

AIRCRAFT CARRIERS



**THE UNIQUE VALUE OF AMERICA'S
MOST FAMOUS COMBAT SYSTEM**

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FINDINGS IN BRIEF

Aircraft carriers are the preeminent expression of U.S. military power. The United States is the only nation that operates a fleet of large-deck, nuclear-powered aircraft carriers. With unlimited range and the capacity to destroy hundreds of surface targets per day, each of the ten carriers in the U.S. fleet is a secure base for protecting and projecting American power. 80% of the world's population lives less than 100 miles from the sea, putting it within reach of carrier air wings that can execute a diverse array of military options.

Large-deck, nuclear-powered aircraft carriers are a good fit for emerging threats. In the years since the Cold War ended, the world has seen a surge in new threats empowered by information-age technologies. Whether state-based or stateless, emerging adversaries seek to deny U.S. forces access to their regions and undermine America's overseas allies. Aircraft carriers enable the U.S. to continuously exert military power in contested areas without having to rely on vulnerable land bases, and can be quickly moved wherever they are needed.

Carriers are in continuous demand from regional commanders. Because the 60-75 aircraft in carrier air wings can perform a diverse array of military functions from sustained strike warfare to counter-terror operations to reconnaissance missions, carriers are in continuous demand from regional combatant commanders. However, the number of overseas deployments has risen since the Cold War ended while the number of carriers in the fleet has declined. The Navy needs more than ten carriers to avoid overstressing its ships and sailors.

Aircraft carriers are extremely difficult to defeat. Aircraft carriers are much harder to target than land bases because they are continuously moving. With hundreds of watertight compartments and extensive armoring, it would be difficult to sink a large-deck carrier without using nuclear weapons. Carrier air wings are equipped to prevent hostile aircraft, surface combatants and submarines from getting near (carriers can outrun submarines). Each carrier is defended by both its own missiles and guns and those on escort ships.

Aircraft carriers cost less than 1% of the federal budget. Large-deck, nuclear-powered aircraft carriers are the biggest warships ever built, and they have a price-tag to match. However, the entire defense budget is only 15% of federal spending, and the Navy is a fraction of that. Even if all the costs of building and operating carriers plus their aircraft are included, the cumulative cost is less than 1% of the federal budget. That is still true if escort warships are included, although more destroyers and cruisers would be needed in the absence of carriers.

None of the alternatives to carriers work as well. Carriers are not the only way of projecting U.S. air power abroad, but in many cases they are the most effective option. Land-based tactical aircraft require access to local bases that might not be available, or could be targeted by enemies. Long-range bombers flying from further away would still need support from planes like tankers tethered to local bases. Using standoff missiles rather than carrier-based aviation to attack targets could raise the munitions costs of an air campaign 50 times or more.

The new Ford class of carriers delivers increased capabilities, decreased costs. The next generation of carriers is called the Gerald R. Ford class and includes a range of technologies aimed at making nuclear-powered carriers more lethal, survivable and efficient. The number of daily aircraft sorties that can be sustained under peacetime conditions will rise from 120 to 160, and can reach 270 in wartime. But crew size will shrink from 3,300 to 2,500 and air wing personnel from 2,300 to 1,800. Manpower and maintenance costs will be greatly reduced.

The Navy needs enough carriers to get the job done. Aircraft carriers deliver unsurpassed versatility and flexibility in dealing with overseas threats. However, a force of ten carriers is required to keep three forward deployed, and indications are that more than three will be needed. The current mismatch between supply and demand wears out warships and sailors alike. Increasing the size of the force to eleven by keeping the Ford class on track is essential, and further steps may be needed to assure regional commanders get the support they require.

Introduction

AIRCRAFT CARRIERS ARE AMERICA'S SIGNATURE COMBAT SYSTEM

Large-deck, nuclear-powered aircraft carriers are the preeminent expression of American military power. Displacing 100,000 tons of water and standing 250 feet tall, they are the biggest warships ever built. The ten Nimitz-class carriers in the current fleet are often referred to as “four and a half acres of sovereign U.S. territory,” because that is the size of the flight deck from which they can launch over 100 aircraft sorties every day for months at a time. No other country in the world has even one warship capable of accomplishing that feat.

Aircraft carriers like the Nimitz class and the Ford class that will replace them are uniquely suited to the strategic needs of the United States -- a country with global interests that is cut off from Africa and Eurasia by vast oceans. Nuclear power gives the carriers unlimited range, and large decks enable them to act as floating bases when it is not feasible or desirable to secure basing rights ashore. These are important features in a world where 70% of the surface is covered by water and 80% of people live less than a hundred miles from the sea.

The air wings on U.S. carriers perform a wide array of missions from deterring aggression to securing the sea lanes to attacking terrorists. The carriers typically operate in “strike groups” that include other warships such as destroyers and submarines capable of defending against the full spectrum of undersea, surface and overhead threats. In fact, U.S. aircraft carriers are the most heavily defended military assets in the world, which is what enables them to safely sustain offensive operations against diverse adversaries.

However, many Americans do not understand why large-deck, nuclear-powered aircraft carriers are needed, how little they cost, or why they are nearly impossible to sink. The purpose of this study is to provide a concise explanation of why aircraft carriers are a bargain for a maritime nation with far-flung responsibilities like America. The study begins by detailing the ways in which carriers are uniquely relevant to the

military challenges America faces, and how heavily they are used on a daily basis by U.S. regional commanders around the world.

It then describes the extensive defenses that make large-deck, nuclear-powered carriers so difficult to defeat, and lays out the modest cost that Washington incurs for sustaining its current fleet of carriers (less than one day of federal spending per year). The study also explains why there are few viable alternatives to aircraft carriers in accomplishing a wide array of combat operations, and how the Navy is working to field a new generation of carriers that will require far fewer personnel to operate while delivering big gains in warfighting capability.

The study concludes by stressing the importance of maintaining carrier production at a steady rate to assure the fleet is big enough to keep 3-4 carriers deployed at all times. That is the minimum number required to deal with all the demands imposed by a chaotic world in which America has many enemies. Because nuclear-powered aircraft carriers remain in service for half a century, it is only necessary to build one every five years to sustain a force of ten.

However, a higher pace may be needed to comply with congressional direction and meet the demand for carriers from regional combatant commanders.



Large-deck, nuclear-powered aircraft carriers are the biggest warships ever built, and pack a powerful punch that can be delivered anywhere near the sea on short notice. Precision-guided munitions and networked warfare enable each carrier air wing to precisely attack hundreds of targets per day for months at a time.

LARGE-DECK, NUCLEAR-POWERED AIRCRAFT CARRIERS ARE A GOOD FIT FOR EMERGING THREATS

The U.S. Navy began experimenting with aircraft carriers shortly after World War One -- early enough so that carriers could play a critical role in the Pacific during World War Two. However, nuclear-powered aircraft carriers did not become a reality until the U.S.S. Enterprise joined the fleet in 1961. Today, all of the carriers in the active fleet are of the Nimitz class, meaning they evolved from the design of the lead ship, which was conceived in the 1950s and joined the fleet in 1975. The lead ship in the Ford class that will replace Nimitz is thus the first all-new carrier the Navy has developed in half a century.

In other words, the Ford class is the only aircraft carrier the Navy has developed that from its inception was intended to deal with the threat environment of the post-Cold War world. That new threat environment is not dominated by the Soviet Union and the possibility of nuclear conflict that preoccupied naval planners two generations ago. Instead, it is characterized by a more diverse array of dangers that includes everything from terrorists to regional aggressors like Iran to rising maritime powers such as China.

All of these potential adversaries have been empowered by information technologies that make their reconnaissance more accurate, their weapons more lethal, and their command structures more resilient. However, in other regards they resemble the threats that earlier classes of aircraft carriers were conceived to address. They typically concentrate their forces and resources within a few hundred miles of the sea. They try to exclude U.S. and allied forces from the areas where they seek influence. And in order for them to be defeated, they require America's military to project power thousands of miles from its home bases in the Western Hemisphere.

During the Cold War, the United States sought to contain aggression by the Soviet Union and its allies by surrounding the Sino-Soviet periphery with military bases. There were dozens of major bases in Central Europe, the Middle East and the Western Pacific. That basing infrastructure has now been largely dismantled, and most countries resist allowing big U.S. force deployments on their territory. So if the U.S. is to reach

out and defeat threats like ISIS and Iran, it will need to do that mainly from bases at sea.

The value of large-deck, nuclear-powered aircraft carriers in this kind of world is fairly obvious. Large-deck carriers providing several acres of deck space, extensive storage area and in-depth logistical support are capable of delivering the same kind of sustained striking power against distant targets that a land base could. A Nimitz-class carrier can launch over a hundred aircraft sorties per day for months at a time. And because nuclear-powered aircraft carriers have unlimited range, they can be dispatched to wherever they are needed on short notice, operating continuously without access to bases on land.

Much has been made in recent years of the "anti-access" strategies some littoral powers such as China and Iran have embraced to discourage U.S. military presence in the areas they seek to dominate. There is no question these strategies pose a potential danger to U.S. aircraft carriers. However, they pose a much greater danger to U.S. and allied military forces operating from land bases within reach of aggressors, because the location of the bases is well known and cannot be changed. Aircraft carriers, on the other hand, are constantly moving and are heavily protected by both their own defenses and those of the other warships in a carrier strike group.

The extensive defenses built into aircraft carrier combat systems and operating plans are discussed later in this study. The important point to understand up front, though, is that a carrier air wing of up to 75 high-performance aircraft can rapidly degrade the military capabilities of virtually any adversary it faces, especially given the availability of smart weapons that enable multiple target kills per flight. Whether the enemy is ISIS or North Korea, a single carrier and its air wing can destroy over a thousand enemy targets per week -- even if bases ashore in friendly nations have been rendered unusable by attacks.



An aircraft carrier is replenished by a supply ship. All of the Navy's aircraft carriers are nuclear-powered, and thus have unlimited range. With timely replenishment at sea, the carriers can remain deployed for many months, minimizing the need for U.S. forces to rely on vulnerable land bases.

CARRIERS ARE IN CONTINUOUS DEMAND FROM REGIONAL COMMANDERS

Because of their unique capacity to sustain high-intensity air operations against regional adversaries without depending on land bases, the Navy's aircraft carriers are in continuous demand from overseas combatant commanders. The U.S. global military presence is organized into geographical commands responsible for security in specific areas such as Europe, the Middle East and the Pacific. The leaders of these commands frequently request aircraft-carrier presence in their areas of operation to provide regional deterrence, protect sea lanes, prosecute air campaigns against enemies ashore, and support other friendly forces.

During Operation Desert Storm in 1991, six carriers were dispatched to the Persian Gulf region, contributing to an air campaign that had largely defeated Saddam Hussein's military before coalition ground forces engaged. Ten years later, four carriers were deployed at the outset of the military campaign in Afghanistan. And when Operation Iraqi Freedom, the invasion of Iraq, commenced in 2003, six carriers were again sent. The Navy's fleet response plan keeps a small number of carriers forward deployed at all times, with an additional number ready to surge on short notice in a crisis.

However, the number of operational carriers has decreased since the Cold War ended while the demand for their capabilities from regional commanders has increased. In the 1980s, the Navy had 14 carriers and kept an average of 2.5-2.75 forward deployed. The number of carriers declined to 11 in subsequent years, and then to 10 with the retirement of the U.S.S. Enterprise in 2012. But demand for forward deployments actually grew during the same timeframe, to an average of 3.5 in some years. In other words, the percentage of the carrier force deployed on a typical day nearly doubled.

That rate of utilization, which peaked in 2011-2013, was not sustainable. The usual metric applied to carrier availability is that a force of 10 carriers can sustain 3 forward-deployed carrier strike groups, while a force of 11 can sustain 3.5. The Navy managed to stretch its resources for several years by extending deployments and deferring maintenance, but at the end of that time it found the warships wearing out and fully half of the

carriers had to be placed in maintenance. As a result, the remaining ships were utilized even more heavily -- meaning that the ripple effects of being used more intensively than designs anticipated will extend many years into the future.

Although the Navy has generated a new, "optimized" fleet response plan to better balance operations, training and maintenance, the service does not expect a return to traditional readiness rates in the current decade. Problems will persist for a while after the lead ship in the Ford class becomes operational in 2021 because the other carriers in the fleet have been driven too hard. Having an eleventh flattop in the fleet (as required by law) will eventually allow the Navy to return to a sustainable operating tempo, assuming no new contingencies arise demanding extended overseas deployments by four or more carriers simultaneously.

What these trends point to is that the demand for U.S. aircraft carriers from regional combatant commanders is greater than the current fleet can support. Carrier deployments must compete with training missions, maintenance availabilities and the inevitable transit times in a budget environment that is likely to remain constrained for the foreseeable future. While this speaks volumes about how useful carriers are in supporting regional security objectives, it also signals that any delay in the construction of new carriers or loss of a carrier in combat will hobble the U.S. ability to execute its global defense strategy.



An F-35C Lightning II fighter on the flight deck of the U.S.S. George Washington during sea trials. The F-35C will provide carrier air wings with greater reach, carrying capacity, survivability and situational awareness. It will also enhance the capacity of carriers to avoid being targeted by adversaries.

AIRCRAFT CARRIERS ARE EXTREMELY DIFFICULT TO DEFEAT

Because aircraft carriers are crucial to America's global military posture, the Navy has invested heavily in defending them against attacks by enemies seeking to drive U.S. warships from nearby seas. In fact, the Navy's current fleet of ten large-deck, nuclear-powered carriers are among the most densely defended assets in the world. Each carrier is surrounded when it deploys by a layered defense designed to prevent hostile warships, aircraft and missiles from reaching the carrier. If any weapons managed to penetrate this shield, they would be unlikely to cause disabling damage.

The survivability of aircraft carriers derives first and foremost from the fact that they are always moving. Unlike land bases whose locations are well known and readily targeted, a nuclear-powered aircraft carrier has unlimited mobility and can move up to 35 miles in an hour -- meaning if it is sighted, it can be anywhere in an area of 6,000 square miles within 90 minutes. Because no potential adversary has overhead reconnaissance systems capable of continuously tracking carriers, this presents an extreme targeting challenge for even the most determined attacker.

In the event of hostilities, U.S. naval forces would move quickly to degrade whatever targeting capabilities an enemy might possess, for example by destroying over-the-horizon radars on land and drones operating near the carrier strike group. Since aircraft carriers are always accompanied by other warships such as destroyers and attack submarines when they deploy, they are not dependent solely on their air wings and on-board weapons for protection. In fact, there are usually several Aegis destroyers or cruisers nearby with networked sensors that can detect and destroy incoming weapons long before they approach the carrier.

The carrier itself is equipped with extensive active and passive defenses, including thousands of tons of armor to mitigate damage from torpedoes or mines. Because the carriers are very big and contain hundreds of water-tight compartments, it would be nearly impossible for anything other than a nuclear weapon to actually sink one. But incoming missiles and munitions might cause significant damage to on-board sensors, command centers and the flight

deck, so the Navy has applied both its technology investments and operational planning to assuring that few if any hostile weapons actually reach the carrier.

The carrier air wing includes radar planes that can monitor surrounding air space for hundreds of miles in search of airborne or ballistic threats, and then alert interceptor aircraft or missile batteries on Aegis warships as circumstances dictate. Because the entire defensive architecture is networked, the warship that first detects a danger need not be the vessel that accomplishes its destruction. An airborne radar plane from the carrier might alert a missile defense destroyer to approaching threats so that the potential for successful interception is maximized.

The carrier air wing also provides defense against hostile submarines, which is bolstered by anti-submarine systems on other friendly warships. For instance, the radar planes in the air wing can detect the periscopes of hostile submarines at considerable distance, and HH-60 helicopters organic to the wing are equipped for anti-submarine, anti-surface and counter-mine warfare. When there is significant danger from hostile submarines, the carrier will typically deploy with an attack submarine far exceeding the capabilities of potential undersea adversaries. In addition, nuclear-powered carriers can outrun submarines.

Some of the capabilities developed to protect America's aircraft carriers are kept secret to complicate the challenge faced by attackers, such as the passive defenses built into the hull of the carriers. However, even a casual review of the capabilities resident in any carrier strike group will reveal extensive, multi-faceted defenses organic or adjacent to the carriers that few enemies could overcome. When these defenses are combined with agile tactics and the introduction of longer-range strike aircraft allowing greater standoff distances, it is clear U.S. carriers are likely to remain lethal and survivable for a long time to come.

AIRCRAFT CARRIERS COST LESS THAN ONE-PERCENT OF THE FEDERAL BUDGET

Aircraft carriers are well suited to the security needs of a nation that must traverse thousands of miles of ocean to reach most of its major allies and trading partners. However, large-deck, nuclear-powered carriers are the biggest warships ever built, and have a price-tag to match. This has led some observers to question whether a force of ten or eleven carriers is affordable, no matter how useful they may be. The short answer is that all aspects of aircraft carrier construction and operations combined consume less than 1% of the federal budget, so the issue of carrier costs is more about political priorities than it is about budgetary burdens.

Defense spending currently represents about 3% of U.S. economic output and 15% of the federal budget. The Department of the Navy's base-budget request for fiscal 2017 was \$165 billion, accounting for about 4% of federal spending. But the Navy Department's budget includes funding for a vast array of activities including the Marine Corps, and carriers consume only a fraction of the total. Some analysts contend that to capture the full burden of being able to operate carrier strike groups, estimates should include the cost of surface combatants and submarines assigned to each formation; however, in the absence of carriers the Navy would probably need larger numbers of these other warship types, so that argument is misleading.

The real cost of the carrier force consists of two types of spending: acquisition and operations. Acquisition is the budgetary burden of designing, developing, building, modifying and refueling carriers. Operations costs include manning, supplies, maintenance, and other kinds of support, plus the significant cost of disposing of nuclear-powered carriers when they retire. With regard to acquisition, the Navy plans to spend an average of \$2.7 billion annually between 2017 and 2021 on construction of carriers. The federal government currently spends \$11 billion per day, so carrier acquisition consumes about six hours of government outlays annually. The Navy needs to buy one new carrier every five years to sustain a fleet of ten -- they remain in service for 50 years -- so the cost of acquiring each carrier adds up to about 30 hours of federal spending (6 hours of spending per year times 5 years).

That cost does not include the additional expenditure required to purchase planes and helicopters for

each carrier's air wing. Naval aircraft are bought at a much different pace than carriers, so it is complicated to assign a fully-loaded cost figure for both a carrier and its air wing. In general, though, the annual cost of buying both carriers and their aircraft is probably equal to about one day's worth of federal spending. It should be noted that the Navy spends considerably more on acquiring other types of warships than it does on acquiring aircraft carriers. For instance, the service plans to spend \$28.6 billion on constructing attack submarines between 2017 and 2021, which is more than twice the \$13.5 billion it has programmed for carrier construction.

With regard to carrier operations, the most widely-cited estimate of what it costs to operate a carrier strike group is \$6.5 million per day. However, that estimate, which was generated by retired naval captain Henry J. Hendrix of the Center for a New American Security, subsumes the cost of both acquisition and operations, and includes the budgetary burden of warships the Navy would likely buy whether it operated carriers or not:

Factoring in the total life-cycle costs of an associated carrier air wing, five surface combatants and one attack submarine, plus the nearly 6,700 men and women to crew them, it costs about \$6.5 million per day to operate each strike group.

Since the Navy has typically operated three or four strike groups at a time in recent years, this estimate suggests the Navy spends about \$26 million daily on the carrier formations it has at sea. The cost of surface combatants and subs should not be included because they would be needed in any event, but there are additional costs associated with training missions, maintenance and support activities for carriers that are not deployed. Even if that were to triple the carrying cost of the carrier force, though, it would still total less than a day's worth of federal spending. The implication is that aircraft carriers cost less than 1% of the federal budget -- a cost that will fall steadily in future years as the less manpower-intensive Ford class gradually replaces legacy carriers.

NONE OF THE ALTERNATIVES TO CARRIERS WORK AS WELL

Aircraft carriers exist to deliver sustained air power overseas in support of U.S. security objectives. The appeal of air power since its inception a century ago has always been that it offered the possibility of achieving major military gains without sacrificing the lives of vast numbers of soldiers, sailors and marines. As military aviation proponent Billy Mitchell put it, aircraft could fly over the front lines to strike at the “vital centers” of enemy strength -- potentially winning an early decision.

It is no coincidence that the U.S. Navy christened its first carrier, the Langley, at the same time Mitchell and other air power enthusiasts were formulating their theories. The Navy was an “early adopter” of the new technology, which was to prove crucial in successfully waging World War Two. Today, the unique war-fighting leverage afforded by air power is universally acknowledged. Innovations such as precision-guided weapons, stealth technology, digital networking and sensor fusion have continuously increased the effectiveness of military air power across the spectrum of conflict, making it indispensable in U.S. war plans.

However, aircraft carriers are only one way in which air power might be brought to bear against adversaries. Other approaches include land-based tactical aircraft, long-range bombers, and missiles launched from afar -- either air-breathing or ballistic. All of these weapons are typically employed by the joint force in major military campaigns. Nonetheless, it is easy to demonstrate that in many, perhaps most, warfighting scenarios, the aircraft carrier is better suited to applying air power in support of U.S. security objectives. A brief review of the drawbacks associated with alternatives illustrates why carriers are likely to remain central to the employment of U.S. air power for many decades to come.

Substituting land-based tactical aircraft for aircraft based at sea necessarily requires access to bases relatively near the action. During the Cold War, the U.S. operated dozens of major air bases around the Sino-Soviet periphery, but many of those bases have been abandoned and few local governments today are willing to permit unfettered use of those that remain. Beyond that, well-equipped adversaries such as Russia and China have the ability to destroy nearby land bases

at the onset of war, precluding their use by friendly forces. Although the tactical aircraft the joint force operates on carriers have similar capabilities to those operated on land, they are likely to be much more useful in wartime because their bases can be moved, are very difficult to target, and are not subject to operational constraints imposed by local powers.

Long-range bombers are sometimes the only way that key assets can be precisely targeted in the interior of hostile states. However, bombers suffer from some of the same disabilities as other land-based strike aircraft. If they are forward-deployed, their bases can be readily targeted by peer or near-peer adversaries. If they are flying from remote bases thousands of miles away, they will likely require support from aerial-refueling tankers and escort aircraft that rely on vulnerable bases close to the action. Carrier-based planes can contribute to the support of long-range bombers, but if the bombers are approaching an area of operations from thousands of miles away, it will be difficult to sustain operations over protracted periods the way carriers can. In any event, the vast majority of important military targets will be near the sea -- i.e., within reach of carrier aviation.

Using precision-guided missiles fired from naval surface and undersea combatants in place of naval aviation to attack land targets can work well against limited numbers of fixed targets. However, the cost of cruise and ballistic missiles suitable for precisely attacking distant targets typically exceeds a million dollars each, and it is not uncommon for major military campaigns to involve strikes on many thousands of aim-points. Thus, the cost of munitions alone might exceed ten billion dollars in a campaign of any duration. In many cases, the missile will be worth more than the intended target. In addition, there simply aren't enough missiles available to attack all the aim-points in an extended campaign. Carrier-based strike aircraft use munitions costing 1-2% of what long-range missiles do, and unlike the missiles strike aircraft can search for mobile targets, assess damage and perform other useful functions.



An E-2C Hawkeye radar plane preparing to take off from the flight deck of the U.S.S. George H.W. Bush. The Hawkeye monitors air space around carriers for any sign of hostile aircraft and can vector fighters to intercept attackers long before they are within range to release their weapons. It is linked with other warships in the carrier strike group to provide integrated fire control.

THE NEW FORD CLASS OF CARRIERS DELIVERS INCREASED CAPABILITIES, DECREASED COSTS

The ten large-deck, nuclear-powered aircraft carriers in the current U.S. fleet are all based on the design of the U.S.S. Nimitz, which joined the fleet in 1975. Design of the Nimitz class commenced in the 1950s, at a time when manpower was inexpensive due to conscription, electronics were still in the vacuum-tube era, and precision-guided weapons had not yet been conceived. The Navy has gradually improved each successive carrier in the class as new technologies and operating requirements emerged, retrofitting key advances onto earlier hulls as necessary. However, the simple truth is that the entire information revolution has unfolded since the Nimitz was designed, so the fleet is overdue for a next-generation carrier.

Senior defense officials approved a Navy proposal to begin detailed design work on a new generation of carriers in 1998. The plan was to combine the most valued features of existing carriers -- large decks, unlimited range, versatile air wings -- with capabilities that only information-age technologies could deliver. Specifically, the Defense Acquisition Board approved development of a carrier similar in size to the Nimitz, but capable of supporting a larger air wing of 75 aircraft, powered by a more efficient nuclear propulsion system, and generating much greater electrical power for on-board sensors, computers, and other electronics.

In 2007, Congress authorized the Navy to begin entering into construction contracts for the first three ships in the new class, and construction of the lead ship in the class has now been completed. That ship, named the U.S.S. Gerald R. Ford, will largely define the features of the carriers that follow, and the entire class is thus designated the Ford class. A second carrier named the U.S.S. John F. Kennedy is being built, and construction of a third will likely be authorized in 2018.

Because aircraft carriers remain in service for half a century, it will be a long time before the Ford class becomes the dominant type of carrier in the U.S. fleet. The last Nimitz is not expected to retire until 2058. Nonetheless, the design features of the lead ship in the new class illustrate why the Navy believed a better carrier was needed. The U.S.S. Ford will incorporate extensive automation thanks to the use of advanced information technologies and an electrical system that generates 300% of the output of Nimitz-class ships.

As a result, the crew size will shrink from about 3,300 sailors to 2,500 and the manpower required to support the air wing will decline from 2,300 to 1,800.

These reduced manning levels help cut the cost of owning and operating each carrier by about 15%, a savings of over \$5 billion across the lifetime of the warship. However, those savings have not been achieved by compromising any aspect of the carrier's performance. In fact, the sortie rate for the on-board air wing under normal operating conditions will increase from the 120 per day typical of a Nimitz carrier to 160, and if necessary can be surged to 270 each day. Because precision-guided munitions enable strike aircraft to hit multiple aim-points in a single flight, it is feasible for one Ford-class carrier to hit 1,000 targets per day in a high-intensity air campaign. Few enemies could withstand such a pounding for long.

Ford-class carriers will also be equipped with an extensive array of active and passive defensive features to assure their survivability is not compromised while executing air operations. In addition to the anti-submarine, anti-surface and anti-aircraft capabilities delivered by various airframes in the air wing, the carriers will have a new ship self-defense system that nets together advanced sensors, missiles, guns and countermeasures to intercept or deflect attackers. The hull and superstructure will incorporate extensive armoring, low-observable ("stealth") technology and other features to further complicate the targeting challenge faced by enemies.

Virtually every aspect of aircraft support and weapons handling has been refined in the Ford design, which contributes to the increase in the sortie rate. For instance, the horizontal distance that weapons must be moved in loading strike aircraft for missions has been reduced by two thirds, from about 1,200 feet to 400. Even the air conditioning capacity has been doubled over that of Nimitz carriers, which contributes to crew productivity during operations in warm climates. Some of the improvements in the Ford class are more subtle, such as the reduced maintenance requirements and increased operational availability that result from using advanced technologies. Collectively, though, the new technologies and processes incorporated in the Ford-class design make such vessels more lethal, survivable and affordable than the carriers they will replace.

Conclusion

THE NAVY NEEDS ENOUGH CARRIERS TO GET THE JOB DONE

As the preceding pages have demonstrated, large-deck, nuclear-powered aircraft carriers are a good match for emerging threats and as a result are in continuous demand from U.S. combatant commanders around the world. Not only are aircraft carriers a more flexible and reliable means of using air power against America's enemies than alternatives, but they are very difficult to defeat and cost a miniscule portion of the federal budget. Although each carrier comes with a hefty price-tag, compared with other ways of waging war in an unpredictable world, they are a bargain. So aircraft carriers will remain central to U.S. war plans for the foreseeable future.

The big question military planners face today with regard to carriers is not whether they are effective or survivable, but whether there will be enough of them to meet all of the nation's far-flung security needs. Until the last non-nuclear carrier was retired in 2009, the Navy was required by law to maintain a force of twelve large-deck carriers. Today, following retirement of the conventionally-fueled Kitty Hawk and the nuclear-powered Enterprise, only ten remain in the active fleet. Because of maintenance and training requirements, a force of ten carriers can only sustain three forward-deployed on a continuing basis. The Navy has frequently sought to deploy more, and now is paying the price.

Specifically, a large portion of the force has been tied up in extended maintenance, and some regions where carriers were traditionally always present such as the Persian Gulf have been left temporarily uncovered. The Navy predicted such problems would arise when overseas demand for carriers surged after 9-11. That does not mean more carriers could not be made available quickly in an emergency, but it does reflect the fact that there is an immutable relationship between how heavily each carrier is used and how much maintenance it will later require. The current problems thus cannot be fully resolved until the U.S.S. Ford becomes operationally available in 2021, increasing the number of active carriers in the fleet by 10%.

The current mismatch between carrier demand and supply suggests that even eleven carriers may not be sufficient to meet military needs if there is an increase in threats. Furthermore, although carriers are nearly

impossible to sink without using nuclear weapons, there probably should be some provision for attrition in war plans given the long lead-times associated with carrier construction. So Congress probably got it right when it mandated a force of twelve large-deck aircraft carriers. Getting back to that level of capability would require accelerating carrier production beyond the current pace of authorizing the construction of one new vessel every five years -- a pace that actually was only established in 2009.

At the time, Secretary of Defense Robert Gates stated that building a new carrier every five years was more fiscally "sustainable" than doing so every four years, but as recent experience has demonstrated, demand for carriers is driven by threats, not fiscal considerations. In other words, if current global conditions continue and the Navy elects to stay with a force of ten or eleven carriers, then some missions will not be accomplished and some threats will not be addressed. There is always a possibility that threats will recede, but in the absence of a firm U.S. response to regional aggression, the more likely outcome is that threats will increase.

At the very least, the Department of Defense should continue its current plan to begin construction of additional Ford-class carriers in 2018 and 2023. But serious consideration should be given to building carriers at a faster pace, until a force of twelve carriers can be sustained. With the man-hours required to build the second vessel in the Ford class projected to fall 20% from those of the lead vessel, the budgetary consequences of building to a twelve-carrier force would be relatively modest -- a few hours of additional federal spending per year at most. The geopolitical consequences of failing to do so could be far more dangerous than the fiscal consequences of investing in an adequate fleet.



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