This aspect of USMC contributions to national defense has been reinforced by service leaders who take pains to allay concerns that their focus on China and the Indo-Pacific will distract them from this important role. The Corps' readiness must therefore account for both high-end conflict against a major opponent in the most complex operational settings and pop-up crises against lesser opponents that cannot be predicted, all of which implies a force that is ready to go at a moment's notice.

Marine Corps guidance identifies multiple levels of readiness that can affect the ability to conduct operations:

Readiness is the synthesis of two distinct but interrelated levels. a. unit readiness—The ability to provide capabilities required by the combatant commanders to execute their assigned missions. This is derived from the ability of each unit to deliver the outputs for which it was designed. b. joint readiness— The combatant commander's ability to integrate and synchronize ready combat and support forces to execute his or her assigned missions.⁶⁷

To this the Commandant has added an expanded perspective that includes force modernization as an essential element to ensure that combat forces remain relevant and therefore ready. As General Berger and Air Force Chief of Staff General Charles Q. Brown, Jr., have argued, only by divesting old capabilities that would not be useful in changed circumstances and investing in new capabilities that account for more capable enemies and the characteristics of key operational theaters can U.S. forces be ready. "To do this," however, "we cannot let our focus on near-term availability consume the resources necessary to generate truly relevant future readiness through adaptive modernization."68

Divestiture carries with it some risk unless replacement capabilities are brought into the force as old or legacy capabilities are retired. For example, the Marine Corps' decision to get rid of tanks and a large percentage of its tube artillery means that the service will not have these capabilities should it be called into battle before new items can be fielded. Early reports of promising replacement capabilities to compensate for the loss of the Abrams main battle tank, for example, are encouraging, but the Corps now no longer has tanks while the improved replacement remains to be fielded.⁶⁹ This has a bearing on readiness to the extent that the force has a *current* ability to win in combat. The force might be ready, but in a different posture. For a few years, the Marines could be more light-infantry than the middle-weight "two-fisted fighter" proudly described by a former Commandant a decade ago.70

Unfortunately for this *Index*, the Corps reports its current readiness in vague, generalized terms instead of providing data by which external audiences can independently assess the status of the service, although this approach is generally used by all of the services. Detailed readiness reports are classified to prevent potential enemies from obtaining sensitive information.

In the past, the services' leaders would report to Congress in formal testimony the various percentages of key equipment that were or were not available, share the status of primary units or types of force capabilities, and perhaps provide insight into maintenance or supply backlogs. The absence of such details from Marine Corps statements during the past year reveals that the Corps prefers not to share such information, at least currently. Consequently, our assessment of the Corps' readiness must rely on the tone of statements and discussions, inferences derived from the totality of efforts and programs, and the sense one gets from anecdotal evidence of the seriousness with which the service is taking preparations for current and future employment.

As mentioned, the Marine Corps has undertaken a great reorientation to ready itself for war against China in a heavily contested maritime environment. The service believes that the changes it is pursuing to this end will be relevant and necessary for other combat environments because many countries are acquiring capabilities that are now possible and affordable with modern technologies. With this as the driver, combined with the reiteration of the Corps' role as a force in readiness, the service's words, actions, and policies strongly imply a focused commitment to combat readiness.⁷¹

To improve force capabilities from the level of the individual to the most senior operational commands, the service is pushing several initiatives. Among them:

• The Marine Corps School of Infantry has revamped its training for entry-level infantry Marines, lengthening its course by half and including new coursework and field training intended to sharpen the thinking skills of Marines who will likely find themselves operating more independently than has been the case in the past.⁷²

- "In May [2021], the Marine Corps broke ground on a new, state-of-the-art wargaming facility intended to house various capabilities to enhance warfighter preparedness."⁷³ The Corps intends that the center, planned for use as early as 2024, will "help Marines better visualize the threat environment" and participate in war games of various sizes with a focus on realism and that it will also "provide data to inform decisions affecting force development [and] support existing and developing weapons platforms and capabilities in all regions of the globe."⁷⁴
- Taking this emphasis on thinking, training, and war-gaming scenarios to the field, the Corps and the Navy teamed to execute a two-week Large Scale Exercise 2021, billed as the largest the services have conducted in many years, that involved 25,000 personnel, 36 live units, 50 virtual units, and a half-dozen major commands spread across 17 time zones.⁷⁵

Such efforts, from improvements to infantry training to war gaming to large exercises, are steps that will have effects in the future rather than the present. However, they do reveal attitudes, priorities, and perspectives that reflect a level of seriousness about warfighting.

Within the Marine Corps, perhaps because it is a smaller service, changes in direction and attitude are more easily conveyed by senior leaders to the force and adopted force-wide than is the case in the larger services. While this does not directly replace hard data on mission-capable rates for equipment used by the Marines or cleanly substitute for unclassified reports about the readiness of units composing the Fleet Marine Force, it can be seen as a surrogate for the attention being paid by the Corps to its level of readiness. In addition, now that the extended operational demands of Iraq and Afghanistan have concluded, the force can reconstitute its readiness as it

Scoring the U.S. Marine Corps

Capacity Score: Marginal

Based on the deployment of Marines across major engagements since the Korean War, the Corps requires roughly 15 battalions for one major regional contingency (MRC).⁷⁶ This requirement is based on the presumption of a rather conventional force using known (current) equipment and capabilities against a similar opponent.

This Index acknowledges the service's work to develop new capabilities and approaches to fighting and is certainly aware of the trends in new technologies and associated thinking about how warfare *might* change in the future, but until this happens, one can assess only what can be known at present. Consequently, the Corps' historical need for 15 battalions (and associated enabling elements) for one major conflict translates to a force of approximately 30 battalions to fight two MRCs simultaneously if we were to retain the metric used in previous Indexes. The government force-sizing documents that discuss Marine Corps composition support the larger measure. Though the documents that make such a recommendation count the Marines by divisions, not battalions, they are consistent in arguing for three Active Marine Corps divisions, which in turn requires roughly 30 battalions.

With a 20 percent strategic reserve, the ideal USMC capacity for a two-MRC force-sizing construct is 36 battalions. However, the Corps has repeatedly made the case that it is a onewar force that must also have the ability to serve as the nation's crisis-response force.⁷⁷ It has just as consistently resisted growing in end strength even during the years of high operational demand associated with peak activities in Operation Iraqi Freedom (Iraq) and reorients toward the requirements of FD 2030, LOCE, and EABO.

Lacking any other direct reporting, this *Index*'s assessment of the Corps' readiness for current operations is an optimistic one.

Operation Enduring Freedom (Afghanistan). Most recently, General Berger has stated flatly that the Corps will trade manpower for modernization and that he intends to shrink the Corps from its current 24 infantry battalions to 21 battalions in order both to free resources so that they can be applied to new formations and to maintain capability investments in other areas such as Marine Special Operations Command.⁷⁸

Manpower is by far the biggest expense for the Marines. As allocated for the Corps' FY 2021 budget, the military personnel account was approximately \$14.68 billion (an increase of \$730 million over FY 2020),79 dwarfing both the approximately \$8.4 billion allocated for operations and maintenance⁸⁰ and the \$2.7 billion allocated for the procurement of new equipment, with both accounts seeing a decline in spending compared with the previous year.⁸¹ Nevertheless, the historical record of the use of Marine Corps forces in a major contingency argues for the larger number. More than 33,000 Marines, for example, were deployed in Korea, and more than 44,000 were deployed in Vietnam. In the Persian Gulf, one of the largest Marine Corps missions in U.S. history, some 90,000 Marines were deployed, and approximately 66,000 were deployed for Operation Iraqi Freedom.

One could reasonably presume that in a war with China, the demand for forces would be similar to the demand during these historical instances of Marine Corps employment. The pacing threat for the Corps is China, which is developing new tools and operational concepts that will likely require the distribution of Marine Corps forces across a large, contested littoral battlespace. But because the Corps has not yet refined what its envisioned formations will require, much less proven them in operational employment, we can only assess the service's current status against historical demand. Consequently, even a one-major-war Marine Corps should possess a larger end strength and more tactical units (infantry battalions as the surrogate measure for the total Corps) than it currently has.

As a one-war force that also needs the ability to provide crisis-response forces, sustain operations in the face of combat losses, and sustain its support for efforts that are not USMC-specific such as its service component contribution to U.S. Special Operations Command, the Corps should have a minimum of 30 battalions.

- One-MRC-Plus Level: 30 battalions.
- Actual 2021 Level: 24 battalions.

The Corps is operating with 80 percent of the number of battalions it should have relative to the revised benchmark set by this *Index* and has stated its intent to shrink from its current 24 battalions to 21 battalions. Marine Corps capacity is therefore scored as "marginal," the same as it was scored in the *2021 Index* but only because the bar has been lowered. Reducing operational strength by three battalions, or 12.5 percent, would drive the Corps' capacity score down to "weak."

Capability Score: Strong

The Corps receives scores of "marginal" for "Capability of Equipment," "marginal" for "Age of Equipment," "very strong" for "Health of Modernization Programs," and "strong" for "Size of Modernization Program." Therefore, the aggregate score for Marine Corps capability is "strong," an increase from the *2021 Index* score of "marginal."

The Corps is aggressively pursuing a host of new capabilities that will modernize the force over the next decade, and those capabilities specifically, the JLTV, ACV, and F-35B—are slowly entering the force. Admittedly, the score was helped by the retirement of the old M1A2 Abrams tank. At the small-unit level, the force will still depend on old AAVs, HMMWVs, LAVs, cargo trucks, and various items of support equipment procured in the 1990s and early 2000s, but the increasing quantity of JLTVs and the aggressive acquisition of ACVs will offset the problem of old equipment as the Corps enters FY 2022.

Readiness Score: Strong

The Corps has exhibited an especially focused and aggressive commitment to ensuring that Marine Corps forces are ready for action. This is the point of FD 2030. That said, however, the history of military services is littered with the debris of grand vision statements and futuristic concepts unrealized in practical implementation.

The Marine Corps' effort appears to be quite different, as evidenced by nearly irrevocable decisions to cashier old equipment and implement significant changes in education and training programs, dramatic investments in experimentation and war gaming, acquisition of new capabilities, and profound redesign of operational units. The Corps seems to mean what it has been saying by making real changes in its programs and organizations that reflect its published rhetoric. This 2022 Index believes it a low-risk proposition to apply the evidence of preparing for the future to current forces in terms of their focus on readiness for combat. The force remains encumbered by old primary equipment, but the service's effort to spend the money needed to keep it serviceable mitigates this problem to a reasonable extent.

The Corps is still too small, but the force it has is fully focused on warfighting. Consequently, the 2022 Index assesses Marine Corps readiness as "strong," a marked improvement over the 2021 Index score of "marginal" and quite a jump in a short three-year period over the 2019 Index measure of "weak."

Overall U.S. Marine Corps Score: Strong

The Marine Corps has made substantial strides in the past few years in regaining its

material readiness and stabilizing key modernization programs and, over the past two years, in profoundly changing its battle orientation, conceptual underpinnings, organizational design, and acquisition of the tools that it believes it will need to win in combat. This admittedly has been accomplished at the expense of capacity, but better to have a combat-relevant force, even if small, than a large force that is ill-suited for war.

The *2022 Index* score of "strong" is buoyed by the status of the Corps' modernization and

readiness efforts. The Marine Corps does run the risk of becoming too small relative to the task of enabling the projection of naval power into the most challenging combat environments, and this will be determined by the level of funding it receives in the coming years. The same holds true for its modernization efforts if the Administration and Congress elect to underfund defense.

But these are future problems. For FY 2021, the Corps achieved fine form, and its efforts augur well for FY 2022.

U.S. Military Power: Marine Corps



Main Battle Tank

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
M1A1 Abrams Inventory: DEACTIVATED Fleet age: 18 Date: 1990			None		
The M1A1 Abrams was the main battle tank of the USMC and provided the Marines with heavy-armor direct fire capabilities. Following the release of Force Design 2030, the Marine Corps decided to discontinue the use of their tanks in order to adapt their fighting capabilities to potential conflicts in the Pacific.					

Light Wheeled Vehicle

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
HMMWV Inventory: 10,859 Fleet age: 23 Date: 1983			Joint Light Tactical Vehicle (JLTV) Timeline: 2017-2022	6	6
The HMMWV, better known as the "Humvee," is a light wheeled vehicle that is used to transport troops with some measure of protection against small arms, blast, and fragmentation. Initially introduced in the 1980s, HMMWV, will be replaced by the loint	2	2	The JLTV program is a joint program with eventual replacement of all HMMWVs. Ful scheduled for early 2019. JLTVs should be capability in FY 2022. The first set of JLTV March 2019; IOC was achieved in mid-sum fielding at Camp Lejeune, North Carolina.	the Army I-rate proc at full ope 's were fie Imer 2019	for the duction is erational Ided in with
HMMWVS WIII be replaced by the Joint Light Tactical Vehicle (JLTV).			PROCUREMENT SPENDING (3) 4,531 613 \$1,5	\$ millions) 118	\$322
JLTV					
Inventory: 4,531 Fleet age: 1 Date: 2019					
The Joint Light Tactical Vehicle (JLTV) is replacing the HMMWV as a light wheeled vehicle for troop transport. The vehicle provides a long-term solution to IEDs and other unorthodox tactics with which the Humvee struggled during the conflicts in Iraq and Afghanistan. The JLTV improves reliability, survivability, and strategic and operational transportability. It achieved initial operational capability in 2019.	6	6			

NOTE: See page 475 for details on fleet ages, dates, timelines, and procurement spending. JLTV spending figures reflect the full joint program spending





Procurement Through FY 2021 and Spending Pending

Amphibious Assault Vehicle

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
AAV Inventory: 692 Fleet age: 49 Date: 1972			Amphibious Combat Vehicle (ACV) Timeline: 2018–2021	3	6
The Amphibious Assault Vehicle (AAV) is an amphibious landing vehicle that transports Marines from large naval vessels to land. Similar to a tank in being fully tracked and armored, the AAV is designed for assault on shores in hostile territory. The AAV will eventually be replaced by the ACV.	0	0	The ACV is tasked with replacing the aging The vehicle achieved IOC in November 202 full-rate production was ordered to begin in PROCUREMENT 98 92 \$1,310	AAV. 0, and 1 2021. \$ millions) \$4,200	
LAV-25 Inventory: 494 Fleet age: 39 Date: 1983 The Light Armored Vehicle (LAV) is an eight-wheeled, armored reconnaissance vehicle. It is designed for off-road and moderate amphibious capabilities. This allows for highly mobile fire support, operational in most terrains. The LAV will be in service until 2035.		2			
ACV Inventory: 98 Fleet age: 0.5 Date: 2020 The Amphibious Combat Vehicle (ACV) is an amphibious landing vehicle that is intended to supplement and eventually replace the AAV. It is designed for increased survivability, the most notable difference being increased ground clearance to reduce the harm from IEDs and mines. A new remote weapons system improves the ACV's situational awareness and ability to track and fire on targets. The ACV is also equipped with tires instead of tracks and has a redesigned interior.	9	6			





Attack Helicopters

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
AH-1W Super Cobra Inventory: 20 Fleet age: 25 Date: 1986			AH-1Z Timeline: 2014-2022	5	5
The Super Cobra was the attack helicopter that provided Marines with close air support and armed reconnaissance. After more than 30 years of effective and dependable service the AH-JW was retired in	0	2	The new AH-1Z Viper program is part of a la modification of the H-1 platform. Replacing Z-Variant will serve as the next generation The AH-1Z features upgrades across multip It is scheduled to achieve full operational ca	arger prog the AH-1\ of attack a le dimens apability ir	ram for N, the iircraft. ions. 1 2021.
October 2020. It is being replaced by the more advanced AH-1Z Viper			PROCUREMENT SPENDING (3 189 \$6	\$ millions) 6,012	\$7
AH-1Z Viper					
Inventory: 125 Fleet age: 7 Date: 2010					
The AH-1Z Viper is replacing the AH-1W Super Cobra as the USMC's premier attack helicopter. The Viper has greater speed, payload, and range as well as upgraded landing gear, advanced weapons systems, and a fully integrated glass cockpit. The Viper provides Marines with close air support, armed escort/reconnaissance, and anti-armor capabilities. The Viper's expected operational life span is 30 years.	6	6			

Airborne Electronic Attack Aircraft/Ground Attack Aircraft

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM			Size Score	Health Score
AV-8B			F-35B/C Timeline: 2007–2031			4	4
Inventory: 109 Fleet age: 29 Date: 1985							
The Harrier is the Marine Corps' ground attack aircraft. It is a subsonic jet and, like a helicopter, is capable of hovering. The Harrier has a Vertical/Short Take- Off and Landing (V/STOL) system and is designed to fly from amphibious assault ships and unconventional runways. These unique capabilities allow it to operate in a variety of environments that are inaccessible to other jets. The aircraft is being replaced by the F-35B and will be fully retired in or near 2024.	6	0	The Marine Corps is purchasing 353 F-35Bs and 67 F-35Cs. The F-35B is the USMC version of the Joint Fighter program. It is meant to replace the AV-8B H completing transition by 2030. The B-variant achiev operational capability in July 2015. Full operational for both variants is expected in the late 2020s. The is the version built for employment on aircraft carri- primarily for the U.S. Navy, but the Marines augmer operations and will use the F-35C for this purpose. PROCUREMENT SPENDING (\$ millions,				Strike arrier, red initial capability F-35C ers. It is t carrier



Airborne Electronic Attack Aircraft/Ground Attack Aircraft (Cont.)

PLATFORM	Age Score	Capability Score
F/A-18 A-D Inventory: 224 Fleet age: 30 Date: 1978 The F/A-18 Hornet is a fighter and attack jet that the Marine Corps uses primarily for traditional strike missions, fleet air defense, and air support. It will be replaced by the F-35C model; however, the F/A-18 fleet's life has been extended to 2030 in order to bridge the gap between the two platforms.	2	2
F-35B Lightning II (STOVL) Inventory: 130 Fleet age: 5 Date: 2015 The F-35B is the Marine Corps variant of the Joint Strike Fighter (JSF) Program. It is a fifth-generation, stealth multi-role fighter. Its next-generation technology allows it to dominate combat missions without being detected by the enemy. Unique to the other variants, the B-model is designed with a Short Take- Off-off and Vertical Landing (STOVL) system that allows it to operate from amphibious assault ships and unconventional runways. This combines the unique operational capabilities of the AV-8B Harrier with a supersonic, fifth-generation stealth fighter.	6	6
F-35C Lightning II (CV) Inventory: 11 Fleet age: 0.5 Date: 2020 The F-35C is the aircraft carrier variant of the Joint Strike Fighter (JSF) program used by both the Navy and the Marine Corps. It is a fifth-generation, stealth multi-role fighter. Its next-generation technology allows it to dominate combat missions without being detected by the enemy. The C-model, also known as the carrier variant (CV), is equipped for traditional carrier catapult launches and tailhook landings. It also features a slightly larger combat radius than the B-model. Although the C-model is used primarily by the Navy, the Marine Corps implemented its first squadron in December 2020 to complement its F-35B fleet.	6	6



Medium Lift

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score		
MV-22B Osprey Inventory: 309 Fleet age: 14 Date: 2007		MV-22B Timeline: 2007-2019		6	6		
The Osprey is a tilt-rotor aircraft that combines the vertical capabilities of a helicopter (V/STOL) with the speed and range of a fixed-wing aircraft. Similar to the AV-8B, this allows the aircraft	a and ir al io OC am e	6	Fielding of the Osprey was completed in 2019 with the MV-22 replacing the CH-46E helicopter, and the platform is meeting performance requirements. The modernization program does not face any serious issues.				
to take off and land in unconventional environments. The Osprey provides transport for ground personnel, cargo lift, and support for raid operations. IOC was achieved in 2007, and the program is still in production. The MV-22B's life expectancy is 23 years.			PROCUREMENT SPENDING (\$ 349 11 \$30,	Smillions) 782 S	\$3,087		

Heavy Lift

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM			Size Score	Health Score
CH-53E Super Stallion Inventory: 138 Fleet age: 29 Date: 1981			CH-53K Timeline: 2017–2029			5	3
The CH-53E is a heavy-lift rotary-wing aircraft. The Super Stallion transports heavy equipment and supplies for amphibious assault. The aircraft will operate through 2027 and will then be replaced by the more advanced CH-53K. The CH-53E's program life is 41 vers	2	0	The program is in development. It is meant to 53E and provide increased range, survivability. The program still has not fully developed the critical technology. The helicopter is schedule initial testing in 2021 and to be fielded as early PROCUREMENT SPENDING (\$ m				te the CH- payload. sary omplete 023.
11 yours.			20	176	\$3,030	\$18,026	





Tanker

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRA	Size Score	Health Score	
КС-130Ј			KC-130J		4	4
Inventory: 45 Fleet age: 9 Date: 2005			Timeline: 2005–2031			
The KC-130J is a large multi-role aircraft, used primarily as a tanker and cargo transport aircraft. It is equipped for a variety of missions, including troop and orwinment transport air to air	4 5		The KC-130J is both a tanker and transport aircraft. The procurement program for the KC-130J is not facing acquisition problems.			
refueling, and medevac operations. The			PROCUREMENT SPENDING		\$ millions)	
airframe is expected to last 38 years.			68 43	\$4,676	\$5,111	

NOTES: See Methodology for descriptions of scores. Fleet age is the average between the last year of procurement and the first year of initial operational capability. The date is when the platform achieved initial operational capability. The timeline is from the start of the platform's program to its budgetary conclusion. Spending does not include advanced procurement or research, development, test, and evaluation (RDT&E). Total program dollar value reflects the full F-35 joint program, including engine procurement. As part of the F-35 program, the Navy is purchasing 67 F-35Cs for the U.S. Marine Corps that are included here. The MV-22B program also includes some costs from U.S. Air Force procurement. AH-1Z costs include costs of UH-1 procurement.

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U.S. Space Force

The U.S. Space Force (USSF) was created with enactment of the fiscal year (FY) 2020 National Defense Authorization Act (NDAA) on December 20, 2019.¹ Established as the fifth uniformed service within the Department of Defense (DOD) and the second service within the Department of the Air Force (DAF), the USSF functions under the direction and leadership of the Secretary of the Air Force. The 2019 NDAA specifies that a four-star general will serve as Chief of Space Operations (CSO) and as a full member of the Joint Chiefs of Staff.

The mission of this newest service is to organize, train, and equip forces "to protect U.S. and allied interests in space and to provide space capabilities to the joint force." Its responsibilities include "developing Guardians [military space professionals], acquiring military space systems, maturing the military doctrine for space power, and organizing space forces to present to our Combatant Commands."²

A 2001 RAND study estimated that 95 percent of all civilian and commercial space technologies have direct applicability to military systems or are of dual use. That fact and the capabilities that those two sectors bring to the Space Force are critical to an assessment of this new service.³ The domination of great-power competition in space relies on the interwoven efforts of all three U.S. sectors—military, civil, and commercial space—and that reliance is growing.

Background

More than any other nation, America has enjoyed the technological advantages of space, and we now rely on it for nearly every aspect of our lives. Banking, commerce, travel, entertainment, the functions of government, and our military all depend on our assets in space.⁴

Though recognized by every President since Dwight Eisenhower in the mid-1950s, various issues kept the United States from developing a single service charged with managing space assets and capabilities. In 1961, the Air Force was named executive agent for space research and development, but at that point, the Army and Navy already had well-established programs.⁵ This splintered approach was sustained by every Administration for the next six decades. Nevertheless, U.S. space capabilities advanced at a stunning pace.

The effectiveness of the DOD's space support missions was put on full display during Operation Desert Storm,⁶ and adversary nations did much more than take note. They recognized the growing U.S. dependence on space and began to position themselves to move against it.

As early as 2001, a congressionally mandated report warned of our growing dependence on space and the vulnerability of U.S. assets in that domain and ultimately recommended establishing a Space Corps within the DAF.⁷ Those recommendations were set aside following the terrorist attacks of September 11, 2001, and by the mid-2010s, the command and control of space had fragmented across at least 60 different DOD offices.⁸ All the while, U.S. reliance on the Global Positioning System (GPS) for air, land, and sea maneuver, targeting, and engagement has grown to the point of being nearly universal, exposing a critical vulnerability that our adversaries have moved to exploit.

Both China and Russia have developed doctrine, organizations, and capabilities to challenge U.S. access to and operations in the space domain. Concurrently, their use of space is expanding significantly. These nations have demonstrated the capability to put American space assets at risk, and until very recently, the United States had not taken overt steps to protect those systems, much less to develop its own warfighting capability in that domain.

The 2017 NDAA mandated that DOD conduct a review of the organization and command and control of space assets within the department. Shortly after the NDAA was enacted, President Donald Trump directed that a Space Force be established within the DAF.⁹ Congress concurred and created the USSF with the 2020 NDAA.

An important addition to the U.S. warfighting command structure was the reestablishment of U.S. Space Command as the 11th combatant command within the Department of Defense with the mission of conducting "operations in, from, and to space to deter conflict and, if necessary, defeat aggression, deliver space combat power for the Joint/Combined force, and defend U.S. vital interests with allies and partners."¹⁰

U.S. Space Force Organization

The USSF Headquarters and Office of the Chief of Space Operations are located in the Pentagon. When Congress authorized the Space Force, it limited its scope to Air Force personnel and assets, equating to a total workforce of approximately 27,300¹¹ comprised of personnel and organizations within five Air Force Wings located at five major installations:

- The 21st Space Wing at Peterson Air Force Base, Colorado;
- The 30th Space Wing at Vandenberg Air Force Base, California;

- The 45th Space Wing at Patrick Air Force Base, Florida;
- The 50th Space Wing at Schriever Air Force Base, Colorado; and
- The 460th Space Wing at Buckley Air Force Base, Colorado.¹²

Those personnel, organizations, and structures have been or will be restructured and rolled into three major field commands that fall directly under the CSO:

- Space Operations Command,
- Space Systems Command, and
- Space Training and Readiness Command.

These three commands are leading or will lead the next tier of organizations, called Deltas and Garrisons. Deltas are equivalent to Air Force Groups, are led by a colonel, and are tasked with and responsible for specific missions and operations. Garrisons are also the equivalent of Air Force Groups and support Deltas with functions similar to those of Air Force "Base"-level command. Squadrons are the final level of command and will fall under Deltas and Garrisons.

Space Operations Command. SpOC was established on October 22, 2020, as the first major USSF field command. Currently located at Peterson Air Force Base, Colorado, SpOC is led by a three-star general and is responsible for organizing, training, and equipping space forces assigned to combatant commands. The already standing SpOC at Vandenberg Air Force Base, California, will be redesignated as SpOC West and will continue to conduct operations in support of combatant commanders.

Space Systems Command. This command was scheduled to stand up in the summer of 2021¹³ to oversee the development, acquisition, and maintenance of satellites and ground systems, the procurement of SATCOM and launch services, and investments in next-generation technologies. Space Systems Command will be headed by a three-star general who will oversee the Space Force's approximately \$11.3 billion annual budget for research, development, test, and evaluation (RDT&E) and the acquisition of new systems.¹⁴

At present, DOD's primary space procurement agency is the Space and Missile Systems Center (SMC), located at Los Angeles Air Force Base, California. When Space Systems Command stands up, it will absorb SMC along with two other procurement agencies: the Commercial Satellite Communications Office based in Washington, D.C.,¹⁵ and the Air Force Research Laboratory (AFRL) Space Vehicles Directorate based at Kirkland Air Force Base, New Mexico.¹⁶

Space Training and Readiness (STAR) Command. STARCOM will be the third USSF field organization and will be based at Peterson Air Force Base in Colorado. It will be led by a two-star general and will be responsible for the education and training of space professionals. Until the two-star command stands up, a provisional command and foundational element of STARCOM, STAR Delta (P), which was established in July 2020, will serve as the parent organization for several education, training, test, and evaluation units.¹⁷

Personnel. The 2020 NDAA specified that only the Air Force was required to provide personnel for the Space Force, and with the redesignation of Air Force Space Command (AFSPC) as Space Operations Command, approximately 16,000 Air Force active-duty and civilian personnel were assigned to support the USSF.18 However, most are still wearing the same uniforms they wore before being reassigned, as well as working in the same offices. "Assigned" personnel remain in the Air Force or another service and perform work in support of the USSF. An officer that transfers will be (re)commissioned in the USSF, and enlisted personnel that transfer will execute an enlistment contract with the new service.19

The 2021 NDAA authorized 6,434 military personnel, 3,545 civilian personnel, and a total end strength of 9,979 on September 30, 2021. 20

More than 6,400 people have been hand selected to make the transition, and as of the end of April 2021, more than 4,840 had transferred to the new service.²¹ Methodically expanding the Space Force to include all DAF military and civilian personnel that the service intends to transfer will probably not be completed until the end of FY 2021.²²

However, even when combined with the new geographic combatant command for space, a service formed just from Air Force assets will not remedy the dysfunctional oversight or command and control issues that the Space Force initiative was intended to resolve.²³ For that to happen, a significant portion of the approximately 21,200 space professionals that remain in the Army and Navy²⁴ will need to be incorporated into the Space Force something that is not likely to happen until FY 2024 or later.

Funding

The President's budget request for FY 2022 lays out a relatively robust level of funding for every aspect of the new service's mission set. The budget for Operations and Maintenance (O&M) is \$3.4 billion; the budget for RDT&E is \$11.3 billion; and procurement adds another \$2.8 billion for a total of \$17.4 billion, a 13 percent increase over FY 2021.

Assuming that the President's budget is fully funded, Space Force end strength will be authorized up to 12,764 military and civilian personnel, an increase of 2,785 over FY 2021.²⁵ The combination of robust funding and manpower levels will allow the CSO to continue to focus on building a strong organizational foundation and filling critical billets with the right people.

Capacity

The classified nature of deployed space assets makes listing specific capacity levels within the Space Force portfolio, much less attempting to assess the service's capability to execute its mission, a challenging exercise. The USSF's position, navigation, and timing (PNT); command and control (C2); communications

U.S. Space Force Budget

In billions of dollars

	Operation and Maintenance	Military Personnel*	Research, Development, Test, and Evaluation	Procurement	Overseas Contingency Operations	Military Construction	Total
FY 2021	\$2.6	0	\$10.5	\$2.3	0.1	0	\$15.4
FY 2022	\$3.4	0	\$11.3	\$2.8	0	0	\$17.4

* U.S. Space Force personnel costs were funded by U.S. Air Force Military Personnel, FY 2021 (\$800.3 million) and FY 2022 (\$929.8 million). **NOTE:** Figures may not sum to totals due to rounding.

SOURCES: Extracted from U.S. Air Force budget summaries for fiscal years 2021 and 2022. For example: Table 3, "U.S. Space Force Budget Summary," in U.S. Department of the Air Force, *Department of the Air Force Fiscal Year 2021 Budget Overview*, p. 8, https://www.saffm.hq.af.mil/Portals/84/documents/FY21/SUPPORT_/FY21%20Budget%20Overview_1.pdf?ver=2020-02-10-152806-743 (accessed September 3, 2021).

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(Comm); and weather satellites (referred to collectively as Backbone satellites) and its intelligence, surveillance, and reconnaissance (ISR) satellites are unrivaled and provide extraordinary capabilities. Its space situational awareness (SSA) satellites and terrestrialbased capabilities, while also unrivaled, are limited and require additional resourcing. Each satellite, satellite constellation, and terrestrial space surveillance site has unique characteristics and an expected life span.

The Space Force has a total of 70 Backbone satellites that enable every facet of modern American warfare, to include the collection of real-time intelligence and the ability to communicate, adaptively maneuver, and deliver precision effects almost anywhere on the planet.

Satellite Constellations

The Space Force mission is conducted through a network of satellites, ground-based radar, ground stations, and situational awareness nodes. In 2018, the Secretary of the Air Force stated that the service operates 77 satellites vital to national security that provide communications, command and control, missile warning, nuclear detonation detection, weather, and GPS for the world.²⁶ An estimated 90 satellites in that portfolio now reside within the Space Force. (See Table 17).

Global Positioning System (38 Satellites). Perhaps the best-known constellation of satellites under Space Force control is the Global Positioning System (GPS), which provides PNT for millions of simultaneous users around the world. It takes 24 of these satellites to provide seamless global coverage, and 31 are currently operational.²⁷ Approximately seven additional satellites that have been decommissioned and serve as on-orbit spares bring the total to 38.

GPS III is the latest upgrade to the platform and incorporates a more robust anti-jamming capability. The fifth GPS III²⁸ satellite was launched into orbit on June 17, and the scheduled launch of the sixth in September 2021 will increase the number in orbit to 39.²⁹ Interoperability with other Global Navigation Satellite Systems (GNSS) such as the European Galileo network and the Japanese Quazi-Zenith Satellite System adds an impressive level of resiliency.³⁰

Types of Earth Orbits



Weather (Four Satellites). Defense weather satellites have been collecting weather data and providing forecasts for U.S. military operations since 1962 through the Defense Meteorological Satellite Program (DMSP).³¹ Currently, four operational DMSP satellites are in polar low-Earth orbits (LEOS).³² The main sensors for these weather satellites are optical, and each provides continuous visual and infrared imagery of cloud cover over an area approximately 1,600 nautical miles wide and provide complete global coverage of weather features every 14 hours.³³ Launched between 1999 and 2009 with a life expectancy of just five years, they have continued to deliver exceptional data well beyond their expected lifetimes.³⁴

Communications (28 Satellites). Milstar is a satellite communications (SATCOM) system designed in the 1980s to provide the National Command Authorities assured, survivable global communications with a low probability of intercept or detection. The technology built into this five-satellite constellation was crafted to overcome enemy jamming and nuclear effects and was considered the DOD's most robust and reliable SATCOM system when it was fielded.

The follow-on to Milstar is the Advanced Extremely High Frequency System (AEHF). This system is a network of satellites operated by the Space Force for the Joint Force that allows the DOD to sustain secure, jam-resistant communications and C2 for high-priority military ground, sea, and air assets located anywhere in the world. The AEHF Constellation includes six satellites³⁵ in GEO.³⁶

The Defense Satellite Communications System (DSCS) has seven operational satellites that provide nuclear-hardened, global communications to the Defense Department, the Department of State, and the National Command Authorities. The system is capable of high data rates and provides anti-jamming capabilities.

Wideband Global SATCOM (10 Satellites). Wideband Global SATCOM (WGS) is a joint-service program funded by the U.S. Air Force and U.S. Army, along with international partners Australia and Canada, and is used by all DOD services as well as National Command Authorities. Once known as the Wideband Gapfiller Satellite,³⁷ WGS provides Super High Frequency (SHF) wideband communications, using direct broadcast satellite technology to provide C2 for U.S. and allied forces. With solid capabilities that include phased array antennas and digital signal processing technology, this system delivers a flexible architecture with a satellite life span of up to 14 years.

Space-Based Infra-Red System (Six Satellites).³⁸ The Space-based Infrared System (SBIRS) is an integrated constellation of satellites designed to deliver early missile warning and provide intercept cues for missile defenses. This surveillance network was designed to incorporate three satellites in high elliptical orbit (HEO) and eight others in geosynchronous orbit (GEO), each working in concert with ground-based data processing and command and control centers. Because SBIRS HEO is a retaskable orbit, these satellites can be moved to more optimum orbits/viewpoints as mission requirements dictate. Five SBIRS GEO satellites have been placed in orbit, and it is expected that the final vehicle, GEO-6, will launch sometime in 2022.³⁹

The funding that was removed from SBIRS shifted to a new program, Next-Generation Overhead Persistent Infrared (Next-Gen OPIR), which will include a new groundcontrol system. The program is intended to deliver resilient detection and tracking capability through a contested environment that includes emerging advances in adversary rocket propulsion technology. It is expected that fielding of a strategically survivable constellation of satellites to provide missile warning will begin sometime in FY 2023.⁴⁰

Defense Support Program (Five Satellites). Defense Support Program (DSP) satellites were designed to detect launches of ICBMs or Sea Launched Ballistic Missiles (SLBMs) against the U.S. and its allies. Its secondary missions include detection of space launch missions or nuclear weapons testing and detonations. The DSP constellation is in GEO and uses infrared sensors to pick up the heat from and booster plumes against the Earth's background. Phase 1 placed four satellites in orbit from 1970 through 1973⁴¹ and was followed by Phase 2, which placed six satellites in orbit from 1979-1987.42 Phase 3 consisted of 10 DSP satellites that were launched from 1989-2007.43

Although Phase 3 DSP satellites have long exceeded their design lifetimes, reliability has exceeded expectations, and at least five⁴⁴ and as many as eight are still providing reliable data and are now integrated with and controlled by the SBIRS program ground station.⁴⁵

Space Situational Awareness Systems

Knowledge of hostile systems—their locations, their positional history, and how those satellites are maneuvering in real time conveys intent and collectively shapes the protocols and counterspace decisions that follow. Space situational awareness is therefore critical to every aspect of defensive and offensive counterspace operations and forms the foundation for DOD counterspace activities.⁴⁶

In addition to adversary systems, other significant threats are in orbit. The National Aeronautics and Space Administration (NASA) estimates that as many as a half-million objects with diameters between 0.4 inches and four inches are circling the Earth,⁴⁷ and the Australian Space Academy says that objects in LEO are traveling between 15,600 and 17,900 miles an hour.⁴⁸

Maintaining a high level of situational awareness of satellites and debris orbiting across the depth and vast dimensions of potential Earth orbits requires a robust and seamless network of space-based and terrestrial-based sensors. Understanding the capabilities and limitations of that network naturally begins with understanding the numbers and types of space-based and ground-based systems.

Six acknowledged satellites and six dedicated and 17 collateral or contributing terrestrialbased sensors help to maintain situational awareness of satellites and other objects in space. The satellites, collectively known as the Space-Based Surveillance System (SBSS), operate in concert with ground-based sensors but without their weather-related and sunlightrelated limitations.

Some satellites track objects and debris fields from LEO. Others operate from a much higher orbital position (GEO) and are capable of maneuvering to perform detailed inspections of orbiting items of especially high interest.

Space-Based Surveillance System (Six Satellites). The Geosynchronous Space Situational Awareness Program (GSSAP) is a classified surveillance constellation of four satellites that can accurately track and characterize objects in orbit.⁴⁹ Operating near GEO, GSSAP satellites are maneuverable and therefore able to perform rendezvous and proximity operations (RPO) on objects of interest in space.⁵⁰ Launched in pairs, the first two GSS-AP satellites were put in orbit on July 28, 2014, followed by the second two on August 19, 2016, and each has a life span of up to seven years.⁵¹

The first of the two remaining satellites, Space-Based Surveillance System-1 (SBSS-1), was launched to LEO in 2010 with a seven-year life expectancy.⁵² The second, Space Tracking and Surveillance System Advanced Technology Risk Reduction (STSS-ATR), is an RDT&E satellite placed in a polar LEO on May 5, 2009, with an unknown life expectancy. It was placed in orbit by the Missile Defense Agency (MDA) but is now part of the USSF portfolio.⁵³

Space Surveillance Network (Six Dedicated Ground-Based Sensors). The U.S. Space Surveillance Network (SSN) is comprised of 23 ground-based radar and optical tracking sites that have the ability to detect, track, identify, and catalog all man-made objects orbiting the Earth. Of the 23 sites, six are dedicated sensors with a primary mission of space surveillance.

Seven collateral sensors are part of the network, but their primary mission is to detect and track ICBMs and SLBMs and to test and evaluate other systems. Another 10 contributing SSN sensors controlled by other organizations or agencies provide space surveillance support upon request from the National Space Defense Center (NSDC).

Reconnaissance and Imaging Satellites (Unknown). Although the history of the Air Force is steeped in these reconnaissance systems, the operational details of each constellation are classified. In the late 1990s and early 2000s, the Air Force moved to develop and field a constellation of space-based radar satellites. That program (known as Lacrosse/ Onyx) launched five satellites, each carrying a synthetic aperture radar (SAR) as its prime imaging sensor. Because SAR systems can see through clouds with high resolution, they offer the potential to provide a capability from which it is hard to hide.⁵⁴

Space Launches by Country Since 2010

	U.S.	China	Russia	India
2010	17	16	16	3
2011	19	19	20	3
2012	12	19	12	2
2013	19	15	18	3
2014	21	15	22	4
2015	19	19	14	3
2016	24	22	13	7
2017	29	18	13	4
2018	29	39	13	7
2019	20	34	14	6
2020	53	19	21	14
2021	66	22	26	7
Total	328	257	202	63

SOURCE: Space Launch Schedule, https://www.spacelaunchschedule.com/ (accessed September 8, 2021).

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Space Launch Capacity

The Space Force manages the National Security Space Launch (NSSL) program, a Major Defense Acquisition Program that acquires launch services from private companies to deliver national security satellites into orbit. Currently, the NSSL uses the Atlas V and Delta IV Heavy launch vehicles from United Launch Alliance (ULA) and the Falcon 9 and Falcon Heavy from SpaceX to launch national security payloads.

In 2018, the Air Force awarded three launch services agreements to space launch companies to develop their launch vehicles for a second phase of the NSSL. In 2020, the Space Force awarded two launch services procurement contracts to ULA and SpaceX, and those two vendors will provide space launch services for the Space Force through $2027.^{55}$

In 2010, four organizations, including NASA, were involved in launching manned

and unmanned systems into space. Today, nine private corporations—twice the number that had launched systems into orbit in 2019—are engaged in placing satellites into orbit.⁵⁶ In 2021, U.S. companies are scheduled to launch 66 missions into space, and China and Russia are scheduled to conduct 22 and 26 launches, respectively.⁵⁷ America has turned the corner on this vital capability, and the access to space that these private companies provide will be a major factor in determining whether the United States is able to prevail in the great-power competition that lies ahead.

Capability

With an estimated 90 satellites in its portfolio, the USSF can meet much of the communications, collection, and imagery demand placed on it by the National Command Authorities and the strategic-level intelligence requirements of the Defense Department. However,

U.S. Satellites in Orbit

System	Function	Satellites
GPS	Positioning, Navigation, and Timing	38
SBIRS	Missile Warning	9
DSP	Missile Warning	5
SBSS	Space Surveillance	1
STSS-ATR	Missile Defense	1
GSSAP	Space Tracking	4
DMSP	Weather	4
Milstar	Communications	5
AEHF	Communications	6
DSCS	Communications	7
WGS	Communications	10
Total		90

NOTE: Data are current as of May 20, 2021. **SOURCES:**

- Union of Concerned Scientists, "UCS Satellite Database," updated May 1, 2021, https://www.ucsusa.org/resources satellite-database (accessed September 3, 2021).
- U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Environmental Satellite Data and Information Service, "Currently Flying," https://www. nesdis.noaa.gov/content/currently-flying (accessed September 3, 2021).
- Gunter's Space Page, "DSP 14, 15, 16, 17, 18, 19, 20, 21, 22, 23 (Phase 3)," last update March 19, 2020, https://space.skyrocket. de/ doc_sdat/dsp-3.htm (accessed September 3, 2021).
- Table, "Spacecraft in Service over Time (As of Sept. 30, 2019)," in "Air Force & Space Force Almanac 2020," *Air Force Magazine*, Vol. 103, No. 6, June 2020, p. 67, https://www.airforcemag.com/app/uploads/2020/06/June2020_Fullissue5.pdf (accessed September 3, 2021).
- Gunter's Space Page, "Trumpet 4, 5 / SBIRS HEO-1, 2," last update November 4, 2020, https://space.skyrocket.de/doc_sdat/trumpet-fo.htm (accessed September 3, 2021).
- Gunter's Space Page, "Trumpet 6, 7 / SBIRS HEO-3, 4," last update April 29, 2021, https://space.skyrocket.de/doc_sdat/ trumpet-fo-2. htm (accessed September 3, 2021).

- Gunter's Space Page, "SBIRS-GEO 1, 2, 3, 4," last update November 4, 2020, https://space.skyrocket.de/doc_sdat/sbirsgeo-1.htm (accessed September 3, 2021).
- Fact Sheet, "Space Based Space Surveillance," U.S. Air Force, Air Force Space Command (Archived), current as of July 2019, https://www.afspc.af.mil/About-Us/Fact-Sheets/ Article/249017/space- based-space-surveillance-sbss/ (accessed September 3, 2021).
- Gunter's Space Page, "STSS-ATRR," last update July 21, 2019, https://space.skyrocket.de/doc_sdat/stss-atrr.htm (accessed September 3, 2021).
- News release, "Missile Defense Agency Space Tracking and Surveillance System Advanced Technology Risk Reduction Satellite Transfers to Air Force Space Command," U.S. Department of Defense, Missile Defense Agency, February 26, 2011, https://www.mda.mil/news/11news0004.html (accessed September 3, 2021).
- Gunter's Space Page, "GSSAP 1, 2, 3, 4, 5, 6 (Hornet 1, 2, 3, 4, 5, 6)," last update November 4, 2020, https://space.skyrocket.de/ doc_sdat/ gssap-1.htm (accessed September 3, 2021).

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Organization	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Space X	2	0	2	3	5	7	10	18	20	13	31	36	147
United Launch Alliance	10	12	9	11	14	12	12	8	7	4	13	12	124
Northrup Grumman	2	4	1	5	2	0	2	3	2	3	5	2	31
Rocket Lab, Ltd	0	0	0	0	0	0	0	0	0	0	2	6	8
NASA	3	3	0	0	0	0	0	0	0	0	0	2	8
Virgin Orbit	0	0	0	0	0	0	0	0	0	0	0	3	3
Firefly Aerospace	0	0	0	0	0	0	0	0	0	0	1	1	2
Blue Origin	0	0	0	0	0	0	0	0	0	0	0	2	2
Astra Space Launch Co.	0	0	0	0	0	0	0	0	0	0	1	0	1
Relativity Space	0	0	0	0	0	0	0	0	0	0	0	1	1
USAF	0	0	0	0	0	0	0	0	0	0	0	1	1
Total	17	19	12	19	21	19	24	29	29	20	53	66	328

U.S. Space Launches by Organization

SOURCE: Space Launch Schedule, "USA Launch Schedule," https://www.spacelaunchschedule.com/ category/usa/ (accessed September 8, 2021).

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getting real-time satellite intelligence to warfighters at the operational and tactical levels is still problematic. The loss of even a small number of those 90 satellites could significantly impact operational capabilities across the DOD.

Backbone Satellites. In spite of an evergrowing demand, the USSF can meet a significant amount of the strategic demand for collection, imagery, and communications placed on it by the National Command Authorities and the Defense Department. The PNT services offered by GPS are unrivaled in both capacity and capability. With 31 operational GPS satellites in orbit and seven spaceborne (dormant) spares, the system has enough redundancy and resiliency to handle losses associated with normal (not-combat-related) space operations.

The current and growing DOD demands for imagery and collection are another thing entirely. The shortfall is projected to be so great that the Departments of the Air Force and Army, the National Reconnaissance Office, and other agencies have invested in and are employing the services of commercial organizations to provide collection and imagery on demand.⁵⁸

In the summer of 2020, the U. S. Army conducted an exercise called Project Convergence 2020 (PC20), which was designed to test the capability of commercial spaceborne systems to provide the intelligence, imagery, and communications linkages for warfighters in the service's "close fight." Brigade Combat Teams (BCTs), Combat Aviation Brigades (CABs), and Expeditionary Signal Battalion-Enhanced (ESB-E) were given access to 600 commercial SpaceX Starlink satellites in LEO to facilitate faster decisions.⁵⁹

When combined with other small satellites (SmallSats), the sensors on Starlink's rapidly

Satellites by Weight

Group Name	Weight	Size
Large Satellite	1,000+ kilograms	Large
Medium Satellite	500-1,000 kilograms	Medium
Mini Satellite	100–500 kilograms	Small
Micro Satellite	10–100 kilograms	Small
Nano Satellite (CubeSats)	1–10 kilograms	Small
Pico Satellite	0.1–1 kilograms	Small
Femto Satellite	<100 grams	Small

SOURCE: Table 1, "Satellites by Mass," in Chalie L. Galliand, "Study of the Small: Potential for Operational Military Use of CubeSats," 24th Annual AIAA/USU [American Institute of Aeronautics and Astronautics/Utah State University] Conference on Small Satellites, August 10, 2010, p. 1, https:// digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1199&context=smallsat (accessed September 3, 2021).

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expanding constellation, which numbered 1,440 satellites as of May 2021,⁶⁰ will enable the Army's concept for a Multi-Domain Operations (MDO)–Capable Force by 2028 and an MDO-Ready Force by 2035.⁶¹ The capabilities demonstrated in PC20 are similar in nature to those sought in the Air Force's Advanced Battle Management System (ABMS) and the Navy's Overmatch C2 development programs.⁶² Starlink reportedly also has the ability to provide a very accurate PNT backup for GPS, which will become increasingly important for all of the services as the competition in space intensifies.⁶³

Intelligence, Surveillance, and Reconnaissance. The USSF has 14 satellites dedicated to missile launch warning. While the SBIRS constellation is two GEO satellites short of design, its nine satellites, coupled with the five DSP satellites, provide global coverage and generally excellent response times.

As noted above, the current portfolio of reconnaissance satellites, while highly classified, meets many of the essential strategic requirements of the NCA and the Defense Department. However, Space Force capabilities fall well short of the needs of the services. The Department of the Air Force is therefore investing in and employing the services of commercial organizations to meet the "on demand" collection and imagery needs of USSF customers.⁶⁴

Space Situational Awareness. The Space Force's six acknowledged SSA satellites and the six dedicated and 17 collateral contributing ground-based sensors within the space-based surveillance system help to maintain situational awareness of satellites and other objects in space. However, the limited number and inherent limitations of the sensors within the SBSS leave significant gaps in coverage. Those gaps are addressed by prediction, and every time a satellite maneuvers, "the process of initial discovery by a sensor, creation of an initial element set, and refinement of that element set needs to be repeated."⁶⁵

The Backbone and ISR assets within the USSF are critically important; however, the focus of the *Index of U.S. Military Strength* is primarily on assessing the classic "hard combat power" found in defensive and offensive systems.

Defensive Capabilities

Defensive systems and operations are designed to protect friendly space capabilities against kinetic anti-satellite weapons, high-powered lasers, laser dazzling or blinding, and high-powered microwave systems.⁶⁶

The first challenge in defense is detecting an attack, and a host of sensors exist that can detect the launch of terrestrial-based antisatellite (ASAT) weapons. With 14 satellites dedicated to detecting missile launches, it is possible for the USSF to determine an ASAT's trajectory, identify the targeted satellite, and alert operators in time for them to take evasive action with those systems. Unfortunately, the gaps in the SSA network highlighted earlier make the timely assessment of and response to such an attack on a specific U.S. satellite difficult.

Detecting other (non-missile) attacks presents another problem, and the Space Force has fielded a system that can deal with one part of that challenge. Operated by ground-based units, Bounty Hunter can detect an adversary's attempts to deceive, disrupt, deny, or degrade satellite communications by monitoring electromagnetic interference across multiple frequency bands. Operators can locate sources of intentional and unintentional interference and minimize them.⁶⁷ Bounty Hunter achieved initial operational capability (IOC) in the summer of 2020. While this system is a significant improvement, it has no known capability to detect or counter laser.

USSF satellites need a sensor package that allows them to self-detect hostile system engagement and report it to operators who are positioned to take defensive actions. That capability is currently not known to exist.

Cyberattacks present a different challenge to space-based systems. Like other kinetic and non-kinetic attacks, cyber intrusions can cause service disruptions, sensor interference, or the permanent loss of satellite capabilities. Additionally, an effective cyberattack could corrupt the satellite's data stream to reliant elements or systems—or even allow an adversary to seize control of a satellite.⁶⁸ A recent Royal Institute of International Affairs report states that the U.S. is well behind its peer competitors in this area and should assume that its satellite constellations have already been penetrated and compromised.⁶⁹

In spite of its current limitations, protective measures that the service can take now to safeguard its spaceborne systems can be separated into two categories of systems and actions: active and passive.

- An active defense is really offensive in nature and includes engagements to destroy, nullify, or reduce enemy systems that put U.S. and allied systems and capabilities at risk.
- Passive defense measures increase survivability through asset diversification, including the deployment of more space systems in different orbits, as well as real-time satellite maneuverability and self-protection.⁷⁰

Shortly before the USSF became an independent service, the Air Force made clear that it wanted to build a constellation of thousands of SmallSats in low-Earth orbit to provide a redundant, diversified portfolio of capabilities. Over time, it is has become apparent that those expanding constellations will be comprised of both military and civilian satellites.⁷¹

In 2018, the Air Force signed a \$28 million contract with SpaceX to evaluate its LEObased Starlink constellation of satellites that provide broadband services. In 2019, the service tested Starlink's ability to provide communications linkages with airborne service aircraft and other spaceborne systems during its Global Lightning program.⁷²

Starlink had 1,440 satellites in orbit as of May 2021, but while significant in number, that constellation would be unable to provide seamless global coverage. Ultimately, however, Starlink is on track to field some 4,500 satellites by the end of 2023, which will lift that limitation.⁷³ Continuing this relationship with Starlink will bode well for the USSF and its ability to support U.S. forces with satellite access, resilience, and the overall survivability of the network of satellites available to the DOD.

Offensive Systems

The Air Force's FY 2017 budget included \$158 million to develop offensive space capabilities over a period of five years.⁷⁴ The only offensive space system of record within the USSF that can be found in open-source literature is a system called Meadowlands.

Meadowlands is a mobile, terrestrial-based, counter-communications system (CCS) that delivers effects to thwart adversary SATCOM in a given area of responsibility (AOR). The effects of Meadowlands are reversible: When the system is turned off, the communications linkages it was targeting return to their original functionality.⁷⁵

Readiness

The Space Force was born of a congressionally mandated study that included a plan for the incremental transition of operational Air Force space assets and personnel to the new service. Throughout the plan's execution, the USSF has been deliberate in its hiring and is on a path to developing a solid cadre of personnel and a strong organizational culture. The operations assumed by the USSF to support strategic and high-end operationallevel support have proceeded uninterrupted, and to that end, readiness has remained high, but those operations were primarily supportive in nature and did not include robust, nearly real-time support to tactical units. While the service is undoubtedly moving forward on credible defensive and offensive readiness, there is little evidence that it is ready for the threat envisioned by Congress when it formed the Space Force.

Available government and commercial systems have the capability and capacity to meet the imagery, collection, and communication linkage demands and throughput requirements of warfighters at the operational and tactical levels. However, the entities driving to fill the gaps in capability, capacity, and the readiness levels required to infuse that intelligence to the operational and tactical levels is coming from the other services.

The Space Force needs to take the reins of this challenge in every dimension (capacity, capability, and readiness) to further the efforts of warfighters at all levels in the other domains, and it should move aggressively to fill the gaps that exist in the readiness that is required to defend our assets and threaten those of our adversaries.

Scoring the U.S. Space Force

Capacity Score: Weak

The number and types of Backbone and ISR assets are sufficient to support global PNT requirements and the majority of strategiclevel communications, imagery, and collection requirements of the National Command Authorities and the Department of Defense. However, the Space Force is not capable of meeting current—much less future—on-demand, operational, and tactical-level warfighter requirements.

As noted in the readiness section, the gaps in the SBSS are covered by prediction, and operators of adversarial satellites can time their maneuvers to take advantage of those gaps. With the influx of small satellites (see Table 19), the potential for the number of U.S. military satellites in orbit to grow from a few hundred to several thousand over the next three years is very real. Add new commercial, allied, and adversary SmallSats to the mix and it is highly likely that the number of operational satellites in orbit will double over that same period. Although increasing numbers alone will challenge the current Space Surveillance Network, the number of unannounced orbital changes among those satellites will make it markedly more difficult to keep track of bad actors.

The U.S. had announced plans to build a second, strategically located Space Fence like the one on Kwajalein Atoll in Western Australia in 2021, but that site has yet to be funded. Even if a second Space Fence does eventually materialize, the Space Force will still need more satellites that are dedicated to this mission.⁷⁶

The service's two counterspace weapons systems (Meadowlands and Bounty Hunter, respectively) cover only a fraction of the offensive and defensive capabilities required to win a conflict in space. Other counterspace systems are likely being developed or, like cyber, are already in play. Nevertheless, the current visible capacity of the Space Force is not sufficient to support, fight, or weather a war with a peer competitor.

Capability Score: Weak

The current space asset modernization plan that is visible to the public follows the same incremental replacement and fielding design that has been in practice for decades. The vast majority of Backbone and ISR assets have exceeded their designed life spans and the DAF's willingness to delay and/or defer the acquisition of replacement systems remains a legacy of that department.

The capability of Backbone and ISR satellites is marginal, but it is more than offset by the gaps in SSA and the apparent lack of defensive and offensive capabilities ("very weak"). The capability score is therefore "weak," the result of being scored "weak" in "Size of Modernization Program," "weak" for "Age of Equipment" and "Health of Modernization Programs," and "weak" for "Capability of Equipment."

Readiness Score: Weak

The mission sets, space assets, and personnel that transitioned to the Space Force and those that have been assigned to support the USSF from the other services have not missed an operational beat since the Space Force stood up in 2019. Throughout that period, the readiness levels have seamlessly sustained backbone and ISR support to the NCA, DOD, combatant commanders, and warfighters around the world.

However, there is little evidence that the USSF has improved its readiness to provide nearly real-time support to the operational and tactical levels ("marginal") or that it is ready in any way to execute defensive and offensive counterspace operations to the degree envisioned by Congress when it formed the Space Force ("very weak").

Overall U.S. Space Force Score: Weak

This is an unweighted average of the USSF's capacity score of "weak," capability score of "weak," and readiness score of "marginal."

U.S. Military Power: Space

	VERY WEAK	WEAK	MARGINAL	STRONG	VERY STRONG
Capacity		 ✓ 			
Capability		 ✓ 			
Readiness		 ✓ 			
OVERALL		 Image: A second s			





Navigation

PLATFORM	Age Score	Capability Score	REPLACEMENT PR	OGRAM	Size Score	Health Score
Global Positioning System (GPS)			GPS III		•	•
Inventory: 38 Fleet age: 14.5 Date: 1997			Timeline: 2019-TBI	D	6	5
GPS satellites provide timing, velocity, and precise navigation for millions of simultaneous users around the world. It takes 24 GPS satellites to provide seamless global coverage; currently, 32 are operational with an additional four decommissioned satellites serving as on-orbit spares.	6	4	GPS III is the latest incorporates more interoperable with Satellite systems, a the GPS system. PROCUREMENT	2 \$598	atform and apabilities. Navigatic adds resil <i>\$ millions)</i>	d . It is on ience to

Missile Warning

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
Space Based Infrared System (SBIRS) Inventory: 9 Fleet age: 7.5 Date: 2006 An integrated constellation of satellites, SBIRS is designed to deliver early missile warning and provide intercept cues for missile defenses. The satellites are retaskable, which means they can be moved to more optimum or viewpoints as mission requirements dictate. The program was ended early because of cost, schedule, and performance issues.	4	4	Next Generation Persistent Infrared (Next-Gen OPIR) Timeline: TBD		
Defense Support Program (DSP) Inventory: 5 Fleet age: 32.5 Date: 1970 These satellites were designed to detect intercontinental ballistic missile and sea-launched ballistic missile launches against the U.S. and its allies. They can also detect space launch missions and nuclear weapons testing and detonations. Phase 3 satellites were launched from 1989 to 2007 and have long exceeded their designed lifetimes, but they are still providing reliable data and are integrated with the SBIRS program.	0	3			

NOTE: See page 500 for details on fleet ages, dates, timelines, and procurement spending.





Space Surveillance

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
Space Based Surveillance System (SBSS)			None		
Inventory: 1 Fleet age: 11 Date: 2010	3	3			
This system uses multiple types of sensors to track man-made objects and debris fields in orbit.					

Missile Defense

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
Space Tracking and Surveillance System Advanced Technology Risk Reduction (STSS-ATR)			None		
Inventory: 1 Fleet age: 12 Date: 2009					
This research, development, testing, and evaluation (RDT&E) satellite was originally launched by the Missile Defense Agency to explore different capabilities and technology but was transferred to the Air Force in 2011.	3	4			

Space Object Tracking

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
Geosynchronous Space Situational Awareness Program (GSSAP)			None		
Inventory: 4 Fleet age: 6 Date: 2014					
This classified surveillance satellite constellation can accurately track and characterize objects in orbit using electro-optical and emissions sensors. Their maneuverability allows these satellites to conduct rendezvous and proximity operations (RPO) on space objects, enabling them to conduct offensive operations against other nations' assets.	6	6			

NOTE: See page 500 for details on fleet ages, dates, timelines, and procurement spending.





Weather

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
Defense Meteorological Satellite Program (DMSP)			Weather System Follow-on Microwave Satellite (WSF-M)		
Inventory: 4 Fleet age: 17 Date: 1999			Timeline: TBD		
Since 1962, defense weather satellites in the DMSP have been collecting weather data and providing forecasts for U.S. military operations. The current four satellites were launched between 1999 and 2009 with only a five-year life expectancy, but they have continued to provide accurate meteorological data well beyond that timeframe and are still in use today.	0	4			

Communications

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
Milstar Inventory: 5 Fleet age: 22.5 Date: 1994			Advanced Extremely High Frequency System (AEHF) Timeline: 2010-2021	TBD	TBD
Milstar is a satellite communications system designed in the 1980s to provide the National Command Authorities with global communications that were assured and survivable and carried low probability of interception or detection. Designed to overcome nuclear effects and enemy jamming, it was considered the most robust and reliable DOD SATCOM system at the time of fielding.	0	3	PROCUREMENT SPENDING	\$ (\$ millions)	\$0
Advanced Extremely High Frequency System (AEHF) Inventory: 6 Fleet age: 6 Date: 2010 The AEHF system is a network of six satellites that provides DOD with secure, jam-resistant communications and command and control for military ground, sea, and air assets located anywhere in the world.	6	6			

NOTE: See page 500 for details on fleet ages, dates, timelines, and procurement spending.





Communications (Cont.)

PLATFORM	Age Score	Capability Score	REPLACEMENT PROGRAM	Size Score	Health Score
Defense Satellite Communications System (DSCS) Inventory: 7 Fleet age: 28.5 Date: 1982			Advanced Extremely High Frequency System (AEHF) Timeline: 2010–2021	TBD	TBD
This system of seven satellites provides nuclear-hardened, global communications with anti-jamming capabilities to the Defense Department, State Department, and National Command Authorities.	1	2	PROCUREMENT SPENDING	(\$ millions) \$8	\$0
Wideband Global SATCOM (WGS) Inventory: 10 Fleet age: 8 Date: 2007 WGS, formerly known as the Wideband Gapfiller Satellite, is a joint-service program funded by the U.S. Air Force and U.S. Army along with international partners Australia and Canada. It uses direct broadcast satellite technology to provide command and control for U.S. and allied forces. Satellites have a life span of as many as 14 years.	4	6			

NOTES: See Methodology for descriptions of scores. Fleet age is the average between the last year of procurement and the first year of initial operational capability. The date is when the platform achieved initial operational capability. The timeline is from the start of the platform's program to its budgetary conclusion. Spending does not include advanced procurement or research, development, test, and evaluation (RDT&E).

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U.S. Nuclear Weapons Capability Patty-Jane Geller

U.S. nuclear weapons have played a critical role in preventing conflict between major powers since the end of World War II. Given their ability to deter large-scale attacks that threaten the U.S. homeland, allies, and forward-deployed troops and to assure allies and partners, nuclear deterrence has remained the number one U.S. national security mission.¹ Operationally, all U.S. military operations rely on the backstop of U.S. nuclear deterrence.² It is therefore critical that the United States maintain a modern and flexible nuclear arsenal that can deter a diverse range of threats from a diverse set of potential adversaries.

An Increasingly Threatening Global Environment

The nuclear threat environment has changed drastically from a stability paradigm based on mutually assured destruction involving the United States and the Soviet Union during the Cold War to a multipolar nuclear threat environment that presents complex challenges. As the threat increases, several negative trends, if not addressed, could undermine the overall effectiveness of U.S. nuclear deterrence. Today, U.S. nuclear forces face three great challenges:

- Aging nuclear warheads, their associated delivery systems, and systems for their command and control;
- An aging and crumbling nuclear weapons infrastructure; and

• An aging workforce.

The United States must fully recapitalize all three legs (land, air, and sea) of the nuclear triad including the systems for nuclear command and control while also conducting timely and cost-efficient warhead life-extension programs—all while operating under the current nuclear testing moratorium. Despite these challenges, the United States must ensure that its nuclear capabilities are sufficient to address the rising nuclear threat for the decades to come.

For the first time in history, the United States must deter two nuclear peers—Russia and China—while contending with a larger number of nuclear weapons states. Russia is engaged in an aggressive nuclear buildup, having added several new nuclear systems to its arsenal since 2010. The United States is only beginning to modernize its existing nuclear systems, but Russia's modernization effort is about 86 percent complete.³ Russia is also developing "novel technologies," such as a nuclear-powered cruise missile and nuclear-capable unmanned underwater vehicle, and arming delivery platforms with nuclear-tipped hypersonic glide vehicles.⁴

In addition, Russia maintains a stockpile of at least 2,000 non-strategic nuclear weapons, unconstrained by any arms control agreement.⁵ Lieutenant General Robert Ashley, Director of the Defense Intelligence Agency, has said that Russia is expected to increase this category of nuclear weapons—a category in which it "potentially outnumber[s]" the United States by 10 to 1.⁶ This disparity is of special concern because Russia's recent nuclear doctrine indicates a lower threshold for use of these tactical nuclear weapons. According to the 2018 Nuclear Posture Review (NPR), Moscow "mistakenly assesses that the threat of nuclear escalation or actual first use of nuclear weapons would serve to 'de-escalate' a conflict on terms favorable to Russia."⁷

China is engaging in what Admiral Charles A. Richard, Commander of U.S. Strategic Command (STRATCOM), has described as a "breathtaking" expansion of its nuclear capabilities as it attempts to project power into the South China Sea and throughout the world. China is well on its way to more than doubling its nuclear stockpile by the end of the decade. It is deploying advanced intercontinental ballistic missiles (ICBMs), completing its nuclear triad with the addition of a strategic nuclear-capable bomber, and deploying numerous theater-range ballistic missiles in the Indo-Pacific that can strike U.S. bases and allied territory with precision. Satellite imagery has also detected three ICBM silo construction sites in China that could hold at least 100 ICBM silos each.8 STRATCOM has described this expansion as a "strategic breakout" and has stated that China's nuclear capabilities will eventually exceed those of Russia.9 Current U.S. nuclear posture is not designed to deter two peer nuclear threats.

Evidence also suggests that China is shifting a portion of its nuclear forces to Launch-on-Warning posture as it improves its early warning systems.¹⁰ Combined with a refusal to discuss its forces or intent with the United States, this shift in posture increases the likelihood of mistakes and miscalculations.¹¹

North Korea is also advancing its nuclear weapons and missile capabilities. It continues to produce fissile material to build new nuclear weapons, recently paraded a new "monster" ICBM supposedly able to carry multiple warheads, and has recently tested ground-based and sea-based ballistic missiles.¹²

Iran, in addition to being the world's principal state sponsor of terrorism, continues to enrich uranium at dangerous levels and may be able to develop a nuclear weapon within just a few months. According to a recent report:

A worst-case breakout estimate, which is defined as the time to produce enough WGU for one nuclear weapon, is as short as 2.3 months. Iran could produce a second significant quantity of WGU early in the fifth month after breakout commences, and a third quantity could be produced early in the seventh month. For comparison, if no explosion had occurred at the FEP [Natanz Fuel Enrichment Plant], the minimum breakout timeline would have been 1.75 months, reflecting a longer breakout by one month. However, it should be noted that the post-explosion breakout estimate has additional uncertainties that suggest that it may be lengthier.13

As current U.S. nuclear capabilities continue to age, the advancing nuclear threat increases the importance of nuclear weapons to U.S. national security. Noting this rapid deterioration of the threat environment since 2010, the 2018 NPR outlined four enduring roles for U.S. nuclear capabilities:

- Deterrence of nuclear and non-nuclear attack;
- Assurance of allies and partners;
- Achievement of U.S. objectives if deterrence fails; and
- Capacity to hedge against an uncertain future.¹⁴

To achieve these objectives, the U.S. nuclear portfolio must balance the appropriate levels of capacity, capability, variety, flexibility, and readiness. Deterrence in a multipolar world is more complicated than in a bipolar world, as it requires a U.S. nuclear force capable of deterring multiple separate adversaries at the same time. What matters most in deterrence is



A Smaller and Less Diverse Nuclear Arsenal

NOTE: The 2017 figure of 3,822 warheads reflects the last year the U.S. government declassified stockpile quantities. These quantities include deployed warheads and warheads in reserve, but the U.S. is limited by New START to only 1,550 deployed warheads. **SOURCES:**

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not necessarily what the United States thinks will be effective. What matters most are the psychological perceptions—among both allies *and* adversaries—of America's willingness to use nuclear forces to defend its interests. If an adversary believes that he can fight a limited nuclear war, for instance, U.S. leaders must convince that adversary otherwise. In addition, military roles and requirements for nuclear weapons will differ from adversary to adversary based on each country's values, strategy, and goals.

The United States also extends its nuclear umbrella to more than 30 allies and partners

that rely on the U.S. to defend them from existential threats. This additional responsibility imposes requirements for U.S. nuclear force posture beyond defense of the U.S. homeland. U.S. nuclear forces underpin the broad nonproliferation regime by assuring allies—including NATO, Japan, South Korea, and Australia—that they can forgo their own development of nuclear capabilities. Erosion of the credibility of American nuclear forces could lead a country like Japan or South Korea to pursue an independent nuclear option, and this could have a profoundly negative impact on stability across the region.

In addition to deterrence and assurance, the United States historically has committed to achieving its political and military objectives if nuclear deterrence fails. As a result, U.S. forces must be postured to engage their targets successfully if such a failure makes it necessary to use nuclear weapons.

Finally, U.S. nuclear capabilities must have the capacity to hedge against an uncertain future. Nuclear weapon capabilities take years or decades to develop, as does the infrastructure supporting them—an infrastructure that the United States has neglected for decades until quite recently. Decisions regarding nuclear forces made today will impact the United States decades into the future. Since the United States cannot predict what the level of the threat will be decades in the future, it is critical that the U.S. maintain a nuclear enterprise that can respond to changes in the global security environment.

A robust, well-resourced, focused, and reliable nuclear enterprise that is able to respond to unforeseen contingencies is itself an important piece of deterrence and will enable a nuclear force that is resilient and adaptable. The U.S. nuclear enterprise today, however, is largely static, leaving the United States at what could well be a technological disadvantage. Such a posture puts the security of the United States, the security of its allies, and the entire free world at risk.

Challenges to Maintaining Nuclear Forces

To provide assurance against failures in the U.S. stockpile or changes in a geopolitical

situation, the United States must maintain the ability to adjust its nuclear force posture. To this end, the United States maintains an inactive stockpile that includes near-term hedge warheads that "can serve as active ready warheads within prescribed activation timelines" and reserve warheads that can provide "a longterm response to risk mitigation for technical failures in the stockpile."¹⁵

The United States preserves upload capability on its strategic delivery vehicles, which means that the nation could increase the number of nuclear warheads on each type of its delivery vehicles. For example, the U.S. Minuteman III ICBM can carry up to three Mk12A/W78 nuclear warheads, although it is currently deployed with only one.¹⁶ Certain modernization decisions (e.g., 12 versus 14 Columbia-class ballistic missile submarines with 16 rather than 24 missile tubes per submarine) will somewhat limit upload capacity on the strategic submarine force. U.S. heavy bombers will continue to retain a robust upload capability that can be used if a geopolitical or technical emergency requires more deployed nuclear warheads.

The United States has not designed or built a nuclear warhead since the end of the Cold War. Instead, the National Nuclear Security Administration (NNSA) uses life-extension programs (LEPs) to extend the service lives of existing weapons in the stockpile, some dating back to the 1960s. Not all of the existing inactive stockpile, however, will go through a life-extension program. Consequently, our ability to respond to contingencies by uploading weapons kept in an inactive status will inevitably decline with the passage of time.

In addition, while LEPs replace or upgrade most components in a nuclear warhead, all warheads will eventually need to be replaced because their nuclear components specifically, plutonium pits that comprise the cores of warheads—are also subject to aging.¹⁷ It is therefore unwise for the United States to rely solely on LEPs to sustain needed levels of reliability. Moreover, the United States is the only nuclear state that lacks the capability to produce plutonium pits in quantity. An effort is underway to restart plutonium pit production, but various challenges have been encountered that could upset U.S. plans to sustain its nuclear weapons.

Part of the U.S. hedge against uncertainty in deterrence is the ability to conduct a nuclear test if testing is ever required to ensure the safety and reliability of U.S. warheads. Presidential Decision Directive-15 (PDD-15) requires the United States to maintain the ability "to conduct a nuclear test within 2–3 years" of direction by the President.¹⁸ However, "the steady degradation" of test readiness after three decades of no testing calls into question the U.S.'s ability to meet this goal.¹⁹ The lack of congressional interest in funding any significant improvements in test readiness further undermines efforts by the NNSA to comply with the directive.

The nuclear weapons labs also face demographic challenges. Most scientists and engineers with practical hands-on experience in nuclear weapons design and testing are retired. This means that the certification of weapons that were designed and tested as far back as the 1960s depends on the scientific judgment of designers and engineers who have never been involved in either the testing or the design and development of nuclear weapons. According to former NNSA Administrator Lisa Gordon-Hagerty, more than 40 percent of the NNSA workforce will be eligible for retirement over the next five years, further adding to the loss of legacy nuclear weapons knowledge.²⁰

The Stockpile Responsiveness Program (SRP), mandated by Congress and being implemented by NNSA, has been effective in exercising critical nuclear weapons design and development skills not fully exercised since the end of the Cold War. It is essential that those skills are available when needed to support modern warhead development programs for U.S. submarine-launched ballistic missiles (SLBMs) and ICBMs.

The shift in emphasis away from the nuclear mission after the end of the Cold War led to a

diminished ability to conduct key activities at the nuclear laboratories. According to former Acting Administrator Dr. Charles Verdon:

The U.S. nuclear weapons stockpile is currently safe, secure, and militarily effective. However, the legacy stockpile systems are aging, and NNSA's production infrastructure has atrophied considerably. America must invest in the weapons and infrastructure modernization programs to provide the capabilities needed to ensure the deterrent's viability into the future. Future American political leaders will not have the weapons and infrastructure in place to support the nuclear arsenal unless we reestablish that capability now.

The need to modernize the nuclear weapons stockpile and recapitalize the supporting infrastructure needed to produce and maintain that stockpile has reached a tipping point. Approximately 60 percent of NNSA's facilities are more than 40 years old and more than 50 percent are in poor condition. Assessments of facilities throughout the enterprise have identified numerous single-point failures. Production capabilities allowed to lapse are needed once again and reestablishing these capabilities is both a priority and a challenge. If not appropriately addressed, the age and condition of NNSA's infrastructure will put at risk NNSA's missions, and the safety of its workforce, the public, and the environment.²¹

As a result of this neglect, at the same time the nation faces a great challenge in modernizing its aging nuclear warheads, "NNSA is undertaking a risk-informed, complex, and time-constrained modernization and recapitalization effort."²²

In recent years, bipartisan congressional support for the nuclear mission has been strong, and nuclear modernization has received additional funding.²³ Preservation of that bipartisan consensus will be critical as these programs mature and begin to introduce modern nuclear systems to the force.

In its budget requests, the Trump Administration advanced the comprehensive modernization program for nuclear forces that was initiated by President Barack Obama. Despite some opposition, Congress funded the two previous Presidents' budget requests for these programs. Because such modernization activities require consistent, stable, long-term funding commitments, this continued bipartisan support has been critical.

The NNSA received \$19.7 billion in fiscal year (FY) 2021, \$3 billion more than it received in FY 2020, which included full funding for major efforts like modernization of plutonium pit production and five warhead modernization programs.²⁴ The FY 2022 budget

would continue these efforts but with a flat NNSA topline of \$19.7 billion.²⁵ Modernization programs to replace the triad-including the Ground Based Strategic Deterrent (GBSD); Long Range Stand Off Weapon (LRSO); Columbia-class nuclear submarine; and B-21 Raider bomber-also continue to progress in 2021 with the FY 2022 budget supporting these programs. The 2018 NPR proposed two supplements to nuclear capabilities in light of the worsened security environment with Russia and China: a low-yield warhead for SLBMs in the near term, which was deployed in 2020, and a low-yield, nuclear-armed, sea-launched cruise missile, for which funding was first included in the FY 2022 budget request after the completion of a preliminary analysis of alternatives.26

Assessing U.S. Nuclear Weapons Capabilities

Assessing the state of U.S. nuclear weapons capabilities presents at least three serious difficulties.

- The United States has not taken full advantage of technologically available developments to field modern warheads (often incorrectly termed "new" warheads) that could be designed to be safer, more secure, and more effective and could give the United States better options for strengthening a credible deterrent. Instead, the United States has largely elected to extend the life of aging nuclear warheads based on designs from the 1960s, 1970s, and 1980s that were in the stockpile when the Cold War ended.
- The lack of detailed publicly available data about the readiness of nuclear forces, their capabilities, and the reliability of their weapons makes analysis difficult.
- The U.S. nuclear enterprise has many components, some of which are also involved in supporting other military (e.g., conventional) and extended deterrence

missions. For example, U.S. strategic bombers perform a significant conventional mission and do not fly airborne alert with nuclear weapons today, as they did routinely during the 1960s, nor stand at quick-reaction strip alert as they did up until the early 1990's.

Additionally, the three key national security laboratories no longer focus solely on the nuclear weapons mission; they also focus extensively on nuclear nonproliferation and counterproliferation, intelligence, biological/ medical research, threat reduction, and countering nuclear terrorism, which includes a variety of nuclear-related detection activities. Moreover, the Nuclear Command, Control, and Communications System entails many assets such as early warning and communications satellites that serve non-nuclear missions, such as routine military communications and detecting and tracking conventional missiles.

Thus, it is hard to assess whether any one piece of the nuclear enterprise is sufficiently funded, focused, and/or effective with regard to the nuclear mission. The U.S. nuclear weapons enterprise is composed of several key elements that include warheads; delivery systems; and the physical infrastructure that designs, manufactures, and maintains U.S. nuclear weapons. The nuclear enterprise also includes and must sustain the talent of people: the nuclear designers, engineers, manufacturing personnel, planners, maintainers, and operators who help to ensure a nuclear deterrent that is second to none. The nuclear weapons enterprise entails additional elements like nuclear command and control; intelligence, surveillance, and reconnaissance; and aerial refueling, all of which also play a major role in conventional operations.

The factors selected below are the most important elements of the nuclear weapons complex. They are judged on a five-grade scale that ranges from "very strong," defined as meeting U.S. national security requirements or having a sustainable, viable, and funded plan in place to do so, to "very weak," defined as not meeting current security requirements and with no program in place to redress the shortfall. The other three possible scores are "strong," "marginal," and "weak."

Reliability of Current U.S. Nuclear Stockpile Score: Strong

U.S. warheads must be safe, secure, effective, and reliable. The Department of Defense defines reliability as "the probability that a weapon will perform in accordance with its design intent or military requirements."²⁷ Since the cessation of nuclear testing in 1992, reliability has been assessed and maintained through the NNSA's Stockpile Stewardship Program, which consists of an intensive warhead surveillance program; non-nuclear experiments (i.e., experiments that do not produce a nuclear yield); sophisticated calculations using highperformance computing; and related annual assessments and evaluations.

The reliability of nuclear warheads and delivery systems becomes even more important as the number and diversity of nuclear weapons in the stockpile decrease. Fewer types of nuclear weapons results in a smaller margin of error if all of one type are affected by a technical problem that might cause a weapon type or its delivery system to be decommissioned. Loss of diversity in the stockpile also increases the risk of "common-mode" failure that could affect multiple systems simultaneously, making the push for commonality with potential single points of failure in U.S. warheads worrisome. America and its allies must have high confidence that U.S. nuclear warheads will perform as expected.

As warheads age, uncertainty about their ability to perform their mission as expected could increase and significantly complicate military planning. Despite creating impressive amounts of knowledge about nuclear weapons physics and materials chemistry, the United States could find itself surprised by unanticipated long-term effects on aging components that comprise a nuclear weapon. "The scientific foundation of assessments of the nuclear performance of US weapons is eroding as a result of the moratorium on nuclear testing," argue John Hopkins, nuclear physicist and a former leader of the Los Alamos National Laboratory's nuclear weapons program, and David Sharp, former Laboratory Fellow and a guest scientist at Los Alamos National Laboratory.28

The United States currently has the world's safest and most secure stockpile, but concerns about overseas storage sites, potential problems introduced by improper handling, or unanticipated effects of aging could compromise the integrity or reliability of U.S. warheads. The nuclear warheads themselves contain security measures that are designed to make it difficult, if not impossible, to detonate a weapon without proper authorization. Some U.S. warheads have modern safety features that provide additional protection against accidental detonation; others do not.

Grade: Absent nuclear weapons testing, the national laboratories' assessment of weapons reliability, based on the full range of surveillance, scientific, and technical activities carried out in NNSA's Stockpile Stewardship Program, depends on the expert judgment of the



laboratories' directors and the weapons scientists and engineers on their staffs. This judgment, albeit based on experience, non-nuclear experimentation, and extensive modeling and simulation, does not benefit from the objective data that could be obtained through direct nuclear testing. Nuclear testing was used in the past to diagnose potential problems with warheads and to certify the effectiveness of fixes to those problems. It also was used to certify current nuclear warheads, as well as to detect potential problems and confirm the effectiveness of fixes to those problems.

The sustained political decision to maintain the nuclear stockpile without nuclear testing a decision made across multiple presidential Administrations—creates some inherent uncertainty concerning the adequacy of fixes to the stockpile when problems are found. These growing numbers of additional uncertainties include updates to correct problems that were found in the weapons or changes
in the weapons resulting from life-extension programs. It is simply impossible to duplicate exactly weapons that were designed and built many decades ago. According to former Sandia National Laboratories Director Dr. Stephen Younger, we have had to fix "a number of problems that were never anticipated" by using "similar but not quite identical parts."²⁹ However, while the United States does not test as part of its stockpile stewardship efforts, it has been U.S. policy to lift its test moratorium and conduct the required testing if the President deems it necessary to do so based on information from the lab directors, the Secretary of Defense, and the Secretary of Energy.

In light of concerns that are inherent in a lack of nuclear testing, the United States maintains the most advanced Stockpile Stewardship Program in the world and continues to make scientific and technical advances to help certify the stockpile. For example, NNSA is working on upgrades to the Enhanced Capabilities for Subcritical Experiments facility in Nevada (such as adding the capability to produce highspeed, high-fidelity X-ray images of subcritical experiments) to improve our understanding of plutonium.³⁰ In addition:

The Exascale Computing Initiative (ECI) will provide NNSA with next-generation simulation capabilities to support weapons design, warhead assessment and certification, and continued development of the underpinning science needed to support the nuclear stockpile long-term. NNSA remains on track to accept and operate NNSA's first Exascale high performance computing system for program use in 2023.³¹

Such advanced capabilities can help the NNSA to certify the stockpile more accurately and without testing. As Deborah Rosenblum, President Biden's nominee to serve as Assistant Secretary of Defense for Nuclear, Chemical, and Biological Defense Programs, explained in her confirmation hearing, "The modernization of the NNSA infrastructure is critical to keeping our stockpile safe, secure, and reliable without testing."³² She also highlighted the importance of producing new plutonium pits to help avoid the need to test if confidence in aging warheads decreases.

To assess the reliability of the nuclear stockpile annually, each of the three nuclear weapons labs (Los Alamos National Laboratory, Lawrence Livermore National Laboratory, and Sandia National Laboratory) reports its findings with respect to the safety, security, and reliability of the nation's nuclear warheads to the Secretaries of Energy and Defense, who then brief the President. Detailed classified reports are provided to Congress as well. The Commander of U.S. Strategic Command also assesses overall nuclear weapons system reliability, including the reliability of both warhead and delivery platforms.

In spite of concerns over aging warheads, "[i]n FY 2021, the science-based Stockpile Stewardship Program allowed the Secretaries of Energy and Defense to certify to the President for the 25th consecutive year the nuclear weapons stockpile remains safe, secure, and militarily effective."³³ Admiral Richard stated in 2021 "that there are no identified conditions at this point that would require nuclear weapons testing to restore that confidence."³⁴

In light of our overall assessment, and based on the results of the existing method used to certify the stockpile's effectiveness, we grade the U.S. stockpile conditionally as "strong." This grade, however, will depend on whether support for an adequate stockpile, both in Congress and in the Administration, remains strong.

Reliability of Current U.S. Delivery Platforms Score: Strong, Trending Toward Marginal or Weak

Reliability encompasses not only the warhead, but strategic delivery vehicles as well. For ICBMs, SLBMs, and air-launched cruise missiles (ALCMs), in addition to a successful missile launch, this includes the separation of missile boost stages, performance of the missile guidance system, separation of the

U.S. Nuclear Delivery Systems Outdated

Current U.S. nuclear delivery systems are between 28 and 59 years old, and some are expected to be retired within a decade.



NOTES: The original retirement date for the B-2 was set at 2058, but in the FY 2019 budget, the Air Force moved up the retirement date by 22 years to 2036. That move could have been caused by projected threats, the cost of sustainment, or both. The original programmed retirement date for the B-52H is not known, but the Air Force recently stated that it plans to continue flying this jet into the 2050s. The average B-52H bomber has logged approximately 20,300 hours, and based on airframe component lifetime estimates and 350 hours of flying time each year, it could continue flying until 2067. **SOURCE:** Heritage Foundation research.

heritage.org

reentry vehicles from the missile post-boost vehicle, accuracy of the final reentry vehicle in reaching its target, and the ability of weapons systems (cruise missiles, aircraft carrying bombs, and reentry vehicles) to penetrate to their targets.³⁵

The United States conducts flight tests of ICBMs and SLBMs every year to ensure the reliability of its delivery systems with highfidelity "mock" warheads. Anything from faulty electrical wiring to booster separations could degrade the reliability and safety of the U.S. strategic deterrent. U.S. strategic longrange bombers also regularly conduct continental United States and intercontinental exercises and receive upgrades to sustain a demonstrated high level of combat readiness. The Air Force tested the AGM-86B ALCM, launched from the B-52H bomber, most recently in 2017.³⁶ The DOD must perform upgrades to existing platforms and develop their replacement programs simultaneously, and already diminished capabilities make this task more difficult.

Grade: In July 2018, the Air Force suffered its first unsuccessful ICBM test since 2011,³⁷ but it has conducted six successful tests since then. These successes include a test in February 2020—the first one to be hosted by Vandenberg Air Force Base since it became part of the U.S. Space Force³⁸—and a test in August 2020 that launched a missile armed with three reentry vehicles.³⁹ However, the May 2020 test experienced a ground abort prior to the launch, which has provoked speculation about the reliability of the Minuteman III missile as it approaches its retirement starting at the end of the decade.⁴⁰ The SLBM tests were successful in 2019 and 2020 and have been thus far in 2021.⁴¹

To the extent that data from these tests are publicly available, they provide objective evidence of the delivery systems' reliability and send a message to U.S. allies and adversaries alike that U.S. systems work and the U.S. nuclear deterrent is ready if needed. The aged systems, however, occasionally have reliability problems, as evidenced by the failed July 2018 and May 2020 Minuteman III launches. Although delivery systems are likely reliable enough today, the evidence indicates that this reliability could dwindle with aging. For instance, because of its obsolescence against Russian air defense systems, the B-52H bomber already no longer carries gravity bombs.42 Despite the fact that the AGM-86B passed its most recent public test in 2017, General John Hyten has stated that because of its age, "it's a miracle that [the missile] can even fly" and that the current ALCMs "do meet the mission, but it is a challenge each and every day."43 Admiral Richard has also stated that "Minuteman-III is increasingly challenged in its ability" to "fly and make it to the target."44

Aging will continue to affect delivery platform reliability until platforms are replaced, but no publicly released data or statements from senior leaders have thus far indicated that U.S. delivery systems cannot currently meet mission requirements. Until that changes, this factor receives the grade of "strong." However, this grade will trend to "marginal" if not "weak" in just a few years if modernization programs are not fully pursued and these aging systems are not replaced on time.

Nuclear Warhead Modernization Score: Marginal

During the Cold War, the United States focused on designing and developing modern nuclear warheads to counter Soviet advances and modernization efforts and to leverage advances in our understanding of the physics, chemistry, and design of nuclear weapons. Today, the United States focuses on extending the life of its aging stockpile rather than on fielding modern warheads while trying to retain the skills and capabilities needed to design, develop, and produce such warheads. Relying only on sustaining the aging stockpile could increase the risk of failure caused both by aging components and by not exercising critical skills. It could signal to adversaries that the United States is less committed to nuclear deterrence.

Meanwhile, potential U.S. adversaries and current and future proliferants are not limited to updating Cold War designs and can seek designs outside of U.S. experiences. Other nations can maintain their levels of proficiency by having their scientists work on new nuclear warheads.⁴⁵ As recently reported by the Department of State, "Russia has conducted nuclear weapons experiments that have created nuclear yield and are not consistent with the U.S. 'zero-yield' standard," and evidence points to China's potential lack of adherence to this standard as well.⁴⁶

Fortunately, the NNSA has made noticeable improvements in this category in recent years. In FY 2016, Congress established the Stockpile Responsiveness Program to "exercise all capabilities required to conceptualize, study, design, develop, engineer, certify, produce, and deploy nuclear weapons."⁴⁷ Congress doubled funding for the SRP from \$34 million in FY 2019 to \$70 million in FY 2020 and appropriated \$70 million again in FY 2021.⁴⁸ The budget request for FY2022 also includes \$70 million for the SRP.⁴⁹

Although it has been operating for only a few years, the SRP has demonstrated some important accomplishments in ensuring critical skills retention. The design and development work planned for the Navy's W93/Mark 7 warhead for the Trident II D5 SLBMs and the W87-1 warhead for GBSD will build on the success of the SRP in exercising these skills on modern warhead programs.

Fielding modern weapons like the W93 would allow American engineers and scientists to improve previous designs and devise more effective means to address evolving military requirements (e.g., adaptability to emerging threats and the ability to hold at risk hard and deeply buried targets). Future warheads could improve reliability (i.e., remedy some ongoing aging concerns) while also enhancing the safety and security of American weapons. The ability to work on modern warhead design options would help to ensure that today's experts and those of the next generation remain engaged and knowledgeable, help to attract the best talent to the nuclear enterprise, and help the nation to gain additional insights into adversaries' nuclear weapon programs.

The nuclear enterprise displayed improved flexibility when it produced the W76-2 warhead, a low-yield version of the W76 warhead designed to counter Russia's perception of an exploitable gap in the U.S. nuclear force posture, within a year. Such efforts warranted an improvement in this score from "weak" to "marginal" in 2019. Additionally, in FY 2021, Congress appropriated initial funding for the W93/Mark 7 warhead program, which will eventually replace the W76-1 and W88 warheads carried by the Trident II D5 SLBMs.⁵⁰ The FY 2022 budget continues funding for the W93 program with \$72 million requested for NNSA in line with the FY 2022 projection in the FY 2021 budget.⁵¹

The effort to restore the ability to produce plutonium pits for future warheads has likewise progressed after Congress provided the NNSA with its full funding request for FY 2021. The NNSA reached the first critical milestone for pit production at Los Alamos National Laboratory in April 2021 and at the Savannah River Site in June 2021.⁵² While production at Los Alamos remains on schedule, the plan to produce 50 plutonium pits per year at the Savannah River Site by 2030 has shifted, and the goal is now somewhere between 2032 and 2035.⁵³

Grade: Before the score for this category can move up to "strong," the NNSA, with the support of Congress, will need to achieve enough progress in the W93/Mk 7, W87-1, and plutonium pit production projects to demonstrate that those projects will be completed on schedule and that the delay in pit production at the Savannah River Site will not significantly affect the ability to meet warhead requirements. An improved score will also depend on other advancements in nuclear warhead modernization.

Specifically, in addition to the W93/Mark 7 program to replace existing SLBM warheads, the NNSA will need to begin a program for a future strategic land-based warhead to succeed the W87-1, a program that remains notional.⁵⁴ Future assessments will also need to examine whether the NNSA's current warhead modernization effort is sufficient to address the increasing threat. For instance, an earthpenetrating warhead is not part of the NNSA's warhead modernization plan, despite Russian progress in hardening and deeply burying facilities to withstand strikes by current U.S. weapons.⁵⁵

For now, the score for this category remains at "marginal," but it could trend toward "strong" in future years.

Nuclear Delivery Systems Modernization Score: Strong

All U.S. delivery systems were built during the Cold War and are overdue for replacement. The Obama Administration, in consultation with Congress, initiated a plan to replace current triad delivery systems within the constraints of the New Strategic Arms Reduction Treaty (New START) with Russia. President Trump advanced this modernization program in his budget requests with bipartisan support from Congress. Under this modernization program:

- The Navy is fully funding the *Columbia*class submarine to replace the *Ohio*class submarine;
- The Air Force is funding the B-21 Raider Long-Range bomber, which will replace conventionally armed bombers before

they become certified to replace nuclear-capable bombers, and the Long-Range Standoff weapon, which will replace the aging air-launched cruise missile;

- Existing Minuteman III ICBMs are expected to remain in service beyond the end of the decade, 50 years after their intended lifetime, and in 2029 will start to be replaced by the GBSD; and
- Existing Trident II D5 SLBMs have been life-extended to remain in service until 2042 through the end of the last *Ohio*class submarine's lifetime.⁵⁶

All of these programs have remained on track for the past few years, but they face high risks of delay. For instance, the U.S. Government Accountability Office (GAO) found risks in the GBSD schedule related to technology maturation, the complexity of concurrently operating Minuteman III missiles and GBSD missiles during the transition, limited schedule margin for testing, and an aggressive plan for construction activities.57 Additionally, issues involving cost estimates and potential industrial base impacts caused by the COVID-19 pandemic could make it harder to achieve the goal of deploying the first Columbia-class submarine in 2031.58 After a contract for development of the LRSO was awarded early, Congress reduced funding in FY 2021 by \$89 million.⁵⁹ Fortunately, the budget for FY 2022 would boost funding for the LRSO beyond what was previously projected for that year.

These risks in schedule are especially dangerous because modernization programs have zero margin for delay after the United States has deferred recapitalization for years. In September 2020, then-Under Secretary of Defense for Acquisition and Sustainment Ellen Lord testified that even a minor cut in funding for the GBSD would affect its schedule.⁶⁰ Since these modernization programs are just-intime, they would be significantly affected by any continuing resolution.

The impacts of schedule delays are significant. As systems like the Minuteman III, AGM 86-B, and Ohio-class submarines continue to age, they take on greater risks. Age degrades reliability by increasing the potential for systems to break down or fail to respond correctly. Corrupted systems, defective electronics, or performance degradation caused by long-term storage defects can have serious implications for U.S. deterrence and assurance. Should GBSD fail to reach initial operating capability by 2029, the United States will be left with a less-capable-and therefore less credible-ICBM fleet, which will also begin to dip below 400 missiles as the Air Force continues to use missiles for annual testing. With respect to the Navy, the GAO has reported that the consequence of failing to deliver the first Columbia-class submarine on time would be a failure for the Navy to meet STRATCOM's force-generation operational requirement, which means a weaker sea-based deterrent.⁶¹

Grade: U.S. nuclear platforms are in dire need of recapitalization. Plans for modernization of the nuclear triad are in place, and Congress and the services have largely sustained funding for these programs. Moreover, some aspects of these programs have progressed in 2021. For instance, the Air Force awarded a contract for GBSD to Northrop Grumman in 2020.⁶² Congress did not cut any major funding for nuclear recapitalization systems in FY 2021, and the budget for FY 2022 would provide the funding necessary to continue these programs on schedule.

Despite these successes, potential modernization delays and congressional funding cuts still hold nuclear delivery system modernization at risk, especially as some Members of Congress push for major funding cuts and unilateral reductions in U.S. nuclear forces.⁶³ Moreover, this plan simply replaces the force structure designed by the Obama Administration in 2010 before China commenced its strategic breakout and the strategic environment was assumed to be much more benign than it is today. Future U.S. nuclear posture will need to adjust to the drastic change in the threat environment since 2010 and account for two nuclear peers. The FY 2022 budget includes funding for the initial stages of a program to develop a nuclear-armed sea-launched cruise missile that, if fielded, would introduce additional regional nuclear capabilities beyond current non-strategic gravity bombs to address the rising threat.

Based on the commitment to nuclear weapons modernization demonstrated by Congress and the Administration this year, this category (for now) again earns a grade of "strong."

Nuclear Weapons Complex Score: Marginal

Maintaining a reliable and effective nuclear stockpile depends in large part on the facilities where U.S. devices and components are developed, tested, and produced. These facilities constitute the foundation of our strategic arsenal and include the:

- Los Alamos National Laboratories (nuclear weapons research and development, or R&D, and plutonium pit production);
- Lawrence Livermore National Laboratories (nuclear weapons R&D);
- Sandia National Laboratory (nuclear weapons R&D and systems engineering);
- Nevada National Security Site (subcritical experiments, test readiness);
- Pantex Plant (assembly of nuclear warheads);
- Kansas City Plant (production of non-nuclear components for nuclear warheads);
- Savannah River Site (second site for pit production, tritium production); and
- Y-12 National Security Complex (manufacture of highly enriched uranium parts for nuclear warheads).

These complexes design, develop, test, and produce the weapons in the U.S. nuclear arsenal, and their maintenance is of critical importance. As the 2018 NPR stated:

An effective, responsive, and resilient nuclear weapons infrastructure is essential to the U.S. capacity to adapt flexibly to shifting requirements. Such an infrastructure offers tangible evidence to both allies and potential adversaries of U.S. nuclear weapons capabilities and thus contributes to deterrence, assurance, and hedging against adverse developments. It also discourages adversary interest in arms competition.⁶⁴

Maintaining a safe, secure, effective, and reliable nuclear stockpile requires modern facilities, technical expertise, and tools both to repair any malfunctions quickly, safely, and securely and to produce new nuclear weapons if required. According to the 2010 NPR, "As the United States reduces the numbers of nuclear weapons, the reliability of the remaining weapons in the stockpile—and the quality of the facilities needed to sustain it—become more important."⁶⁵

The existing nuclear weapons complex, however, is not fully functional. The United States cannot produce some of the nuclear components needed to maintain and modernize the stockpile.⁶⁶ For instance, the United States has not had a substantial plutonium pit production capability since 1993. A plutonium pit is the core of a nuclear weapon that contains the nuclear material. The NNSA currently plans "to produce no fewer than 80 pits per year during 2030, consistent with federal law, national policy, and DoD requirements," which is a challenging timeline by the agency's own admission.⁶⁷

If the NNSA's facilities are not properly funded, the U.S. will gradually lose the ability to conduct the high-quality experiments needed to ensure the reliability of the stockpile without nuclear testing. In addition to demoralizing the workforce and hampering recruitment, old or obsolete facilities and poor working environments make maintenance of a safe, secure, reliable, and militarily effective nuclear stockpile difficult. The NNSA's facilities are old: About 40 percent date back to World War II, about 60 percent are over 40 years old, and more than half are in poor condition.⁶⁸ As a consequence, the NNSA had accumulated about \$5.8 billion in deferred maintenance as of FY 2020.⁶⁹ Aging facilities have also become a safety hazard: In some buildings, for example, chunks of concrete have fallen from the ceiling.⁷⁰

The U.S. currently retains more than 5,000 old plutonium pits in strategic reserve in addition to pits for use in future LEPs. Uncertainties regarding the effect of aging on plutonium pits and how long the United States will be able to depend on them before replacement remain unresolved. In 2006, a JASON Group study of NNSA assessments of plutonium aging estimated that, depending on pit type, the minimum pit life was in the range of 100 years.⁷¹ A work program was recommended to address additional uncertainties in pit aging, but that did not reach fruition. Moreover, numerous pits have been in the stockpile for decadessome for more than 50 years-and will need to be replaced. Depending on the rate at which NNSA can produce new pits, replacement will need to start sooner rather than later.

Today, the production rate is insufficient to replace aging pits. The United States has only demonstrated an ability to produce about 10 plutonium pits a year at the Los Alamos PF-4 facility. If executed as planned, infrastructure modernization of PF-4, as mandated by the 2018 NPR, will boost that number to 30 by 2026.

A second plutonium pit production facility is being planned to exploit the Mixed Oxide Fuel (MOX) facility that was being constructed at the Savannah River Site in South Carolina. The MOX building is being repurposed for plutonium pit production with a required production of no fewer than 50 pits per year by 2030 for an overall requirement of no fewer than 80 per year. Unfortunately, the NNSA reported this year that it will not be able to meet the required timeline for the Savannah River Site. Achieving this timeline is difficult because the NNSA is concurrently embarking on the most ambitious warhead sustainment program since the end of the Cold War, overhauling some five warhead types and stressing the capacity of both workforce and facilities. Meanwhile, certain warhead types will require modern pits.

Aside from plutonium, the NNSA must also maintain production of several other key materials and components that are used to build and maintain nuclear weapons. For instance, NNSA plans to increase the supply of tritium as demand increases. Other projects currently underway include a new lithium processing facility and the new Uranium Processing Facility at Y-12. So far, this facility is moving forward on schedule and cost.

Grade: Modernizing U.S. nuclear facilities is critical because the NNSA's warhead modernization plans depend on the ability to produce certain components like plutonium pits. The W87-1, for example, will be composed of all newly manufactured components.⁷²

On one hand, the United States maintains some of the world's most advanced nuclear facilities. On the other, some parts of the complex have not been modernized since the 1950s. Plans for long-term infrastructure recapitalization remain essential even as the NNSA is embarking on an aggressive warhead lifeextension effort. Sustaining or increasing critically essential but always decaying tritium gas is likewise essential; delays only increase production needs for its timely replenishment.⁷³

Significant progress has been made over the past decade in getting funded plans in place to recapitalize plutonium pit production capacity and uranium component manufacturing in particular. This effort, however, faces great technical challenges in addition to the challenge of ensuring stable funding to support it. The recent shift in deadline for plutonium pit production at the Savannah River Site from 2030 to the 2032–2035 range is one example. After years of deferred modernization, any unexpected failure or disruption at a critical facility could significantly affect schedules for nuclear warhead modernization.⁷⁴

According to former Acting NNSA Administrator Charles Verdon, "Continued recapitalization is imperative, otherwise there will be a point at which no amount of money will be able to mitigate the operational risks and losses to infrastructure capabilities that accrued over time."⁷⁵ Until demonstrable progress has been made toward completion of infrastructure modernization, the grade for this category will therefore remain at "marginal."

Nuclear Test Readiness Score: Weak

In the past, nuclear testing was one of the key elements of a safe, secure, effective, and reliable nuclear deterrent. The U.S. is currently under a self-imposed nuclear testing moratorium, but it is still required to maintain a low level of nuclear test readiness at the Nevada National Security Site (formerly Nevada Test Site).

"Test readiness" refers to a single test or a very short series of tests, not a sustained nuclear testing program, reestablishment of which would require significant additional resources. Specifically, under the 1993 PDD-15 (which is still U.S. policy), "a capability to conduct a nuclear test within 6 months up to FY 1996, and to conduct a nuclear test within 2-3 years after that time will be assumed by the Department of Energy [now NNSA]."76 Because of a shortage of resources, the NNSA has been unable to achieve this goal. Test readiness has not been funded as a separate program since FY 2010 and is instead supported by the Stockpile Stewardship Program that exercises testing elements at the Nevada National Security Site and conducts subcritical nuclear laboratory experiments.77

However, whether this approach can assure that the United States has the timely ability to conduct yield-producing experiments to correct a flaw in one or more types of its nuclear weapons is open to question. The United States might need to test to assure certain weapon characteristics that only nuclear testing can validate or potentially to verify render-safe procedures. The ability to conduct timely yield-producing experiments is likewise important, especially if the United States needs for political reasons to respond to another nation's nuclear weapons tests or communicate its unquestioned resolve.

The NNSA is mandated to maintain a capability to conduct a nuclear test within 24 to 36 months of a presidential decision to do so. However, the FY 2020 Stockpile Stewardship and Management Plan (SSMP) states that "[a]ssuring full compliance with domestic regulations, agreements, and laws relating to worker and public safety and the environment, and international treaties, would significantly extend the time required for execution of a nuclear test."78 According to the FY 2018 SSMP, it would take 60 months to conduct "a test to develop a new capability."79 Because the United States is rapidly losing its remaining practical nuclear testing experience, including instrumentation of very sensitive equipment, the process would likely have to be reinvented from scratch.80

Grade: As noted, the United States can meet the legally required readiness requirement only if certain domestic regulations, agreements, and laws are waived. In addition, the United States is not prepared to sustain testing activities beyond a few limited experiments because it no longer retains the deep drilling technology in Nevada and has only a few "holes" that are able to contain a nuclear test. In recognition of these concerns, Admiral Richard testified in 2021 "that I am concerned about the Nation's test-readiness and that I endorsed the [NNSA] lab director's calls... for a national review of our test-readiness to understand where we sit."⁸¹

The Senate-passed version of the FY 2021 National Defense Authorization Act (NDAA) included an additional \$10 million within existing budgets to practice test readiness capabilities, which would have made only a minor improvement in test readiness.⁸² A July 2020 amendment to the House bill would have prohibited the use of funds to conduct nuclear tests.⁸³ The conference report on the NDAA did not include either provision.⁸⁴

Opposition to a mere \$10 million for test readiness and willingness to prohibit testing altogether are matters of great concern. The effort to improve the NNSA's technical and scientific capabilities to certify the stockpile without testing for the foreseeable future is worthwhile, but the United States must maintain at least the mandated level of test readiness so that it can deal with an emergency that requires testing if one should arise.

Thus, testing readiness earns a grade of "weak."

Personnel Challenges Within the National Nuclear Laboratories Score: Marginal but Trending Toward Strong

Combined with nuclear facilities, U.S. nuclear weapons scientists and engineers are critical to the health of the complex and the stockpile. The 2018 NPR emphasizes that:

The nuclear weapons infrastructure depends on a highly skilled, world-class workforce from a broad array of disciplines, including engineering, physical sciences, mathematics, and computer science. Maintaining the necessary critical skills and retaining personnel with the needed expertise requires sufficient opportunities to exercise those skills. Should a technical or geopolitical development demand a new nuclear weapon, it is crucial that the nuclear weapons workforce possess the skills and the knowledge needed to design, develop, and manufacture warheads of different design in a timely manner.85

The ability to maintain and attract a high-quality workforce is critical to ensuring the future of the American nuclear deterrent, especially when a strong employment atmosphere adds to the challenge of hiring the best and brightest. Today's weapons designers and engineers are first-rate, but they also are aging and retiring, and their knowledge must be passed on to the next generation of experts. This means that young designers need meaningful and challenging warhead design and development programs to hone their skills. The SRP offers one visible means to address such concerns. The NNSA and its weapons labs understand this problem and, with the support of Congress, are beginning to take the necessary steps through SRP and foreign weapon assessment to mentor the next generation. To continue this progress, SRP funding should be maintained if not increased.

The United States currently relies on non-yield-producing subcritical experiments and other laboratory experiments, flight tests, and the judgment of experienced nuclear scientists and engineers, using robust modeling and simulation, to ensure continued confidence in the safety, security, effectiveness, and reliability of its nuclear deterrent. Without their experience, the nuclear weapons complex could not function. Few of today's remaining scientists or engineers at the NNSA weapons labs have had the experience of taking a warhead from initial concept to "clean sheet" design, engineering development, production, and fielding. The SRP is remedying some of these shortfalls by having its workforce exercise many of the nuclear weapon design and engineering skills that are needed.

The average age of the NNSA's enterprisewide workforce had decreased slightly to 46.9 years as of September 2018, the most recent year for which data are available.⁸⁶ Still worrisome, however, is that NNSA sites are reporting rates of retirement eligibility "from 15 percent to 44 percent, which will likely increase over the next 5 years."⁸⁷ Given the distribution of workforce by age, these retirements, if not addressed in plans for the hiring and mentoring of new hires, will create a significant knowledge and experience gap.

Grade: In addition to employing worldclass experts, the NNSA labs have had good success in attracting and retaining talent (e.g., through improved college graduate recruitment efforts). As many scientists and engineers with practical nuclear weapon design and testing experience are retired, continued annual assessments and certifications of nuclear warheads will rely increasingly on the judgments of people who have never tested or designed a nuclear weapon. Moreover, demand for skilled personnel will increase as NNSA ramps up production capabilities and moves some operations to around-the-clock, sevendays-a-week scheduling.⁸⁸ Admiral Richard has emphasized the importance of investing in the workforce now: If "[w]e lose those talent bases, you can't buy it back, it will take five to ten years to...retrain and redevelop the people."⁸⁹

In light of these issues, the NNSA workforce earns a score of "marginal," but will trend toward "strong" with these continued improvements.

Readiness of Forces Score: Strong

The readiness of forces that operate U.S. delivery platforms is a vital component of America's strategic forces. The military personnel operating the three legs of the nuclear triad must be properly trained and equipped. It is also essential that the crews responsible for the nuclear mission are maintained in an appropriate state of readiness.

During FY 2021, the services have continued to align resources to preserve strategic capabilities in the short term. Nevertheless, long-term stable funding will be essential for the timely execution of programs and associated readiness activities.

U.S. general-purpose forces are critical to ensuring the overall effectiveness of our nuclear forces (e.g., by providing a pool of qualified candidates to operate nuclear weapon delivery systems). Changes prompted in part by the 2014 Navy and Air Force cheating scandals have addressed most morale issues and have recast the role of forces supporting the nuclear deterrent by, for example, providing additional funding for equipment purchases, creating more mid-career billets to help career-field continuity, focusing leadership attention, and changing training to focus on mission in the field rather than on a theoretical ideal.⁹⁰ Sustained attention to this issue remains critical to ensuring the strong recruitment and training of personnel.

Grade: Despite uncertainties regarding the future impacts of budgetary shortfalls, the young men and women who secure, maintain, plan for, and operate U.S. nuclear forces are of an extremely high caliber. General Timothy Ray, Commander of Air Force Global Strike Command, has testified that "our combat mission readiness rates among our bomber aircrews is at its highest in the history of the command."⁹¹ Nuclear force commanders have provided assurance that the COVID-19 pandemic has had no impact on force readiness and the ability to launch nuclear weapons.⁹²

Force readiness thus receives a grade of "strong."

Allied Assurance Score: Strong

The credibility of U.S. nuclear deterrence is one of the most important components of allied assurances. The United States extends nuclear assurances to more than 30 allies who in turn have maintained the commitment to forgo nuclear programs of their own. If allies were to resort to building their own nuclear weapons because their confidence in U.S. extended deterrence had been degraded, the consequences for nonproliferation and stability could become dire.

In Europe, the United States can coordinate with France and the United Kingdom, which already have nuclear weapons. The U.S. also deploys B-61 nuclear gravity bombs in Europe as a visible manifestation of its commitment to its NATO allies and retains dual-capable aircraft that can deliver those gravity bombs. The United States provides nuclear assurances to Japan, South Korea, and Australia, all of which face increasingly aggressive nuclear-armed regional adversaries: China, Russia, and North Korea. Continued U.S. nuclear deterrence assurances are critical and must be perceived as credible. Both Japan and South Korea have the capability and basic know-how to build their own nuclear weapons quickly. A decision to do so would be a major setback for U.S. nonproliferation policies.

The 2018 NPR took a positive step when it placed "Assurance of allies and partners" second on its list of four "critical roles" that nuclear forces play in America's national security strategy. The 2018 NPR proposed two supplements to existing capabilities—a lowyield SLBM warhead and a new nuclear sealaunched cruise missile—as important initiatives to strengthen assurance along with the Obama and Trump Administrations' initiatives to bolster conventional forces in NATO.⁹³ The recent successful deployment of the W76-2 low-yield warhead is an important component of America's ability to deter regional aggression against its Asian and NATO allies.

Grade: At this time, U.S. allies are not seriously considering developing their own nuclear weapons. European members of NATO continue to express their commitment to and appreciation of NATO as a nuclear alliance even as they worry about the impact of Russia's growing non-strategic nuclear capabilities not limited by New START. The NATO Secretary General's annual report and the recent NATO summit in the United Kingdom reiterated NATO's commitment to remaining a nuclear alliance as long as nuclear weapons exist.94 While significant percentages of South Koreans continue to express support for an indigenous nuclear weapons capability or nuclearsharing agreement with the United States,95 neither South Korea nor Japan has expressed serious concern about the U.S. commitment to extended deterrence.

Allied assurance will likely remain strong as long as the United States remains committed to modernizing its own nuclear deterrent and rejects calls to reduce its nuclear forces unilaterally. The Biden Administration has emphasized a renewed focus on allies and partners in American foreign policy; achieving this goal will require the prioritizing of extended deterrence. Continued commitment from the Administration and Congress to development of the nuclear sea-launched cruise missile, which can be deployed as a regional nuclear capability in both the European and Indo-Pacific theaters, is one important way to meet this goal.⁹⁶ Rejecting calls for a "no first use" or "sole purpose" declaratory policy will also be critical, as such policies are not popular with most of our allies because, among other things, they could call into question America's commitment to extending its nuclear deterrent for non-nuclear, but still existential, attacks on its allies.⁹⁷

The score for allied assurance therefore remains "strong."

Overall U.S. Nuclear Weapons Capability Score: Strong but Trending Toward Marginal or Weak

It is necessary to emphasize that the grade of "strong" assumes that the United States maintains its commitment to modernization of the entire nuclear enterprise—warheads, platforms, command and control, personnel, and infrastructure—and allocates needed resources accordingly. Without this commitment, this overall score will degrade rapidly to "weak." Since every other military operation—and therefore overall national defense—relies on a strong nuclear deterrent, the United States cannot afford to fall short in fulfilling this imperative mission.

There have been major issues with nuclear capabilities since the end of the Cold War, ranging from degraded infrastructure to the inability to produce plutonium pits to delivery platforms at risk from aging. Yet progress in modernization efforts, combined with assurances from senior leaders that the forces remain reliable, warrants an improvement to the grade of "strong" this year.

Although modernization programs have yet to produce many tangible results (e.g., delivery systems have not yet entered production), a sustained bipartisan commitment to nuclear modernization extending through the previous two Administrations reflects a positive trend. Both the 2010 and 2018 NPRs strongly articulate a core nuclear weapons policy that is solidly grounded in the realities of today's threats and growing international concerns, as well as a continued commitment to extended deterrence. Moreover, presidential budgets and congressional appropriations in recent years have continued to provide the necessary funding for modernization programs. As a result, this is a more optimistic assessment of the nuclear portfolio than we have been able to provide in previous editions.

That being said, this score of "strong" with a conditional trend toward "marginal" or "weak" reflects a greater risk than in previous years of a degradation in nuclear deterrence. Current forces are assessed as reliable today, but nearly all components of the nuclear enterprise are at a tipping point with respect to replacement or modernization and have no margin left for delays in schedule. Failure of on-time appropriations and lack of Administration support for nuclear modernization could lead to a rapid decline in this portfolio to "weak" in future editions.

	VERY WEAK	WEAK	MARGINAL	STRONG	VERY STRONG
Nuclear Stockpile				 Image: A second s	
Delivery Platform Reliability				×	
Warhead Modernization			~		
Delivery Systems Modernization				~	
Nuclear Weapons Complex			~		
National Labs Talent			 Image: A second s		
Force Readiness				 Image: A second s	
Allied Assurance				×	
Nuclear Test Readiness		~			
OVERALL				 Image: A second s	

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Endnotes

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- 89. Stenographic transcript of hearing To Receive Testimony on United States Strategic Command and United States Space Command in Review of the National Defense Authorization Request for Fiscal Year 2022 and the Future Years Defense Program," p. 74.
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Missile Defense

Patty-Jane Geller

M issile defense is a critical component of the U.S. national security architecture that enables U.S. military efforts and can protect national critical infrastructure, from population and industrial centers to politically and historically important sites. It can strengthen U.S. diplomatic and deterrence efforts and provide both time and options to senior decisionmakers amid crises involving, for example, cruise missiles and hypersonic weapons that fly on ballistic and non-ballistic trajectories.

The Growing Missile Threat

Missiles remain a weapon of choice for many U.S. adversaries who view them as cost-effective and symbols of power compared to other types of conventional weapons.¹ The number of states that possess missiles will continue to increase, as will the sophistication of these weapons as modern technologies become cheaper and more widely available.

Despite U.S. diplomatic efforts, North Korea continues its aggressive pursuit of a nuclear intercontinental ballistic missile (ICBM) program—including a new "monster" ICBM supposedly able to carry multiple warheads and decoys—that will allow it to strike the United States. It also recently tested ground-based and sea-based ballistic missiles and appears to direct its missile advancements toward overcoming U.S. missile defenses.²

Iran continues to modernize and proliferate its regional missile systems. Its recent successful solid-fuel rocket launch demonstrates that Iran has the ability to build and successfully launch sophisticated missiles, which implies that it has or is developing the ability to advance to the ICBM level of capability.³

China and Russia, in addition to their vast ballistic missile inventories, are investing in new ground-launched, air-launched, and sealaunched cruise missiles that uniquely challenge the United States in different domains and are deploying new hypersonic glide vehicles.4 China is rapidly building up its missile inventory, to include hundreds of new silo-based ICBMs and road-mobile ICBMs that reportedly can carry 10 warheads, as well as theater-range missiles that can strike U.S. assets with precision.⁵ Russia is developing entirely new capabilities, such as a nuclearpowered cruise missile, that are intended to avoid U.S. sensors and missile defenses, and its conventionally armed sea-launched and air-launched cruise missiles can strike strategic nodes within the U.S. homeland, even from Russian territory.6

The Strategic Role of Missile Defense

Because they are designed to detect and defeat incoming missile attacks, missile defense systems can save lives and protect civilian infrastructure from damage or destruction. More important, missile defense plays a critical role in strategic deterrence.

The ability to deter an enemy from attacking depends on convincing him that his attack will fail, that the cost of carrying out a successful attack is prohibitively high, or that the consequences of an attack will outweigh the perceived benefit of attacking. A U.S. missile defense system strengthens deterrence by offering a degree of protection to the American people and the economic base on which their well-being depends, as well as forwarddeployed troops and allies, making it harder for an adversary to threaten them with missiles. By raising the threshold for missile attack, missile defense limits the option for a "cheap shot" against the United States.

A missile defense system also gives a decision-maker a significant political advantage. By protecting key U.S. assets, it mitigates an adversary's ability to intimidate the United States into conceding important security, diplomatic, or economic interests.

Missile defense systems enable U.S. and allied conventional operations. Adversaries want to deny the United States the ability to conduct offensive operations during a regional conflict, which they can do by targeting U.S. and allied forward-deployed personnel or military assets. In addition, they might try to decouple the United States from defense of its allies by threatening to strike U.S. forces and assets if the United States intervenes in a regional conflict. Missile defenses in place, by making it easier for the U.S. military to introduce reinforcements that can move more freely through a region, can strengthen the credibility of U.S. extended deterrence.

Finally, a missile defense system gives decision-makers more time to choose the most de-escalatory course of action. Without the ability to defend against an attack, U.S. authorities would be limited to an unappealing set of responses ranging from preemptively attacking an adversary to attacking his missiles on launch pads or even acceding to an enemy's demands or actions. By assuring some level of protection from a missile attack, robust missile defense systems would affect the dynamics of decision-making by removing the need to take immediate action.

In other words, missile defense creates additional options and provides more time to sort through them and their implications to arrive at the one that best serves U.S. security interests. This can make them profoundly stabilizing.

The U.S. Missile Defense System

The U.S. missile defense system has three critical physical components:

- Sensors,
- Interceptors, and
- Command and control infrastructure that provides data from sensors to interceptors.

Of these, interceptors receive much of the public's attention because of their visible and kinetic nature. Components of missile defense systems can be classified based on the phase of flight during which intercept occurs, although some—for example, the command and control infrastructure or radars—can support intercepts in various phases of flight. Interceptors can shoot down an adversarial ballistic missile in the boost, ascent, midcourse, or terminal phase of its flight. As cruise missiles and hypersonic glide vehicles continue to proliferate, the Missile Defense Agency (MDA) and the services must therefore consider intercept in the boost, glide, or terminal phase of flight.

Another way to classify missile defense systems is by the range of an incoming missile (short-range, medium-range, intermediaterange, or intercontinental-range) that an interceptor is designed to shoot down. An interceptor's flight time determines both the time available to conduct an intercept and the optimal interceptor placement to improve intercept probability. With ICBMs, the United States has "30 minutes or less"7 to detect the missile, track it, provide the information to the missile defense system, find the optimal firing solution, launch an interceptor, and shoot down the incoming missile, ideally with enough time to fire another interceptor if the first attempt fails. The time frame for intercepting short-range, medium-range, and intermediate-range ballistic missiles is shorter.

U.S. Missile Defense Assets



GBI—Ground-based interceptors GFC—Fire control center GMD—Ground-based midcourse defense



IDT—In-Flight Interceptor Communications System (IFICS) Data Terminal

- Schriever AFB, CO · GFC
 Ft. Drum, NY · IDT
 Cape Cod, MA · UEWR
 Thule, Greenland · UEWR
 Fylingdales, UK · UEWR
 Rota, Spain (base) · Sea-based Aegis BMD SPY-1 radar
- Kurecik AFB, TurkeyTPY-2 radar

TPY-2—Transportable Radar Surveillance and Control Model 2 UEWR—Upgraded early warning radar

14 Israel TPY-2 radar **15** CENTCOM-Middle East • TPY-2 radar 16 Shariki, Japan TPY-2 radar 🚺 Kyogamisaki, Japan TPY-2 radar 18 Outer space • Defense support program satellites Space-based infrared system satellites Space tracking and surveillance system-demonstrator

NOTE: Locations are approximate. **SOURCES:**

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U.S. Missile Defense: Interceptors

MISSILE THREAT TYPE



SOURCE: Lieutenant General Daniel L. Karbler, USA, Commanding General, U.S. Army Space and Missile Defense Command, and Commander, Joint Functional Component Command for Integrated Missile Defense, statement on "Fiscal Year 2022 Authorization Request for Missile Defense" before the Subcommittee on Strategic Forces, Committee on Armed Services, U.S. Senate, June 9, 2021, pp. 18 and 19, https://www.armed-services.senate.gov/imo/media/doc/Karbler%20Written%20Statement%20to%20SASC% 206-091.pdf (accessed August 17, 2021).

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Finally, missile defense can be framed by the origin of interceptor launch. At present, U.S. interceptors are launched from the ground or from the sea. In the past, the United States explored possible ways to launch interceptors from the air or from space, but efforts on that front have been limited since the U.S. withdrawal from the Anti-Ballistic Missile Treaty in 2002.⁸

The current U.S. missile defense system is a result of investments made by successive U.S. Administrations. President Ronald Reagan envisioned the program—the Strategic Defense Initiative (SDI)—as a layered ballistic missile defense (BMD) system, including BMD interceptors in space, that would render nuclear weapons "impotent and obsolete."⁹ These layers would have boost, ascent, midcourse, and terminal interceptors, including directed-energy interceptors, providing the United States with more than one opportunity to shoot down an incoming missile.

The United States stopped far short of this goal, even though the SDI program generated tremendous technological advances and benefits.¹⁰ Instead of a comprehensive layered system, the U.S. has no boost-phase ballistic missile defense systems and no defense against the advanced ballistic missile threats from China or Russia. The volatility and inconsistency of priority and funding for missile defense by successive Administrations and Congresses-Administrations and Congresses controlled by both major political parties-have yielded a system that is numerically and technologically limited and incapable of defending against more sophisticated or more numerous longrange missile attacks.

Beginning with the National Missile Defense Act of 1999, it was U.S. policy to protect the homeland only from a "limited ballistic missile attack."11 The National Defense Authorization Act (NDAA) for Fiscal Year 2017 dropped the word "limited" even as it continued to focus on ballistic missiles.¹² Then the 2020 NDAA made it a matter of policy to rely on nuclear deterrence to defend against "near-peer intercontinental threats" and focus on improving missile defense against "rogue states."13 In the future, as technological trends progress and modern technologies become cheaper and more widely available, North Korean or Iranian ballistic missiles may rival, in sophistication if not in numbers, those of Russia or China. Consequently, the U.S. must remain aware of how such threats are evolving and alter its missile defense posture accordingly.

In January 2019, the Trump Administration published its congressionally mandated Missile Defense Review (MDR), a statement of policy intended to guide the Administration's missile defense programs. The 2019 MDR addresses the dangerous threat environment that has evolved since the previous MDR in 2010 and advocates a comprehensive approach to all missile threats—no longer only ballistic—that integrates offensive capabilities, active defenses, and passive defenses. It acknowledges that the United States is no longer vulnerable only to ballistic missiles and recognizes that future missile defense systems must defend against cruise and hypersonic missiles as well.¹⁴

For fiscal year (FY) 2022, the Biden Administration requested \$8.9 billion for the MDA,¹⁵ a decrease from the FY 2021 budget request's projection of \$9.1 billion¹⁶ and a decrease of \$1.6 billion from the FY 2021 enacted budget of \$10.5 billion.¹⁷

Interceptors

Interceptors are one major component of the U.S. missile defense system. Different types of interceptors that respond to different missile threats have been emphasized over the years, and the composition of today's U.S. missile defense reflects these choices.

While the United States is working to improve its ability to strike down cruise missiles and hypersonic glide vehicles, the primary mission of its fully operational missile defense systems today is to intercept ballistic missiles. In particular, missile defense interceptors are designed to intercept ballistic missiles in three different phases of flight.

- **The boost phase** extends from the time a missile is launched from its platform until its engines stop thrusting.
- **The midcourse phase** is the longest and thus offers a unique opportunity to intercept an incoming threat and, depending on other circumstances like the trajectory of the incoming threat and quality of U.S. tracking data, a second shot if the first intercept attempt fails.
- **The terminal phase** is less than one minute long, occurring as the missile

plummets through the atmosphere toward the target, and offers a very limited opportunity to intercept a ballistic missile threat.

Boost-Phase Interceptors. The United States currently has no capability to shoot down missiles in their boost phase. Technologically, boost-phase intercept is the most challenging option because of the very short time frame in which a missile is boosting, the missile's extraordinary rate of acceleration during this brief window of time, and the need to have the interceptor close to the launch site.¹⁸ This phase, however, is also the most beneficial time to strike. A boosting ballistic missile is at its slowest speed compared to other phases; it is therefore not yet able to maneuver evasively and has not yet deployed decoys that complicate the targeting and intercept problem.

In the past, the United States pursued several boost-phase programs, including the Airborne Laser, the Network Centric Air Defense Element, the Kinetic Energy Interceptor, and the Air Launched Hit-to-Kill missile. Each of these programs was eventually cancelled because of technical, operational, or cost challenges. The current MDR discusses the option of incorporating the F-35 initially as a sensor platform and later as an interceptor platform for boost-phase intercepts. However, this effort has not progressed.

Midcourse-Phase Interceptors. Intercepting missiles in their midcourse phase offers more time for intercept and presents fewer technological challenges than intercept in the boost phase presents, but it also allows the missile time to deploy decoys and countermeasures that are designed to complicate interception by confusing sensors and radars. The United States deploys two systems that can shoot down incoming missiles in the midcourse phase of flight:

- The Ground-Based Midcourse Defense (GMD) system and
- The Aegis defense system.

The Ground-Based Midcourse Defense system is the only operational system capable of shooting down a long-range ballistic missile headed for the U.S. homeland. It consists of 40 Ground-Based Interceptors (GBIs) at Fort Greeley, Alaska, and four at Vandenberg Air Force Base, California. A GBI consists of a multi-staged rocket booster and an Exoatmospheric Kill Vehicle (EKV), which intercepts the incoming missile with hit-to-kill technology. In March 2019, the MDA conducted a groundbreaking and successful "salvo" GMD test against an ICBM target during which one GBI intercepted the target and a second intercepted the biggest piece of debris from the exploded target.19

To increase the probability of an intercept, the United States has to shoot multiple interceptors at each incoming ballistic missile. At present, because its inventory of interceptors is limited, the United States can shoot down only a handful of ballistic missiles that have relatively unsophisticated countermeasures.

In 2017, Congress approved a White House request to increase the number of GBIs from 44 to 64 to keep up with the advancing ballistic missile threat, particularly from North Korea. Construction of 20 new silos has been underway, but they remain empty.²⁰ The MDA intended to produce a Redesigned Kill Vehicle (RKV) to top 20 additional GBIs to fill these silos, but this program was canceled in 2019 because of technological difficulties. The MDA instead initiated the Next Generation Interceptor (NGI) program to build an entirely new interceptor that would add both capacity and capability to the GMD system. NGIs will begin to fill the 20 empty silos in 2028 and eventually will replace at least some of the existing 44 GBIs, the result of which will likely be a mixed fleet of interceptors. Unlike the GBIs, the NGI will feature multiple kill vehicles, enabling a single NGI to shoot at multiple objects ejected from one incoming missile.21

Contracts to develop the NGI were awarded to Lockheed Martin and a Northrop Grumman– Raytheon team in March 2021.²² The FY 2022 budget request includes \$926 million for NGI to support these two competing designs through Preliminary Design Review.²³

The Aegis defense system is a sea-based component of the U.S. missile defense system. It is designed to address the threat of short-range, medium-range (1,000–3,000 kilometers), and intermediate-range (3,000–5,500 kilometers) ballistic missiles. It utilizes different versions of the Standard Missile-3 (SM-3) depending on the threat and other considerations like ship location and quality of tracking data. The Aegis system also has capability against aerial threats and cruise missiles.²⁴

"Under the FY2021 budget submission," according to the Congressional Research Service, "the number of BMD-capable Navy Aegis ships is projected to increase from 48 at the end of FY2021 to 65 at the end of FY2025."²⁵ The increase reflects an increase in demand for these assets.

The Aegis Ashore system in Romania and another being deployed to Poland will relieve some of the stress on the fleet because missile defense–capable cruisers and destroyers are multi-mission and are used for other purposes, such as wartime fleet operations and even antipiracy operations. These Aegis Ashore sites will help to protect U.S. allies and forces in Europe from the Iranian ballistic missile threat.

Two Aegis Ashore batteries were being built in Japan to help protect U.S. allies and forces in the Indo-Pacific from the North Korean and Chinese threats, but the Japanese canceled the project in June 2020 because of costs and technical issues.²⁶ Instead, Japan will build two additional destroyers to deploy SM-3 interceptors.²⁷

Moreover, the former Commander of U.S. Indo-Pacific Command (INDOPACOM), Admiral Philip Davidson, has testified that "the most important action we can take to increase the joint force's lethality [in the region] is to introduce a 360-degree, persistent, air and missile defense capability on Guam (Guam Defense System (GDS))," a capability that only the Aegis Ashore system can provide.²⁸ The FY 2022 budget request includes \$78.3 million to support the continued assessment of systems to defend Guam as well as \$40 million to begin procuring components for a missile defense system.²⁹

In November 2020, the U.S. Navy and the MDA shot down an intercontinental-range ballistic missile using the SM-3 interceptor class Block IIA against an ICBM target.³⁰ The test, FTM-44, was the first step in a plan to use SM-3 Block IIAs as an "underlay" to the GMD system to defend the homeland, with GBIs taking the first shot at an incoming target and SM-3 interceptors taking a second shot if the GBIs miss.³¹ Deploying such an underlay would require a concept of operations that includes optimal locations for the deployment of SM-3 interceptors on Aegis ships or at Aegis Ashore sites across the United States.

The November 2020 test was against a simple ICBM target; the next step will be to test against a more complicated and realistic ICBM target that could be armed with decoys or other missile-defense countermeasures. The FY 2022 budget request supports the continued pursuit of a layered homeland defense (LHD) approach with funding for continued assessment of the SM-3 Block IIA against ICBMs.³²

Terminal-Phase Interceptors. The United States currently deploys three terminal-phase missile defense systems:

- Terminal High Altitude Area Defense (THAAD);
- The Patriot missile defense system; and
- Aegis BMD.

A THAAD battery is capable of shooting down short-range and intermediate-range ballistic missiles inside and just outside of the atmosphere.³³ It consists of a launcher, interceptors, the Army Navy/Transportable Radar Surveillance and Control Model 2 (AN/TPY-2) radar, and fire control.³⁴ The system is transportable and rapidly deployable.

THAAD batteries have been deployed to such countries as Japan, South Korea, Israel, and the United Arab Emirates. The United States temporarily deployed a THAAD battery to Romania in support of NATO ballistic missile defense in the summer of 2019 as Romania's Aegis Ashore system was being updated³⁵ and signed a deal in 2020 to deliver THAAD to Saudi Arabia.³⁶ In FY 2022:

[The MDA will also] continue to evaluate a new Terminal High-Altitude Area Defense (THAAD) interceptor prototype to support Contiguous United States Defense as part of the LHD effort. This effort will result in a series of technology demonstrations allowing for expansion of engagement options and coverage areas for the THAAD weapon system culminating in a flight test in FY 2023.³⁷

Patriot is an air-defense and short-range ballistic missile defense system. A battery is comprised of a launcher, interceptors, AN/ MPQ-53/65 radar, an engagement control station, and diesel-powered generator units. The Patriot family of missile defense interceptors has been upgraded over time, from the initial Patriot Advanced Capability-1 (PAC-1) deployed in Europe in 1988 to the PAC-3 configuration deployed around the world today. The most recent Patriot upgrade, the PAC-3 Missile Segment Enhancement, expands the lethal battlespace with an advanced solid rocket motor.³⁸ The system is transportable, and the United States currently deploys it in several theaters around the world.³⁹

Assessment. Interceptor strength is difficult to assess because, while deploying more interceptors to increase capacity or defend more targets would always be better, deploying more short-range to medium-range interceptors to unprotected locations or increasing interceptor capacity *ad infinitum* is simply not feasible. Congress provided funding in FY 2021 to procure additional PAC-3, SM-3, and THAAD interceptors, and the FY 2022 budget continues this effort for PAC-3 and SM-3 interceptors. However, the FY 2022 budget sharply reduces support for THAAD interceptor procurement.⁴⁰ To increase the defended battlespace, the MDA is also pursuing the Patriot Launch-on-Remote (THAAD) capability, which integrates the PAC-3 and THAAD systems by enabling a PAC-3 launch using a THAAD AN/TPY-2 radar. Launch-on-Remote is an important capability that can help to increase the defended area by spreading out missiles.⁴¹ The MDA conducted two flight tests for this capability in 2020, and both failed.⁴² However, the test failures do not necessarily indicate lack of progress; the MDA can now use the test data to proceed with development of this capability. The Army plans to field this capability "across all Patriot battalions beginning in Fiscal Year 2023."⁴³

In addition, Congress provided funding for an eighth battery that appeared on the Army's unfunded priorities list. Nine THAAD batteries have long been required, but sufficient funds have not been available to support more than seven.⁴⁴

One way to improve interceptor capability would be to fully fund an Aegis Ashore system on Guam using SM-3 interceptors in FY 2022. Such a system for Guam has appeared on the INDOPACOM unfunded priorities list for the past three years, but efforts to build the system have yet to begin. This year's budget includes funding to study a missile defense architecture on Guam and begin procuring components that would be common to any missile defense system. However, the budget does not commit to any specific system that will be built on Guam. Congress could move this critical capability forward by providing the additional \$231.7 million requested for the Guam Defense System on INDOPACOM's FY 2022 unfunded priorities list.45

In terms of capacity and capability to defend the homeland, the Commander of U.S. Northern Command (NORTHCOM), General Glen VanHerck, recently stated that he is "comfortable with my ability to defend the homeland, including Hawaii, against a limited state actor such as DPRK, which the system is designed for, for the foreseeable future" but that we need "to maintain the timeline of no later than 2028 for NGI, to ensure that we maintain capacity and capability to defend against a ballistic missile threat."⁴⁶ Among General VanHerck's specific concerns are the increasing capacity of North Korean ballistic missiles to strike the U.S. homeland and North Korea's ability to deploy decoys.⁴⁷

The recent NGI contract award follows a delay in schedule of more than a year. Fortunately, both competitors have been challenged to meet or exceed the schedule of 2028 for an operational capability.⁴⁸ This program also seems to enjoy bipartisan support in Congress.

In addition to accelerating the NGI program, Congress provided additional funds in both FY 2020 and FY 2021 for a GMD service life extension program (SLEP). The GMD system was largely built in the early 2000s, and many parts—like the GBI kill vehicles and boosters—are subject to degradation from aging. Regardless of how quickly NGI can be delivered, GBIs will likely remain a part of the fleet of interceptors beyond this decade.

Moreover, it is important to distinguish between GBIs, which are the interceptors themselves, and GMD, which is the entire homeland defense system that encompasses other components like silos, fire control, and even training methods for personnel. The MDA has begun to replace aging boosters on the GBIs, for instance, but as MDA Director Admiral Jon Hill has stated, "It's not just about the GBIs but it's also about the weapon system and its support."⁴⁹ Since the NGI will be integrated into the GMD system for the long term, upgrading the entire GMD system to last beyond the fielding of NGI will remain critical.

In FY 2020, to compensate for the delay in adding 20 additional interceptors to the fleet, the Trump Administration proposed that an underlay using SM-3 Block IIA and THAAD interceptors be developed. General VanHerck agreed to the value of an underlay, stating that "an underlayer would give us additional capacity and capability" to address threats to the homeland, but he also specified that an underlay should focus on more than just ballistic missiles, to include other threats like cruise missiles or unmanned aerial vehicles.⁵⁰

Despite the MDA's original plan to field an underlay quickly as U.S. forces await NGI, the Department of Defense (DOD) has yet to specify a concept of operations for employing the SM-3 Block IIA and THAAD for homeland defense, as requested by Congress. The FY 2022 budget request states that homeland underlay systems "could begin fielding as early as 2025" but does not address where in the United States those systems could be deployed or how many would be required.⁵¹ The utility of exploring the use of SM-3 and THAAD interceptors for ICBMs can also extend beyond an underlay for the continental United States, as they can also work for other missions or defended assets like Hawaii, Alaska, and Guam. Therefore, using SM-3 and THAAD interceptors to defend against ICBMs is a worthwhile effort, but the DOD will eventually need a more specific deployment plan.

The cruise missile threat to the homeland, for which the United States does not have a dedicated missile defense system, is also advancing. That Russia can strike key strategic nodes in the U.S. homeland from its own territory is of particular concern. To address the cruise missile threat, General VanHerck has emphasized improving domain awareness, because early identification of a threat allows for options like left-of-launch operations or diplomacy to avoid having to shoot down cruise missiles in the U.S. homeland.⁵² Ensuring that the NORTHCOM Commander has the capabilities needed to address this advancing threat will therefore be important.

The Army's Indirect Fire Protection Capability (IFPC) Increment 2 program has been moving very slowly but has seen recent improvement. The IFPC 2 would defend against short-range rockets, artillery, and mortars, as well as cruise missiles, against which the United States, as noted, lacks a sufficient defensive capability.⁵³ As a system, IFPC would fill the gap between short-range tactical air defense and ballistic missile defense like PAC-3 and THAAD.

In response to a congressional requirement to field an interim cruise missile defense capability in response to the increasing cruise missile threat, the Army purchased two Iron Dome batteries manufactured by the Israeli company Rafael.⁵⁴ Despite prior concerns about integrating Iron Dome as part of an enduring IFPC solution, the Army is preparing the Iron Dome systems for operational deployment and integration into its future missile defense command and control system.⁵⁵ In April 2021, the Army issued the solicitation for its own enduring IFPC 2 system, to reach combat capability by 2023.⁵⁶

Overall, the United States has multiple capable interceptors, but there is much room for improvement. The most important step for the near future will be on-time or early delivery of the NGI to ensure protection of the homeland from North Korea.

Sensors

The sensor component of the U.S. missile defense system is distributed across the land, sea, and space domains and provides the United States and its allies with the earliest possible warning of a launch of enemy missiles in addition to missile tracking and discrimination. These sensors can detect a missile launch, acquire and track a missile in flight, and even classify the type of projectile, its speed, and the target against which the missile has been directed. They relay this information to the command and control stations that operate interceptor systems like Aegis (primarily a sea-based system) or THAAD (a land-based system).

Land-Based. On land, the major sensor installations are the upgraded early warning radars (UEWRs), which are concentrated along the North Atlantic and Pacific corridors that present the most direct flight path for a missile aimed at the United States. They include the phased array early warning radars based in California, the United Kingdom, and Greenland that scan objects up to 3,000 miles away.⁵⁷ Two additional sites—one in Cape Cod, Massachusetts, and the other in Clear, Alaska—are being modernized for use in the layered ballistic missile defense system, but their certifications have been delayed.⁵⁸ These sensors focus on threats that can be detected in the missile's boost or launch phase when the release of exhaust gases creates a heat trail that is "relatively easy for sensors to detect and track."⁵⁹ A shorter-range (2,000-mile) radar called the Cobra Dane is based in Shemya, Alaska.⁶⁰

The United States also deploys mobile landbased sensors, called AN/TYP-2s. These sensors can be forward deployed for early threat detection or kept in terminal mode to provide tracking and fire control support for the THAAD interceptors.⁶¹ Of the United States' 12 AN/TPY-2 systems, five are forward deployed with U.S. allies.⁶²

In cooperation with the Republic of Korea, the United States deploys a THAAD missile system accompanied by an AN/TPY-2 on the Korean Peninsula. Despite China's long-standing opposition to a U.S. radar deployed so close to its homeland, the THAAD system is critical to countering the North Korean threat.⁶³

To fill a gap in missile discrimination capability for tracking North Korean missiles over the Pacific, the MDA is developing the Long Range Discrimination Radar (LRDR) in Northern Alaska to improve coverage in the northern Pacific. There had been plans to develop the Homeland Defense Radar-Hawaii (HDR-H) as well to fill a tracking and discrimination gap over Hawaii. In its FY 2021 budget request, the Trump Administration omitted funding for HDR-H because of budget constraints, but Congress provided the full funding needed to proceed with the radar. The FY 2022 budget does not include funding for HDR-H, so this radar's future again lies with Congress.

Sea-Based. There are two types of seabased sensors. The first is the Sea-Based X-band (SBX) radar, which is mounted on an oil-drilling platform and can be relocated to different parts of the globe as threats evolve.⁶⁴ SBX is employed primarily in the Pacific. The second radar is the SPY-1 radar system, which is mounted on all U.S. Navy vessels equipped with the Aegis Combat System and therefore is able to provide data that can be utilized for ballistic missile missions. Of these ships, 40 are BMD-capable vessels that carry missile defense interceptors.⁶⁵

Space-Based. Finally, U.S. missile defense sensors operate in space. From the ultimate high ground, space-based sensors can detect and track missile launches from almost any location from boost to terminal phase, compared to ground-based radars that are limited in their tracking range.⁶⁶ The MDA, the U.S. Space Force, and the Space Development Agency (SDA) all control aspects of the space missile defense sensor system.

Of the systems that contribute to the missile defense mission, the oldest is the Defense Support Program (DSP), a constellation of satellites that use infrared sensors to identify heat from booster and missile plumes. The DSP satellite system has gradually been replaced by the Space-Based Infrared Radar System (SBIRS) to improve the delivery of missile defense and battlefield intelligence.⁶⁷ For instance, SBIRS can scan a wide swath of territory while simultaneously tracking a specific target, making it a useful means for observing tactical, or short-range, ballistic missiles.⁶⁸

The Air Force and Space Force have launched five SBIRS satellites out of a planned total of six.⁶⁹ The Air Force originally planned to launch eight SBIRS satellites, but due to congressional funding delays, it decided to end production of SBIRS early and move on to development of its replacement, the Next-Generation Overhead Persistent Infrared (Next-Gen OPIR) satellite, in 2017.⁷⁰ The seventh and eighth SBIRS satellites will be switched to Next-Gen OPIR satellites, the first of which is to be delivered "no later than FY 2025."⁷¹ The Next-Gen OPIR satellites are designed to be more survivable against cyber and electronic attacks.

The MDA also operates the Space Tracking and Surveillance System-Demonstrators (STSS-D) satellite system. Two STSS-D satellites were launched into orbit in 2009 to track ballistic missiles that exit and reenter the Earth's atmosphere during the midcourse phase.⁷² STSS-D satellites provide operational surveillance and tracking capabilities and have the advantage of a variable waveband infrared system to maximize their detection capabilities. Data obtained by STSS-D have been used in ballistic missile defense tests and are now providing risk reduction to support a future space tracker. After more than a decade of serving risk reduction efforts, the MDA recently announced its plans to deorbit the STSS-D satellites within "the next couple [of] years."⁷³

In addition, the United States is developing a system of satellites capable of providing global detection, tracking, and discrimination of any missile launch. Dating back as far as President Reagan's Strategic Defense Initiative, successive Administrations have called for a proliferated layer of sensing satellites in space to track the flight of any type of missile—not just ballistic—from birth to death.

A layer of space-based sensors can be particularly useful in tracking hypersonic vehicles, which fly at lower altitudes than ballistic missiles and can maneuver during their trajectories. Comparatively, the DSP and SBIRS systems were designed for ballistic missiles and can lose track of missiles flying at lower altitudes. Since many new threats are not flying on ballistic trajectories, the Trump Administration paid close attention to developing this space sensor layer as endorsed by the MDR.

As a result, the SDA, in conjunction with the MDA, is developing a space Tracking Layer of satellites proliferated in Low-Earth Orbit (LEO) as part of the SDA's National Defense Space Architecture. According to the SDA:

Once fully operational, the SDA Tracking Layer will consist of a proliferated heterogeneous constellation of Wide Field of View (WFOV) space vehicles (SVs) that provide persistent global coverage and custody capability combined with the Missile Defense Agency (MDA) Hypersonic and Ballistic Tracking Space Sensor (HBTSS) Medium Field of View (MFOV) SVs that provide precision global access capability.⁷⁴ Once deployed, the Tracking Layer will be able to detect, track, and discriminate among any types of missile launches throughout the entirety of the missiles' flights. The SDA is also exploring the ability of space sensors to provide fire control information directly to weapon platforms like the NGI (as opposed to the data's going through a ground station).

Last year, Congress provided \$130 million about \$30 million above the President's budget request—for the HBTSS and affirmed that the MDA, not the SDA, would develop the system.⁷⁵ It also fulfilled the President's request for \$48 million for the SDA.⁷⁶ This year's budget request includes \$256 million for the HBTSS to enable an on-orbit demonstration for two contractors in FY 2023.⁷⁷

Assessment. Senior defense leaders have stated repeatedly that the most important way to advance sensor capability is to deploy sensor satellites to space in order to track missiles from the high ground throughout their entire flight. According to Admiral Charles Richard, Commander of U.S. Strategic Command (STRATCOM):

Future space-based sensors may be able to provide birth-to-death detection, tracking, and discrimination of hypersonic glide vehicle, cruise missile, and ballistic missile threats globally. These abilities cannot be fully achieved with the current or future terrestrial-based radar architecture due to the constraints of geography and characteristics of future missile threats.⁷⁸

Fortunately, the U.S. government has progressed in the space-based sensor effort despite a slow start. In FY 2019, FY 2020, and FY 2021, the program was plagued by insufficient funding requests and bureaucratic infighting over whether the SDA or MDA would develop the HBTSS.⁷⁹ These issues seem to have been resolved as clear roles for the SDA and MDA have been defined. The space-based sensor effort must continue to be fully funded, especially in view of commanders' urgent need for improved missile tracking as well as the technological challenges associated with developing a sensor that can perform in LEO.⁸⁰

Development of land-based sensors to fill the missile discrimination capability gap over the Pacific has progressed slowly. Development of the LRDR has been delayed by at least a year.81 The HDR-H project resumed in FY 2021, but local opposition to its development threatens to create delays.⁸² Because the DOD originally proposed the HDR-H to fill the critical discrimination gap identified over Hawaii, the lack of funding for HDR-H again in the FY 2022 budget also demonstrates a disconnect with DOD priorities. Additionally, the Pentagon initially planned to build a radar elsewhere in the Pacific (HDR-Pacific), but the FY 2021 budget request excluded this program, and Congress did not restore its funding. If NGI is the solution to a strong homeland missile defense, the NORTHCOM Commander must have the sensor coverage necessary to execute the mission.

With respect to Next-Gen OPIR, Congress fulfilled the FY 2021 budget request, which should keep the program on schedule, and this year's budget request continues to fund the program.⁸³ The Army is also progressing quickly on development of the Lower-Tier Air and Missile Defense System radars that will provide 360-degree threat coverage for PAC-3 and other regional missile defense batteries; the current Patriot radar can scan only onethird of the sky at a time.⁸⁴

Fortunately, the space-sensor project is now on track compared to previous years. It is important that land-based radar coverage move forward in order to stabilize the future sensor architecture.

Command and Control

Command and control of the U.S. ballistic missile defense system requires bringing together data from U.S. sensors and radars and relaying those data to interceptor operators so that they can destroy incoming missile threats against the U.S. and its allies. The operational hub of missile defense command and control is the Joint Functional Component Command for Integrated Missile Defense (JFCC IMD), a component of STRATCOM housed at Schriever Air Force Base, Colorado. JFCC IMD brings together Army, Navy, Marine Corps, Space, and Air Force personnel and is co-located with the MDA's Missile Defense Integration and Operation Center (MDIOC). This concentration of leadership from across the various agencies helps to streamline decision-making for those who command and operate the U.S. missile defense system.⁸⁵

Command and control of the GMD system to defend the homeland utilizes the Groundbased Midcourse Defense Fire Control (GFC) system, which consists of a suite of hardware, software, and personnel located in Fort Greeley, Alaska, and Vandenberg Air Force Base, California.⁸⁶ The system involves collecting data on missile movement from sensors and radars to inform the launch of GBIs.

Once a missile is launched, data from the U.S. global network of sensors and radars travel through secure satellite communications and ground-based redundant communications lines to the Command Launch Equipment (CLE) software that can task GBIs to fire at the incoming missile. Then, once the NORTHCOM Commander-who becomes the supported commander during GMD execution-in consultation with the President has determined the most effective response to a missile threat, the CLE fire response option is relayed to the appropriate GBIs in the field.⁸⁷ When the selected missiles have been fired, they maintain contact with In-Flight Interceptor Communications System (IFICS) Data Terminals (IDTs) to receive updated flight information that helps to guide them to their target.88

To prepare for and execute GMD operations, the NORTHCOM Commander can also utilize situational awareness data from the Command and Control, Battle Management and Communication (C2BMC) system. Through its software and network systems, C2BMC helps to process and integrate sensor information to provide a more complete picture of the battlespace.⁸⁹ The GMD Fire Control system acts as the primary decision aid for GMD execution, and the C2BMC system provides integrated battlefield awareness information before and during GMD operations.⁹⁰ It also provides information to other missile defense systems like THAAD and Patriot. Dozens of C2BMC workstations are distributed throughout the world at U.S. military bases.

C2BMC has undergone multiple technical upgrades, called "spirals," since 2004 to bring more missile defense elements into the network. In 2019, the MDA completed an upgrade that will help to expand Aegis missile defense coverage by enabling Aegis Weapons Systems to engage on remote.

Regional missile defense systems like THAAD, PAC-3, and Aegis are equipped with their own individual fire control systems to command and control the launch of their interceptors. The C2BMC system can also provide tracking information to individual missile defense batteries from other regional sensors. Aegis BMD systems have onboard command and control governed by the Aegis Combat System, and they can provide their sensor data to the GMD system through C2BMC.⁹¹

C2BMC connects sensors and shooters around the world to a global network, but there is no comparable system to link sensors and shooters in a single region. The Army is developing the Integrated Air and Missile Defense (IAMD) Battle Command System (IBCS) to provide this capability. Once fielded, IBCS would connect all sensors and shooters in a region to a single fire control network.⁹² Like IFPC, IBCS would also link defenses against smaller threats with ballistic missile defense.

Assessment. A strong global command and control system is critical to missile defense because linking information from sensors can increase domain awareness and decision time, thereby improving the probability of intercept. According to General VanHerck, "Decision space starts with that domain awareness." With more information about the threat, decision-makers can move "further left" to engage a target sooner.⁹³ For instance, it was recently reported that the MDA provided U.S. Indo-Pacific Command with a hypersonic missile defense capability, largely as a result of C2BMC improvements that allow sensors to see the threat sooner.⁹⁴ Future spirals that are planned will continue to increase the integration of ballistic missile defense elements across the world.

The MDA planned to complete another upgrade to incorporate the LRDR into C2B-MC in FY 2021, but this upgrade has been delayed, primarily by the COVID-19 pandemic.⁹⁵ Domain awareness can also allow decisionmakers to use other tools to deescalate conflict before missiles are launched. This option is especially important in dealing with cruise missile threats to the homeland, for which the U.S. does not have a comprehensive interceptor capability.

The United States will need a more advanced command and control capability as global missile threats shift to include cruise and hypersonic missiles in addition to ballistic missiles. The DOD is currently developing a Joint All Domain C2 (JADC2) system to integrate non-compatible sensors across all domains into a single network so that it can respond to the complex threat more efficiently. Missile defense command and control will strengthen as the services begin to field JADC2 capabilities.

North American Aerospace Defense Command is also pursuing a program called Pathfinder that "ingests data from multiple sources, infuses that data and uses machine learning and intelligence capabilities to process and share in real time."⁹⁶ Sensor information can tend to exist in stovepipes, and if it is not integrated, the result can be failure to detect a threat.⁹⁷ Pathfinder's use of artificial intelligence can help to ensure that the commander receives a full data picture.

IBCS will also provide an important improvement in regional missile defenses. The system will link all missile defense sensors and interceptors to one fire control center, as opposed to today's more stovepiped approach in which each unit operates its co-located sensor and launcher independently. By permitting air and missile defenses to function as a joint kill web rather than as a linear kill chain, IBCS will be able to determine the best shooter to take down an incoming missile, in turn increasing the defended battlespace.

IBCS was originally scheduled to reach initial operating capability in FY 2019, but it was delayed to FY 2022 because of technical issues.⁹⁸ The program remains on this new schedule today and successfully engaged two targets during a limited user test conducted last year.⁹⁹ Advancements underway in missile defense command and control will become increasingly necessary to enable defense against the growing missile threat.

Conclusion

By successive choices of post–Cold War Administrations and Congresses, the United States does not have in place a comprehensive set of missile defense systems that would be capable of defending the homeland and allies from robust ballistic missile threats. U.S. efforts have focused on a limited architecture that protects the homeland and on deploying and advancing regional missile defense systems.

Although the United States has in place multiple types of capable interceptors, a vast sensor network, and a command and control system, many elements of the missile defense system need to be improved to defend against today's threat more efficiently. At the same time, the development of missile threats, both qualitative and quantitative, is outpacing the speed of missile defense research, development, and deployment to address those threats. Senior leaders continue to stress the importance of U.S. missile defense, but if the nation is to realize the strategic benefits that missile defense provides, Congress must make sure that the funding of critical programs like NGI, space sensors, and JADC2 is commensurate with that importance.

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Cyber Warfare and U.S. Cyber Command James Di Pane

The world of cyber operations is notoriously secretive. Nevertheless, even a rudimentary understanding of the domain, the threats and opportunities associated with it, and the ability of the Department of Defense (DOD) to protect the U.S. from cyberattack and enable military operations against enemies is of the greatest importance. To supplement the concise overview of military cyber capabilities provided in this chapter, more detailed discussions of the characteristics of cyber warfare can be found in "National Defense and the Cyber Domain"1 and "The Reality of Cyber Conflict: Warfare in the Modern Age."² These essays, published in previous editions of the Index of U.S. Military Strength, provide a wealth of information about the cyber domain and how it fits into the world of national defense.

Cybersecurity has been very much in the forefront of public attention this year, with several large cyber incidents from foreign actors drawing considerable public attention. The Solar Winds hack and the Colonial Pipeline and other notable ransomware attacks demonstrate the potential threat to the homeland from malicious cyber actors and provide a window into the types of threats the U.S. could face on a broader scale during wartime. They also demonstrate the link between private networks and public networks, as well as the broad approach that is necessary to ensure cybersecurity.

The vulnerability of allies and the private sector has an indirect effect on military affairs because the compromise of just one can lead to complications for the military services. In the

words of Kenneth P. Rapuano, former Assistant Secretary of Defense for Homeland Defense and Global Security:

Their vulnerability means that adversaries could disrupt military operations without actually targeting military networks and systems themselves.... To address these challenges, we are strengthening alliances and attracting new partners to take a whole-of-society approach to enabling better security and resilience of key assets.³

Because of this, cybersecurity for the military is very expansive and goes beyond the Department of Defense alone.

The use of cyber as a military tool to target enemy forces and capabilities falls into categories similar to those of other military operations. Cyber tools can be used in the form of conventional operations, like the operations against the Islamic State that were used to disrupt command and control nodes and the group's ability to distribute propaganda.⁴ In this type of campaign, cyber accompanies the other military capabilities as a way to target enemy forces.

Or they can take the form of special operations-type activity like the Stuxnet cyber operation against Iran, which could be compared to the U.S. Navy SEAL raid to kill Osama Bin Laden.⁵ In these operations, cyber is used to achieve targeted goals, sometimes in a covert way that, like special operations, falls below the threshold of traditional armed conflict.

In conventional operations, cyber is used to support forces and commanders by ensuring that they can operate uninhibited in cyberspace or by disrupting the enemy's ability to operate in order to achieve necessary objectives more effectively. In this way, cyber is used to gain an advantage over an adversary similar to the way advantage is sought in the other domains.⁶ This is similar to the use of naval forces to restrict the enemy's ability to use the seas to achieve strategic ends.

Like naval power, cyber is an important means with which to maximize one's own access and effectiveness while restricting the opponent's access and effectiveness. However, it differs from other domains in the sense that time and space are incredibly compressed. A cyber force can launch an attack from anywhere in the world and strike very quickly, unlike more traditional forces that take time to move and launch attacks.

U.S. Cyber Command

U.S. Cyber Command (USCYBERCOM) is a capability-based Unified Combatant Command similar to U.S. Special Operations Command and is the military's primary organization for both offensive and defensive cyber activity. It is currently commanded by General Paul Nakasone, who serves simultaneously as Director of the National Security Agency (NSA). The two organizations have a close cooperative relationship: The NSA and Cyber Command operate, respectively, under Title 50 and Title 10 of the U.S. Code, the sections that govern intelligence and military affairs.⁷

U.S. Cyber Command was founded in 2010 as a sub-unified command under U.S. Strategic Command. In 2018, the Trump Administration elevated it to full Unified Combatant Command status, and it reached full operational capability in that same year.⁸ Over the past approximately 11 years, Cyber Command has grown from a very small organization that was largely dependent on the NSA for personnel and resources into the much more robust and independent organization that exists today.

Missions

U.S. Cyber Command has a wide range of missions, from offensive and defensive cyber operations to monitoring DOD networks and assisting with the defense of critical infrastructure. Its primary role is to ensure the DOD's ability to operate in a world that is increasingly dependent on cyber. To this end, according to General Nakasone:

Our three enduring lines of operation are as follows:

- Provide mission assurance for the Department of Defense (DoD) by directing the operation and defense of the Department of Defense Information Networks (i.e. the DoDIN) and its key terrain and capabilities;
- Defeat strategic threats to the United States and its national interests; and
- Assist Combatant Commanders to achieve their missions in and through cyberspace.⁹

These "lines of operation" are critical to ensuring the success of the military enterprise and national defense, as any compromise in the ability to communicate or operate could jeopardize the full range of U.S. military activities.

The types of operations that Cyber Command is tasked with performing encompass defensive cyber activity coupled with offensive options to impose costs on an adversary. For example, USCYBERCOM is helping to lead the government's response to the SolarWinds hack.

Discovered in December 2020, the Solar Winds hack was one of the most significant breaches of computer networks in history, and its effects are still being felt because of the number of organizations affected and the sophistication of the hackers. A Russia-aligned hacking organization known as Cozy Bear was most likely behind the breach. Thousands of private-sector organizations, as well as government agencies like the Departments of the Treasury, Commerce, and Homeland Security, were compromised following the corruption of the widely used Orion software. Cyber Command has worked to search for compromise within networks and expel the adversary when found, and it will provide options to policymakers for imposing costs on the attacker.

With respect to election security, U.S. Cyber Command conducted a number of operations aimed at preventing meddling in the 2020 presidential election. Another example was the 2018 targeting of the Russian Internet Research Agency (IRA), "a troll farm that led the effort to spread disinformation around the 2016 presidential election and 2018 midterm elections."¹⁰ USCYBERCOM proactively shut down the organization's Internet access to prevent it from engaging in influence operations against the United States.

In 2021, Cyber Command has also continued to support the ongoing counterterrorism fight, including force protection and target prosecution in Afghanistan in support of U.S. Central Command. These efforts are continuous and extend to other regions as well, including support for U.S. Special Operations Command. Cyber is used to disrupt terrorist organizations' financing and ability to communicate in addition to intelligence collection and targeting.

A key part of these missions is the concept of "defending forward." As described in the 2018 DOD Cyber Strategy, "[t]his includes working with the private sector and our foreign allies and partners to contest cyber activity that could threaten Joint Force missions and to counter the exfiltration of sensitive DoD information."¹¹

Defending forward means operating as close to the origins of the cyber threat as possible before it reaches critical networks in the U.S. with the goal of collecting threat intelligence or disrupting attacks. This is contrasted with passive defense, which involves monitoring within U.S. networks for intrusions. Cyber compresses time and space in the battlespace by its very nature, and attacks can emanate from anywhere in the world with similar speed. U.S. forces must therefore engage adversaries in their networks and work to disrupt attacks in their early stages because it is often too late once the networks have been compromised.

Budget

Analyzing the budget for cybersecurity is difficult because of the large degree of classification involved, but there are some data that can be tracked with respect to USCYBERCOM and the broader Department of Defense. President Joseph Biden's FY 2022 DOD budget request includes \$10.4 billion for cyberspace.¹² This is slightly higher than the \$9.8 billion requested for FY 2021.¹³

General Nakasone has testified that U.S. Cyber Command alone executed a budget of \$605 million in FY 2021.¹⁴ This was \$9 million over the reported executed budget for FY 2020, which was \$596 million.¹⁵

Capacity

The Cyber Mission Force is the operational arm of U.S. Cyber Command, and CMF teams are distributed across various mission sets. In 2013, a force of 133 teams with 6,200 personnel was envisioned based on the mission requirements at that time. All 133 CMF teams reached full operational capability in 2018.¹⁶ These teams are distributed across functional areas. Specifically, there are:

- 13 National Mission Teams that defend the U.S. against high-impact cyberattacks and provide for election security;
- 68 Cyber Protection Teams that are focused on defending DOD networks and systems and ensuring that the department is not compromised by a hack;
- 27 Combat Mission Teams that support the combatant commands with integrated cyber effects in various theaters across the globe, either in tandem with or independent of other military forces, and ensure that the Combatant Commanders have cyber tools at their disposal; and
- 25 Support Teams that support the national mission and combat teams with analysis and planning.¹⁷

The teams are supported by four service components: Army Cyber Command (ARCYBER); Air Force Cyber Command (AFCYBER); Navy Fleet Cyber Command (FLTCYBER); and Marine Corps Forces Cyberspace Command (MARFORCYBER). These four commands, created at the same time that U.S. Cyber Command was created, provide the operational forces that make up the teams.

- ARCYBER supplies 41 teams to the CMF;¹⁸
- AFCYBER supplies 39 teams;¹⁹
- FLTCYBER supplies 40 teams, which reached full operational capability a year ahead of schedule in 2017;²⁰ and
- MARFORCYBER provides 13 teams.²¹

As of January 2021, according to General Nakasone, Cyber Command had "roughly 6,000 service members and civilians out of an authorized total of 6,187 positions."²² The Biden Administration is proposing a 10 percent increase to expand the CMF by approximately 600 personnel to meet its growing demands for FY 2022.²³

In addition, there are about 12,000 personnel outside of U.S. Cyber Command who maintain DOD networks and fall under the command of the various services. Asked by House Armed Services Committee Chairman James Langevin (D–RI) to specify "how many people will be part of the new Cyber Operations Force," General Paul Nakasone, Commander of U.S. Cyber Command and Director of the National Security Agency, testified that "I would say the 6,187 that are part of our Cyber Mission Force. And then I would say probably double that with regards to our cybersecurity service providers across all four services."²⁴

The recruiting and retaining of cyber talent is one of the key challenges for U.S. Cyber Command, which has invested in retention and incentive programs in an effort to keep the talent it cultivates. The high demand for cyber personnel in the private sector makes this a difficult challenge.

Capability

Due to the nature of cyber and the classification of methods, analyzing USCYBERCOM's capability as reflected in open-source (i.e., unclassified) literature is nearly impossible. However, the United States is considered to be one of the world's most capable cyber actors, an assessment that is based on its wide range of infrastructure and strategies and the advanced technologies that the U.S. is known to employ.²⁵

Readiness

Because of the lack of open-source reporting, it is also nearly impossible to assess the readiness of America's cyber forces. The U.S. Government Accountability Office has identified some issues of training consistency in the past.²⁶ Standardizing and improving training is one of the main priorities for U.S. Cyber Command, along with retaining its talent, and both are critical to maintaining readiness.

Conclusion

Cyber is a key domain for the U.S. military. It also is increasingly important and expansive in the modern world generally. As seen in the various breaches and ransomware attacks that have come to light, cybersecurity for defense extends well beyond the Department of Defense. For the Joint Force, cyber supports military capabilities both by ensuring that U.S. forces can operate in cyberspace without disruption and as a tool on its own to achieve goals.

U.S. Cyber Command is the primary organization for the full spectrum of military cyber operations, and it has grown as an organization, reaching full operating capability in 2018. Now that USCYBERCOM has reached its authorized manning levels, the emphasis has shifted to training the force to ensure that in the coming years, it will be as capable as possible in helping to advance and protect the nation's interests.

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Conclusion: U.S. Military Power

The Active Component of the U.S. military is two-thirds the size it should be, operates equipment that is older than it should be, and is burdened by readiness levels that are more problematic than they should be. Some progress has been made, but it has been made at the expense of both capacity and modernization. Accordingly, this *Index* assesses the:

- Army as "Marginal." The Army's score remains "marginal" in the 2022 Index. The Army has fully committed to modernizing its forces for great-power competition, but its programs are still in their development phase, and it will be a few years before they are ready for acquisition and fielding. In other words, the Army is aging faster than it is modernizing. It remains "weak" in capacity with 62 percent of the force it should have but has significantly increased the readiness of the force, scoring the highest level of "very strong." The Army has a better sense of what it needs for war against a peer, but funding uncertainties could threaten its ability to realize its goals.
- Navy as "Marginal," Trending Toward "Weak." The Navy's overall score remains "marginal" in the 2022 Index but is trending toward "weak" in capability and readiness and remains "weak" in capacity. The technology gap between the Navy and its peer competitors is narrowing in favor of competitors, and the Navy's ships are aging faster than they are being replaced. The Navy sustained its focus on improving

readiness in 2021, but it has a very large hole to fill, its fleet is too small relative to workload, and supporting shipyards are overwhelmed by the amount of repair work that is needed to make more ships available. Funding to improve any of these serious deficiencies remains problematic.

- Air Force as "Weak." The USAF scores "marginal" in capacity and capability but has dropped to "weak" in readiness. Retirement of aircraft is outpacing the introduction of new aircraft, worsening the service's capacity problem. The shortage of pilots and flying time for those pilots degrades the ability of the Air Force to generate the amount and quality of combat air power that would be needed to meet wartime requirements. Although it could eventually win a single major regional contingency (MRC), the time needed to win that battle and the attendant rates of attrition would be much higher than they would be if the service had moved aggressively to increase high-end training and acquire the fifth-generation weapon systems required to dominate such a fight.
- Marine Corps as "Strong." The score for the Marine Corps was raised to "strong" from "marginal" for two reasons: (1) because the 2021 Index changed the threshold for capacity, lowering it from 36 infantry battalions to 30 battalions in acknowledgment of the Corps' argument that it is a one-war force that also stands

U.S. Military Power: Army

	VERY WEAK	WEAK	MARGINAL	STRONG	VERY STRONG
Capacity		✓			
Capability			 Image: A set of the set of the		
Readiness					 ✓
OVERALL			 Image: A second s		

U.S. Military Power: Navy

	VERY WEAK	WEAK	MARGINAL	STRONG	VERY STRONG
Capacity		<			
Capability			 Image: A second s		
Readiness			 Image: A second s		
OVERALL			 Image: A second s		

U.S. Military Power: Air Force

	VERY WEAK	WEAK	MARGINAL	STRONG	VERY STRONG
Capacity			 Image: A second s		
Capability			 Image: A set of the set of the		
Readiness		 ✓ 			
OVERALL		 Image: A second s			

U.S. Military Power: Marine Corps

	VERY WEAK	WEAK	MARGINAL	STRONG	VERY STRONG
Capacity			 Image: A second s		
Capability				~	
Readiness				×	
OVERALL				~	

U.S. Military Power: Space

	VERY WEAK	WEAK	MARGINAL	STRONG	VERY STRONG
Capacity		 ✓ 			
Capability		 ✓ 			
Readiness		 ✓ 			
OVERALL		 Image: A second s			

	VERY WEAK	WEAK	MARGINAL	STRONG	VERY STRONG
Nuclear Stockpile				×	
Delivery Platform Reliability				×	
Warhead Modernization			~		
Delivery Systems Modernization				~	
Nuclear Weapons Complex			~		
National Labs Talent			 ✓ 		
Force Readiness				×	
Allied Assurance				×	
Nuclear Test Readiness		v			
OVERALL				×	

U.S. Military Power: Nuclear

ready for a broad range of smaller crisisresponse tasks, and (2) because of the Corps' extraordinary efforts to modernize (which improves capability) and enhance its readiness during the assessed year. However, in the absence of additional funding in FY 2022, the Corps intends to reduce the number of its battalions even further from 24 to 21, and this reduction, if implemented, would harm the Corps' overall ability to perform the role it has set for itself: enabling the projection of naval power into heavily contested combat environments. The service has moved ahead aggressively with a redesign of its operating forces and the acquisition of new warfighting tools, but it remains hampered by old equipment and problematic funding.

• **Space Force as "Weak."** The Space Force was formally established on December 20, 2019, as a result of an earlier proposal by President Trump and legislation passed by Congress. The *2021 Index* provided an overview of the new service, explaining its mission, capabilities, and challenges, but did not offer an assessment. With an additional year to gain more insight, the 2022 Index scores the USSF as "weak" in all measured areas. The service has done quite well in transitioning missions from the other services without interruption in support, but it does not have enough assets to track and manage the explosive growth in commercial and competitor-country systems being placed into orbit. The majority of its platforms have exceeded their planned life span, and modernization efforts to replace them are slow and incremental. The force also lacks defensive and offensive counter-space capabilities.

• Nuclear Capability as "Strong" but Trending Toward "Marginal" or even "Weak." The U.S. nuclear enterprise rates a score of "strong" primarily because of the serious attention it has received during the past couple of years. There has been strong, largely bipartisan political support for modernizing warheads, delivery platforms, command and control systems, and supporting infrastructure

	VERY WEAK	WEAK	MARGINAL	STRONG	VERY STRONG
Army			 Image: A second s		
Navy			 Image: A set of the set of the		
Air Force		 ✓ 			
Marine Corps				×	
Nuclear				×	
Space		~		_	
OVERALL			~		

U.S. Military Power

and for the development of essential personnel. However, it should be emphasized that the U.S. must maintain its commitment and allocate resources accordingly. Without this sustained commitment, the overall score for America's nuclear capability will degrade rapidly to "weak."

In the aggregate, the United States' military posture is rated "marginal." The 2022 Index concludes that the current U.S. military force is likely capable of meeting the demands of a single major regional conflict while also attending to various presence and engagement activities but that it would be very hard-pressed to do more and certainly would be ill-equipped to handle two nearly simultaneous major regional contingencies. In general, the military services have continued to prioritize readiness and have seen improvement over the past couple of years, but modernization programs continue to suffer as the failure of resources to keep pace with inflation leads to cancelations, truncation, or delay. The services have normalized the reduction in size and number of military units, and the forces remain well below the level they need to meet the two-MRC benchmark.

Mounting U.S. federal debt and creeping inflation will pressure defense accounts further at a time when competitor countries like China and Russia are redoubling their efforts to expand and improve their military forces. If it continues on this trajectory, the U.S. risks falling very short in its ability to secure its core national interests.