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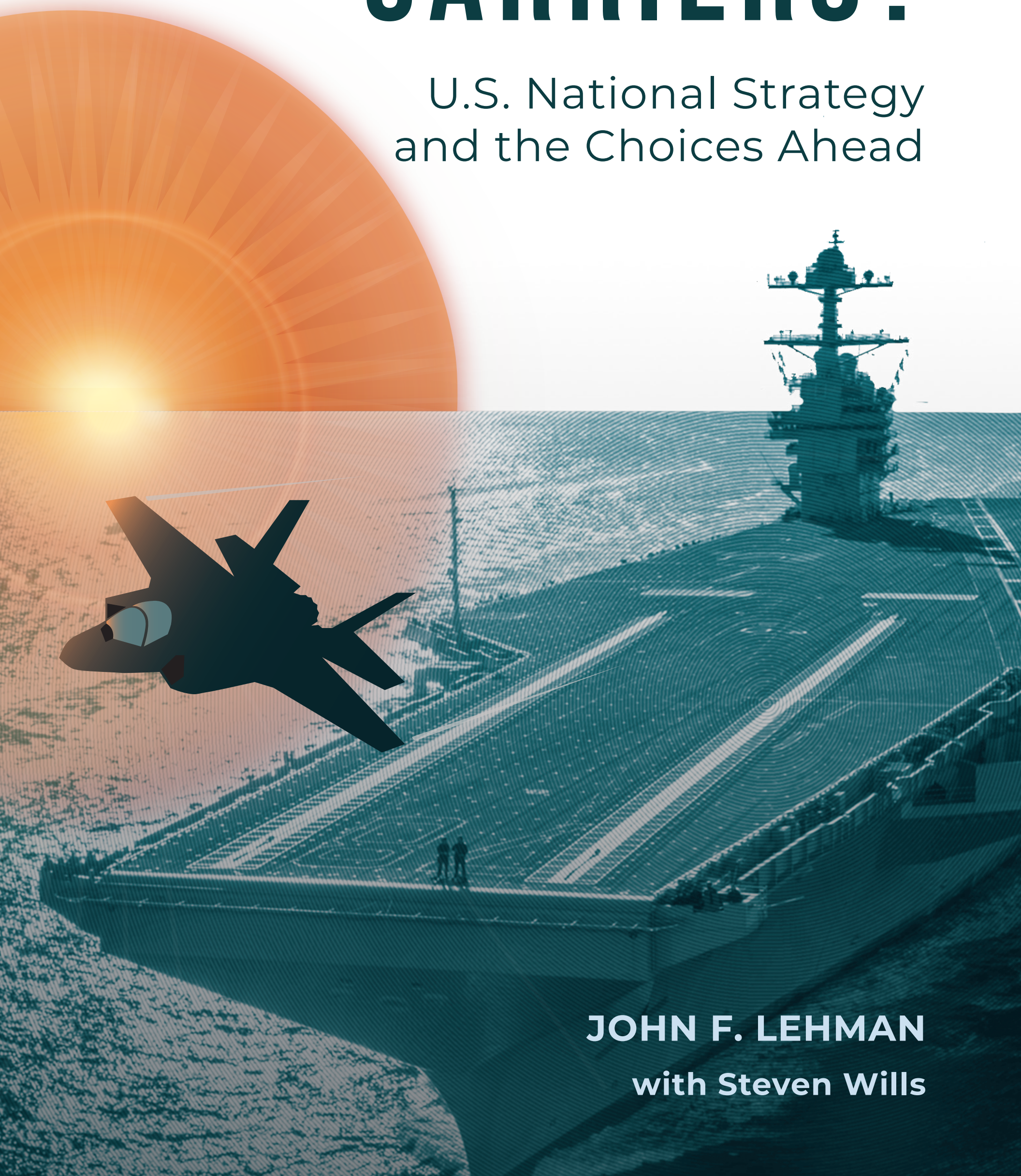
WHERE ARE THE CARRIERS?

U.S. National Strategy and the Choices Ahead



JOHN F. LEHMAN

with Steven Wills

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EXECUTIVE SUMMARY

As the United States seeks to prepare for a potential conflict with a peer-level adversary, the debate around the utility of the aircraft carrier—and its role in such a contingency—once again has resurfaced. Since the carrier's adoption over 100 years ago, policymakers and servicemembers have argued over the ship's mission, size, vulnerability, and—of course—cost. These arguments have become increasingly more pointed as the armed services compete over diminishing financial resources. Former Secretary of the Navy John Lehman, with the assistance of Center for Naval Analyses Analyst Steve Wills, evaluates aircraft carrier options as he has done numerous times in the past. These choices include:

- *Gerald R. Ford*-class nuclear-powered, large carrier
- Light carriers based on amphibious warfare ships of the *Wasp* and *America* class
- French nuclear-powered carrier *Charles de Gaulle* or conventionally powered British *Queen Elizabeth*-class carrier
- A new medium carrier the size of the Cold War *Midway*-class ships

Lehman and Wills analyze these choices with fact-based criteria by considering a number of questions. What are the missions for air power at sea as the United States again confronts great power rivals in the form of the People's Republic of China and the Russian Federation? How "survivable" is the carrier in conditions of "modern" combat? How many carriers are needed for a global conflict? How big or small should that flattop be? How many and what type of carrier-based aircraft should it support? Can carrier aviation survive as an effective component of U.S. power projection and sea control capabilities without the kind of longer-range strike aircraft that it possessed during the Cold War?

Where are the Carriers examines a wide range of sources, including those from Congress and the Defense Department, as well as carrier studies from both federally and privately funded research institutions, to develop a surprising conclusion on what the next U.S. carrier choice should be.

1

INTRODUCTION

"Events of October 1962 indicated, as they had all through history, that control of the sea means security. Control of the seas can mean peace. Control of the seas can mean victory. The United States must control the seas if it is to protect your security…"

– President John F. Kennedy, June 6, 1963, on board USS *Kitty Hawk* (CVA-63)

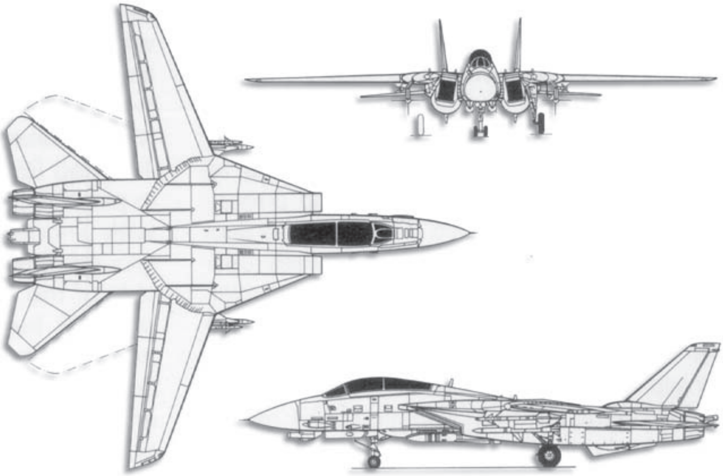
The aircraft carrier has been the stage for momentous events in U.S. history such as President John F. Kennedy's address onboard USS *Kitty Hawk* in 1963. Carriers have also been the source of intense debate since their operational introduction just over a century ago with the commissioning of HMS *Argus* into the Royal Navy on September 14, 1918[1] and the USS *Langley* into the U.S. Navy four years later. At that time and ever since, the carrier has faced intense criticism from rival services and political opponents. The arguments have not changed in the last century. Carriers—*it is said by critics*—are too expensive and too vulnerable. In times of peace, these same arguments are raised anew. In war, the carrier's ability to absorb battle damage; to defeat attacking bombers, kamikazes, and

1 David K. Brown, *The Grand Fleet* (Barnsley, U.K.: Seaforth Publishing, 2010), p. 117.

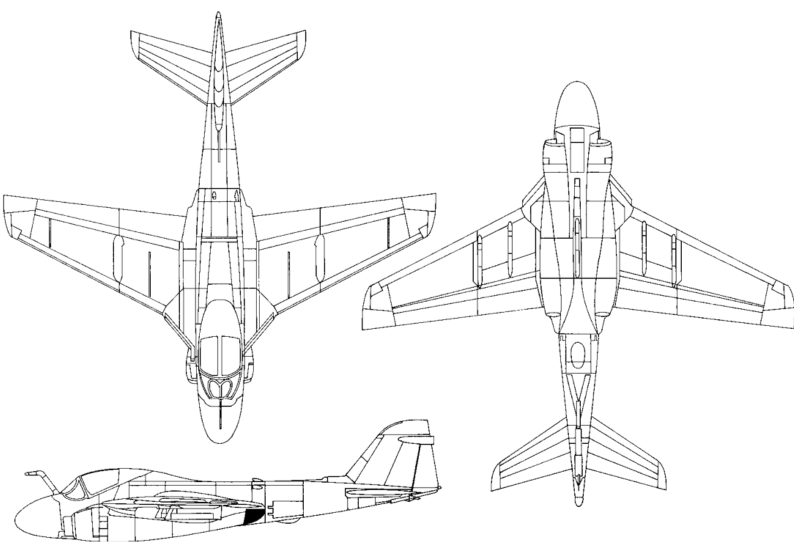
advanced missiles; and, above all, to provide the decisive winning power in combat ends the discussion.

There have been moments of high political drama in this perennial debate, including in 1949 the famous “Revolt of the Admirals” just after the Second World War when the Truman administration ordered the scrapping or mothballing of all but seven of the Navy carriers and the dismantling of the first supercarrier, USS *United States,* then under construction. The outraged Secretary of the Navy, John Sullivan, who was not even consulted on the decision, resigned immediately in protest. Many captains and admirals lobbied and testified against the administration, and many were fired in response. Led by the future Chief of Naval Operations Admiral Arleigh Burke, the Navy fought against efforts by Secretary of Defense Louis Johnson and Secretary of the Air Force Stuart Symington to go even further and give the Air Force all Navy and Marine aviation. Burke survived an attempt to be retired as a Captain, but the Navy’s future carrier programs seemed at best in shoal water at the end of the 1940s.

The Navy’s flattop force soon got a chance to prove their worth in the emerging Cold War world. Secretary of State Dean Acheson provided to Congress a survey of vital U.S. interests in the Pacific that excluded Korea. That exclusion, combined with the dramatic disarmament of the U.S. Navy, provided an irresistible temptation to the Soviet Union and the People’s Republic of China, and, on



F-14 (Courtesy of combataircraft.com)



A-6 (Courtesy of U.S. Navy History and Heritage Command)

June 25, 1950, North Korea attacked South Korea.[2] That, of course, brought about an abrupt end to the Truman administration's naval disarmament. Since the invasion captured all air force bases in South Korea, carrier-based aviation in the form of the strike groups from USS *Valley Forge* and her Royal Navy counterpart in the Western Pacific HMS *Triumph* began fighting against North Korean forces on July 3, 1950. These ships provided the only available tactical aviation support (86 U.S. and 40 British carrier aircraft) to United Nations forces opposing the North Korean offensive.[3] Carriers quickly proved their worth. With no more than four fleet carriers ever deployed against Korea, the Navy flew 276,000 combat sorties, only 7,000 short of its total for World War II, and dropped 177,000 tons of bombs, 74,000 tons more than the service had dropped in all of World War II.[4]

President Harry S. Truman sent an emergency bill to Congress, trebling the defense budget and cancelling the retirement of aircraft carriers; a few months later, he fired Secretary Johnson. The House Armed Services Committee and its Chairman, Representative Carl Vinson (D-GA), hailed the value of carrier aviation, and the first supercarrier USS *Forrestal* was authorized in July 1951.[5] The dramatic role that carrier air played in Korea ended criticism for the

2 Michael T. Isenberg, *Shield of the Republic: The United States Navy in an Era of Cold War and Violent Peace, 1945-1962 (*New York: St. Martins Press, 1993), p. 181.
3 Ibid, pp. 182, 183.
4 Ibid, p. 279.
5 Jeffrey Barlow, *The Revolt of the Admirals: The Fight for Naval Aviation, 1945-1950* (Washington, D.C.: U.S. Navy Historical Center, 1994), p. 288.
Authors' note: A "supercarrier" is generally a flattop displacing over 70,000 tons, but definitions vary.

next 20 years, but its use as a power-projection tool in bombing the North in the Vietnam War ensured another post-war debate.

The election of Jimmy Carter in 1976 started a new carrier battle with the same, now 60-year-old, arguments. Carter, a former submariner, was opposed to building more fleet carriers and intended to phase them out of the naval order of battle. In February 1977, Carter's selection for Defense Secretary, former Secretary of the Air Force Harold Brown, testified to Congress that he thought, "The age of the aircraft carrier was passing," and that, "In 20 years, he believed, many of their jobs would be done by cruise missiles, advanced tracking, detection, and identification of targets by satellites and radio transmissions."[6]

Carter succeeded in blocking the Navy's request for another nuclear carrier in the 1977 budget cycle, but big carrier advocates quickly regrouped. Despite Carter spokesmen arguing that a carrier would "require most of its resources simply to stay afloat in a conflict in the Mediterranean or Barents Sea against Soviet forces,"[7] Congress added another $2 billion *Nimitz*-class carrier to Carter's budget. In an unprecedented move, Carter vetoed the FY1979 defense budget because of the carrier. A major battle resulted in Congress, in which I played an active part, led by the bipartisan Committee on the Present Danger. We came within a few votes of overriding the veto, but Carter prevailed. World events, however, have usually determined the outcome of these periodic carrier debates, and this

6 Edward C. Keefer, *Harold Brown: Offsetting the Soviet Military Challenge, 1977-1981* (Washington, D.C.: Historical Office of the Secretary of Defense, 2017), pp. 37, 38.
7 Ibid, p. 233.

one was no exception. The Soviet invasion of Afghanistan and the Iranian takeover of the U.S. embassy set the stage for a walkover by the carrier advocates, augmented again by the presence in the Navy Senate office of Captain (and future U.S. Senator) John S. McCain. We clearly had more than enough votes to override a Carter veto, so he did not use it when the fourth *Nimitz*-class carrier was authorized by Congress and signed into law on November 9, 1979.[8] This authorization effectively ended the late 1970s "carrier crisis."[9]

It was not long after its passage, when I, as the new Secretary of the Navy, had the keen pleasure of naming that carrier USS *Theodore Roosevelt,* with Barbara Lehman as its sponsor. It was the first contract that I signed under the new competitive fixed-price procurement philosophy of the Reagan administration. Two decades later, this special relationship was strengthened when my son, John III, spent four years aboard *Theodore Roosevelt* flying Prowlers with VAQ-141 projecting power into Iraq and Afghanistan.

The Reagan Administration: "High-water Mark of the Carrier Force"

The U.S. Navy reached a high point of 15 carriers and 594 total ships in 1987, a growth of 74 ships from the end of the Carter administration stemming from the 600-ship navy initiative spearheaded by President Ronald Reagan.[10] Two "block buys," each

8 Ibid, p. 368.
9 Norman Polmar, *Aircraft Carriers, Volume 2,* (Sterling; VA, Potomac Books, 2008,) p. 364.
10 "US Navy Ship Force Levels, 1886 to the Present," U.S. Navy History and Heritage Command, 2020, https://www.history.navy.mil/research/histories/ship-histories/us-ship-force-levels.html, last accessed July 13, 2020.

of two carriers, a process where multiple ships of a single class are purchased in one year with significant cost savings, were executed in the FY1983 and FY1988 budgets, a feat not accomplished with fleet carriers since the Second World War.[11] The development of the 600-ship force came directly from the specific requirements to carry out the new Forward Maritime Strategy, the ultimate realization of the Reagan administration's determination to achieve unquestioned "command of the seas."

The experience of the 1970s made a 600-ship navy possible. With the Navy worn down and diminished by the essentially unfunded Vietnam War, Admiral Elmo Zumwalt was the first Chief of Naval Operations ever to declare that in his judgment the Navy had declined to the point that we would lose a naval war with an enemy (the Soviet Union).[12] Zumwalt and his two successors, Jim Holloway and Tom Hayward, rejected the purely defensive role of protecting the sea lanes between North America and Europe assigned to them by the groupthink of the Washington policy establishment. They were not, however, allowed by their superiors to advocate a forward strategy, or even use the terms command of the seas, naval superiority, or naval supremacy, in Navy documents or policies.

It was not until Reagan arrived with a fully thought-through and budgeted forward strategy with a strong bipartisan team to carry it out that the Navy's time had again come to regain superiority. For the first time since President Franklin D. Roosevelt in WWII, the

11 Ronald O'Rourke, "Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress," Congressional Research Service, June 14, 2012, p. 20.
12 Elmo Zumwalt Jr, *On Watch* (New York: Quadrangle Books, 1976), p. 281.

nation had a president and a bipartisan consensus in Congress that comprehended the absolute requirement for command of the seas, how to achieve it, and, above all, how to use it.

The Forward Naval Strategy

The culture of the U.S. Navy has been built from its earliest days on offense, and its orthodox creed on geopolitics. The Navy was never comfortable with the post-Vietnam defense policy of détente and convergence, nor with the fixation of the Army and Air Force on the North Atlantic Treaty Organization (NATO) central front as the only measure of the military balance. Historians will look back in wonder at how this myopia could demoralize and dispirit an alliance that, with its Asian allies, controlled the seas surrounding its adversaries. The Navy was seen in Washington as disruptive, and as, in that worst of all bureaucratic sneers, "not a team player." The top Navy leaders truly believed that, with an achievable increase in submarines, surface combatants, aircraft, and support, they could soundly defeat the Soviet Navy in a conventional war and use that command of the seas to strike strategic and tactical targets in the Soviet Union and their attacking land forces in Central and Western Europe.

Reagan and his principal advisors shared that belief and in extensive dialogue with those Navy leaders forged a strategy on which he ran for President of the United States. The heart of that strategy was shifting naval operations from defense to an aggressive offense. Instead of accepting existing policy to keep the Navy below the Greenland-Iceland-United Kingdom line ferrying supplies to Europe, the Navy, Marines, and Air Force would—in the event of war—go on the offensive in the Barents and Norwegian Seas and Eastern Mediterranean. Instead of abandoning the Pacific and swinging the Pacific Fleet to the Atlantic, the Navy would shift to the offensive in the northwest Pacific against the Soviet Far East. The Navy would effectively surround the Soviet Union with combat action.

The Navy enabled this shift by working with Congress to build, arm, and train its fleet to operate forward in all the seas near the Soviet Union. It exercised and demonstrated that it could not only defeat Backfire bomber stream raids, sea-skimming, and supersonic and ballistic missiles, as well as destroy the Soviet naval threat, but the Navy also demonstrated that it could strike deep into the Soviet heartland from the northwest Pacific Ocean and the Bering, Norwegian, Barents, and Mediterranean Seas.

Aircraft carriers were indispensable to this strategy. Each carrier—with its E-2C radar command and control aircraft, F-14 interceptors with Phoenix missiles, along with Aegis cruisers—supplied a 600-mile-wide dome of air superiority without which no surface combatant or logistic ship could survive. It supplied anti-submarine S-3 attack bombers and dipping-sonar helicopters that augmented the attack submarine undersea protection. Each carrier airwing included some 40 strike aircraft equipped with anti-ship and anti-tank missiles and precision-guided bombs. The requirement for 15 carriers, 100 attack submarines, and several hundred surface combatant and support ships was derived analytically from the global operations of the forward strategy, not the reverse as some critics alleged.[13]

The Navy lost no time in carrying out the new strategy. Seven months after Reagan's inauguration, 83 ships, including four carriers (two supercarriers, one vertical/short take-off and landing (V/STOL) carrier, one helicopter carrier), hidden by sophisticated cover and deception technology, raced north into the Norwegian Sea. The first the Soviets knew that these vessels were there was when USS *Eisenhower* sent four F-14s, four A-6s, and four KA-6 tankers 1,000 miles to fly at 550 knots through a Soviet exercise 13 miles off Murmansk.[14] The Soviets were flabbergasted and never really recovered from their previous confidence in the defense of their homeland from U.S. naval attack.

Every year thereafter, U.S.-led allied fleets carried out these realistic training exercises in those seas where they would fight if the Soviets attacked. Each exercise refined and improved tactics incorporating the newest technology. By 1985, the carriers were operating in Norwegian fjords and among Norwegian Sea archipelagos, making enemy targeting next to impossible.

Soviet Chief of the General Staff Marshal Sergei Akhromeyev visited the United States in July 1988 as part of Soviet leader Mikhail Gorbachev's desire to reduce tensions with the West. Akhromeyev flew out to the USS *Theodore Roosevelt* and observed a demonstration

13 John Hattendorf, *The Evolution of the U.S. Navy Maritime Strategy, 1977-1986* (Newport, RI: U.S. Naval War College Press, 2004), pp. 10, 11, 50; and Peter Swartz, "Peter Swartz on Creating Maritime Strategy, Pt. 1: Tactics and Creators," Center for International Maritime Security, January 19, 2021.
14 Recounted in the preface to John Lehman, *Oceans Ventured: Winning the Cold War at Sea* (New York: W.W. Norton, 2018).

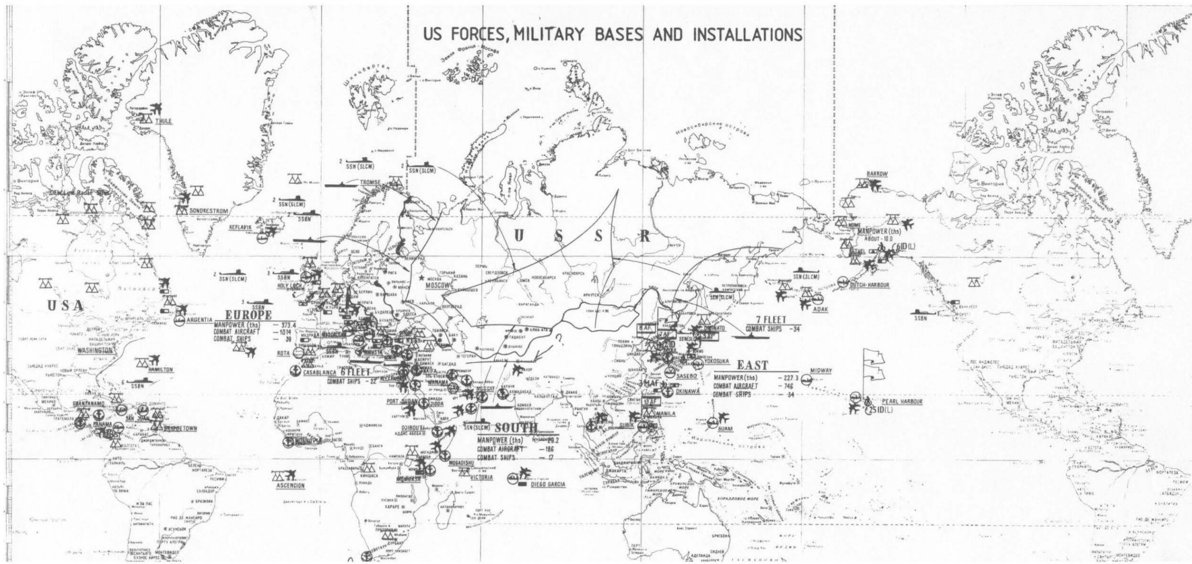
of the carrier airwing's capabilities. During the visit, Akhromeyev presented a global map to U.S. Chairman of the Joint Chiefs Admiral William Crowe that detailed a ring of U.S. naval bases, submarine, and aircraft carrier symbols surrounding the Eurasian continent and specifically the Soviet homeland. Akhromeyev told Crowe, "Your navy and bases surround my country and threaten the security of the Soviet Union."[15] The union of the Forward Maritime Strategy and 600-ship navy was the core of the Reagan administration's military and naval rearmament, crucial to deterrence and ultimate Cold War victory.

The Soviet Navy and Air Force came to realize that they could not cope with American sea and air superiority. In 1986, the Soviet General Staff sent a demarche to the Politburo, urgently requesting a tripling of the budgets for the Northern Fleet and Northern Air Force; otherwise, they believed, that in the event of war, they could not defend the northern flank for more than a week.[16] This belief hit the Politburo like a thunderclap and was a major factor in the Soviet collapse.

The 15 carrier battle groups, 100 nuclear attack submarines, and the equally essential elements of the 600-ship Navy—especially their deployment for seven-plus years of ever-improving exercises in waters adjacent to Soviet vulnerabilities around the world—were key in bringing about the end of the Cold War and the breakup of

15 Lehman, *Oceans Ventured*, pp. 236-237; Dmitry Filipov, "Spencer Johnson on Writing and Briefing the Maritime Strategy," The Center for International Maritime Security, April 28, 2021.
16 Ibid, p. 200.

Akhromeyev Map



Courtesy of Secretary Lehman

the Soviet Union.[17]

Post-Cold War

As in previous conflicts, Cold War victory brought an over-reaction in disarmament. The fleet was reduced in size below numbers needed to maintain a stable global deterrent despite strong Navy arguments to the contrary.[18] Chairman of the Joint Chiefs of Staff General Colin Powell and his staff designed and got approval for the "Base Force" of 1991 that cut the size of the Navy by one-third.[19] Those cuts included the carrier force, with numbers slipping from 15 flattops in 1991 to 12 in just three years.[20]

Aircraft carriers proved themselves as the indispensable platforms of the Cold War through operations in the Korean War, the Vietnam conflict, and dozens of other short-term crises. Every American president since WWII has often had the occasion to utter the words, "Where is the nearest carrier?" I first heard it demanded by President Richard Nixon when I worked for Henry Kissinger, on April 15, 1969.[21] That day, North Korea shot down a Navy EC-121 over international waters killing 31 sailors. There was no carrier in the theater, and we did nothing.

17 Dov S. Zakheim and John Lehman, "Lehman's Maritime Triumph," *Naval War College Review,* vol. 71, no. 4, (2018), p. 145.
18 Frank Kelso with Paul Stillwell, *The Reminiscences of Admiral Frank B. Kelso II, USN (retired)* (Annapolis, MD: U.S. Naval Institute Press, 2009), p. 595.
19 Lorna Jaffe, *The Development of the Base Force, 1989-1992,* Office of the Chairman of the Joint Chiefs of Staff, July 1993, p. 12.
20 "US Ship Force Levels, 1886-present," U.S. Navy History and Heritage Command, November 17, 2017, https://www.history.navy.mil/research/histories/ship-histories/us-ship-force-levels.html.
21 "The National Security Agency and the EC-121 Shootdown,"The Office Of Archives And History, National Security Agency/Central Security Service, 1989, p. 37.

Nimitz-class aircraft carrier USS Carl Vinson (CVN 70) transits the Pacific Ocean (U.S. Navy)

Carriers and Costs

To build the force of 15 carriers, we froze the design of the *Nimitz* class and built five more on fixed-price contracts that varied only in the steady introduction of ever-improving weapons technology. With the passage of the Goldwater-Nichols "reforms," decisions on new weapons were taken from the services and given to the significantly enlarged Defense Department bureaucracy. Under this new joint system, it was decided that the Navy should have a new carrier design. That new vessel's systems and design were decided not by the service, but rather by the Joint Requirements Oversight Council (JROC). This Pentagon council of the Vice Chiefs of the Armed Services and chaired by the Vice Chairman of the Joint Chiefs of Staff is charged generally with the assessment and approval of any "joint" capability fielded in support of the National

Defense Strategy (NDS).[22] While nominally a good idea, sometimes the JROC adds too many capabilities or makes decisions that result in poor outcomes. In the case of the *Ford*-class carrier, the desire to field so many transformational technologies and capabilities in one platform has resulted in the proverbial "design by committee of a horse" that results in a camel. USS *Gerald R. Ford* has been an unmitigated disaster. Started in 2008, it was some five years late and more than double the cost of the last *Nimitz*-class ship.[23] As of this writing, it may not be able to deploy for several more years.

Table 1: Carrier Statistics since World War II

Carrier Statistics since World War II					
Ship Class	Year Commissioned	Displacement tonnage (initial)	Length (feet)	Beam (feet)	Crew size (including airwing)
Essex	1942	27,100	872	147	3,170
Midway	1945	45,000	968	136	3,960
Forrestal	1955	60,000	1,039	252	4,100
Kitty Hawk	1961	64,000	1,072	252	4,600
Enterprise	1961	75,000	1,125	252	4,600
Nimitz	1973	75,800	1,092	252	5,244
Theodore Roosevelt	1986	80,753	1,092	252	6,275
America LHA	2014	44,971	844	108	1,200
Ford	2017	100,000	1092	256	4,660

Given the *Ford's* exorbitant price tag, many have advocated a return to smaller carriers. The USS *America*-class large deck amphibious

22 *Charter of the Joint Requirements Oversight Council (JROC) and Implementation of the Joint Capabilities Integration and Development System (JCIDS),* The Joint Staff, August 31, 2018, pp. A1-A2.
23 "Aircraft Carrier Named the USS George H.W. Bush Commissioned," Associated Press, January 10, 2009.

warship can be operated as a so-called "light" carrier and represents an alternate choice in flattop. We explore these smaller options later in the book.[24]

Table 2: Carrier Costs Since World War II

Ship Class	Year Commissioned	Cost when purchased/2019 value
Essex	1942	$68-$78 million / $1 billion
Midway	1945	$85.6 million in 1945/ $1.2 billion
Forrestal	1955	$217 million in 1952 / $3.13 billion
Kitty Hawk	1961	$400 million in 1961 / $3.4 billion
Enterprise	1961	$451 million in 1960 / $4.11 billion
Nimitz	1973	$1 billion in 1975 / $5 billion
Theodore Roosevelt	1986	$2.46 billion in 1986 / $5.74 billion
America LHA	2014	$3.4 billion in 2014 dollars
Ford	2017	$13.3 billion (with costs still rising)

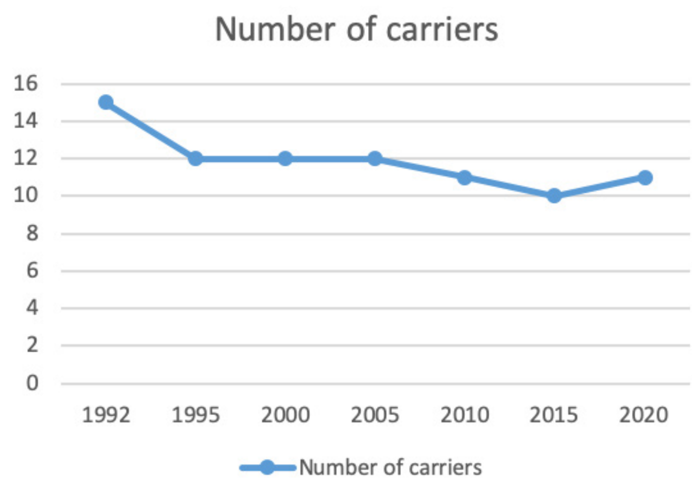
While carrier costs have steadily increased, their overall numbers have declined since the high point of 15 carriers in 1991, when the fifth *Nimitz*-class carrier USS *Abraham Lincoln* had been commissioned and the last 1940s-era flattop USS *Midway* had not yet retired. Since 1992, the number of carriers declined from 15 to 10 vessels, but increased to 11 ships with the commissioning of USS *Gerald R. Ford* in 2017.

24 Table figures: John Lehman, *Aircraft Carriers: The Real Choices,* Center for Strategic and International Studies, 1978, p. 8; Eric Wertheim, *The Naval Institute Guide to Combat Fleets of the World, 16th edition* (Naval Institute Press, 2013); and Norman Polmar, *Aircraft Carriers, Volume 2.*

The FY2017 budget specifically required the Navy to maintain at least 11 aircraft carriers and 9 carrier airwings.[25] That same legislation set a goal of 12 carriers as a component of the proposed 355-ship fleet. Challenges to these goals have continued. There was a brief dip to 10 carriers in the period December 2012 to July 2017 due to the retirement of the USS *Enterprise* (CVN 65).

Back to Great Power Competition

Figure 1: Number of Aircraft Carriers over the post-Cold War Era



The rise of the People's Liberation Army Navy (PLAN) and the return of a revanchist Russian Federation Navy have brought about a return of so-called "great power competition" to U.S. military planning and operations.

25 George C. Wilson, "USS Theodore Roosevelt Joins Active Service as 15th Carrier," *Washington Post*, October 26, 1986.

While the Russian Navy has struggled for decades to keep its sole carrier *Admiral Kuznetsov* operational, the Chinese Navy has forged ahead with an impressive carrier program that could lead to six full-sized flattops by 2035.[26] The Chinese have long been interested in carriers, having acquired the flight deck of the decommissioned Australian carrier HMAS *Melbourne* in 1985 for experiments.[27] The Chinese currently possess the sister ship of *Kuznetsov*, the former Russian carrier *Varyag* which was abandoned incomplete in the Ukraine and towed to China in 2001, where it was completed as the *Liaoning* (001.) This first carrier is referred to as a training platform by the Chinese and supports 40 fixed wing aircraft and helicopters.[28] It utilizes a ski jump in a "short takeoff but arrested recovery" (STOBAR) configuration. A second, improved version of the *Liaoning* built in Chinese yards and named *Shandong* (002) was completed in 2019. *Shandong* supports 44 fixed wing aircraft and helicopters including the Shenyang J-15 fighter, the Changhe Z-18 medium transport helicopter, and the Harbin Z-9 utility helicopter.[29] A third carrier is well under construction with integrated electric propulsion and potentially three electromagnetic catapults utilized by the USS *Ford*. This flattop designated 003 is well underway in construction and is expected to be completed in 2023. This larger flattop may support at least 40 fixed wing aircraft alone, and in

26 Mark Episkopos, "Could China Have 6 Aircraft Carriers by 2035?," *National Interest*, December 29, 2020.
27 Ian Storey and Yu Ji, "China's Aircraft Carrier Ambitions," *Naval War College Review*, vol .57, no. 1, Winter, 2004, p. 4.
28 "How Does China's First Aircraft Carrier Stack Up?," The Center for Strategic and International Studies (CSIS) , August 26, 2020.
29 Kelvin Curnow, "A look at China's new Type 002 'Shandong' aircraft carrier," *U.K. Defence Journal*, January 10, 2020.

addition to the J-15 and helicopters, this ship could operate the J-31 "clone" of the US F-35, the KJ-600 airborne early warning aircraft, and the JH-7 utility attack fighter.[30]

While formidable on paper, it has taken other powers decades to fully develop and utilize naval aviation. The Russian Navy has yet to engage *Kuznetsov* in an extended air strike campaign without accidents or the shift of her airwing to a land base.[31] While China may not yet be a great carrier navy, it has taken firm, positive steps in that direction. This choice by the Chinese perhaps suggests that the carrier is not an obsolete platform as many U.S.-based carrier detractors state.

The Trump administration called for an increased fleet of 355 ships, including 12 aircraft carriers, but his Defense Department requested only five new combatants and two tugs in the FY2020 budget, freezing Navy funding while increasing the Army budget by three percent. At the time of this writing, the Biden administration has yet to firmly voice its opinions on the Navy size, despite stating, "Navy shipbuilding will be a top area of focus for the Administration's review of the Trump Administration's defense plans and programs."[32] President Joseph Biden's first budget submitted in May 2021 included a topline of $211.7 billion, which is a 1.8% increase from

30 H. I. Sutton, "China's New Super Carrier: How It Compares To The US Navy's Ford Class," *Naval News*, July 2, 2021.
31 "Russian Combat Jets To Operate From Syria Airbase Following Carrier Landing Malfunction," *Defense World,* December 6, 2016, https://www.defenseworld.net/news/17876/Russian_Combat_Jets_To_Operate_From_Syria_Airbase_Following_Carrier_Landing_Malfunction#.YPx4yKhKg2x
32 O'Rourke, "Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress," April 22, 2021, p. 2.

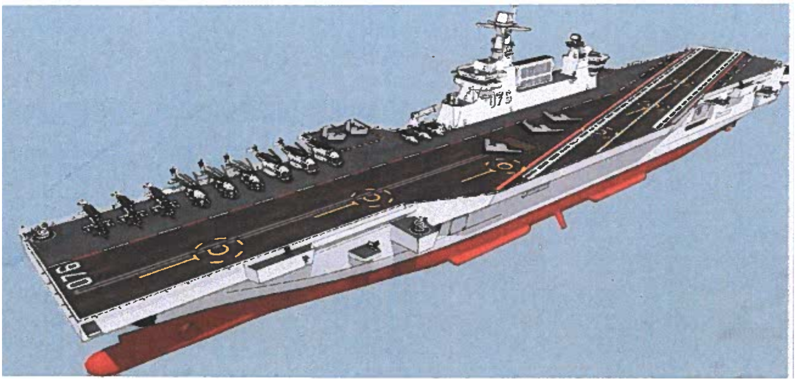
the last Navy authorization.[33]

As in my 1978 volume, this book will examine the key issues of the current carrier controversy:

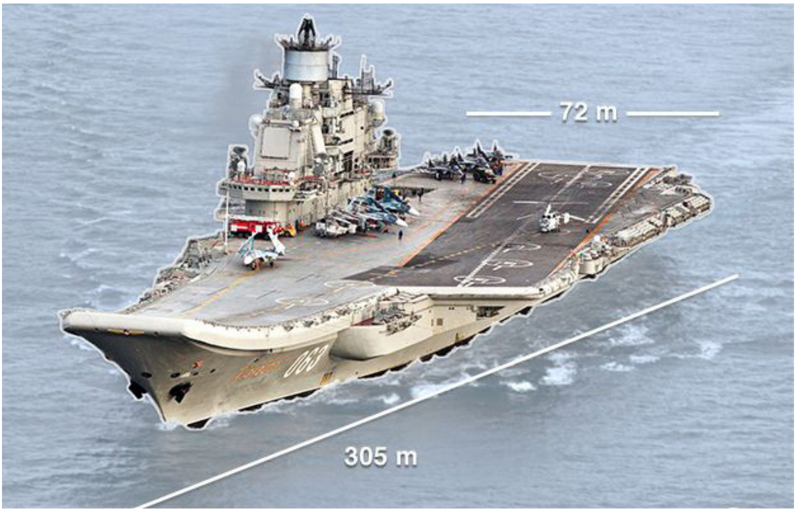
- *First*, what are the missions for air power at sea going into the third decade of the 21st century?
- *Second*, can land-based aircraft and missiles perform these missions better and more affordably than carrier aircraft?
- *Third,* how "survivable" is the carrier in conditions of "modern" combat?
- *Fourth,* how many carriers are needed?
- *Fifth,* can their costs be reduced significantly?
- *Sixth,* what are the options for carrier size and capability?
- *Seventh,* what are the choices for propulsion?
- *Eighth*, realistically, what is to be the role of unmanned aircraft?
- *Ninth,* what is to be done about the fact that the carriers now, unlike in 1978, lack long-range fighter and attack aircraft, a severe disadvantage for flattops of any size today and in the future?

As in 1978, all of these nine issues need to be understood in order to reach a sound, commonsense decision on the future of the Navy's carrier.

33 Mandy Mayfield, "BUDGET 2022: New Biden Budget Would Cut Navy Shipbuilding, Aircraft," *National Defense,* May 28, 2021.



Chinese Carrier (Courtesy of AD Baker III)

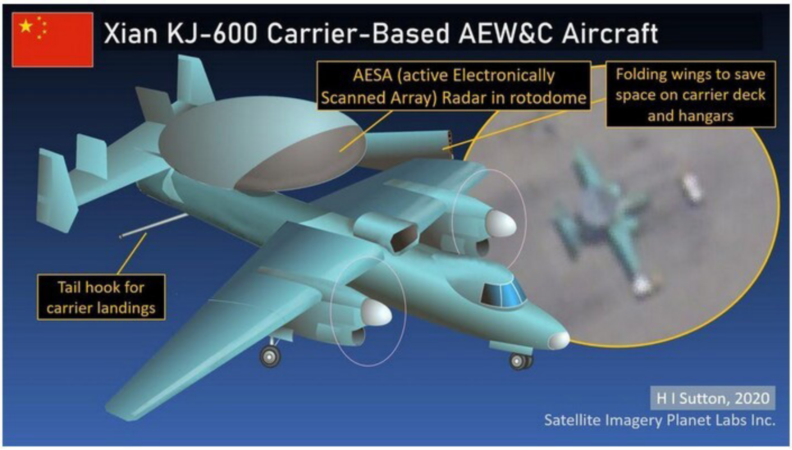


Admiral Kuznetsov: Russian flagship aircraft carrier (Courtesy of BBC)

F-31/J-35 Chinese stealth fighter (Courtesy of metadefense.fr)

Xian JH-J Flying Leopard (Courtesy of airvectors.net)

JI-5 (Courtesy of AP)



Xian KJ-600 Carrier-based AEW7C Aircraft (HI Sutton/Satellite Imagery Planet Labs, Inc).

2

LAND-BASED AIRPOWER AS A SUBSTITUTE FOR SEA-BASED AIRPOWER

"To the extent to which reliance can be placed in the next twenty years or so on fixed bases is at best very uncertain and we may in this period be faced with having no land base between the United Kingdom and Australia, there will be need for aircraft carriers to provide floating airfields from which British airpower can be operated."

– Chief of the Defence Staff Lord Mountbatten to UK Defence Minister, December 20, 1961

The United States, like Great Britain in the 1960s, may not be able to count on the availability or survivability of land-based aviation as it has for the last 30 years. Power projection has been the primary mission since the end of the Cold War, but the strategic situation is changing to one where sea-based aviation is again vital to sea control. As was the case at the start of the 1980s the mission is still an offensive one.

The change to the U.S. Navy's maritime strategy in the early 1980s, returned naval forces to an offensive posture from the defensive, convoy-escort role directed by the Carter administration in the

1970s. The maritime strategy, however, still focused on the land fronts of Central Europe, Norway, and the wider Mediterranean Sea region as well as those of Korea, Japan, and, possibly, China. Action by the Navy on the flanks of the assumed Soviet and Warsaw Pact advance into Central Germany would draw Soviet attention and resources away from this primary effort, weaken the main Soviet effort, and contribute to war termination.

The first Gulf War in 1991 was also a conflict driven by events on land, but it was the first post-Cold War conflict where naval forces were without a seagoing opponent to which the main part of their combat capability was normally devoted. It marked a return to power projection ashore, but with all aviation units harnessed to the Joint Force Air Component Commander (JFACC) for employment. The Gulf War JFACC, General Chuck Horner (USAF), rejected the Navy's ideas for the air campaign that included attacking air defenses before Baghdad and dividing geographic strike responsibilities between the Navy and Air Force (called "route packages"), as used in Vietnam.[28] Central Command (CENTCOM) Commander General Norman Schwarzkopf backed Horner, and naval aviation units became just another entry on the JFACC's daily Air Tasking Order (ATO) document.

The Air Force might not always be the right choice to lead the overall air battle. The position of JFACC tends to go to the service component responsible for the geography (maritime or land), or

28 Edward Marolda with Robert Schneller Jr., *Shield and Sword, The United States Navy and the Persian Gulf War* (Washington, D.C.: Naval Historical Center, 1998), pp. 114-115.

the one that brings the most aircraft to the fight. Though the U.S. Navy flew 72 percent of all combat sorties in the 2001-02 Operation *Enduring Freedom* in Afghanistan, the Commander of U.S. Forces European Theater (EUCOM) selected the Air Force to be the JFACC with its headquarters in Vicenza, Italy, far from the carriers in the Red Sea or the targets in Afghanistan.[29] The focus of the fight was not maritime, but placing the JFACC so far from the actual source of aviation combat power and the target set was only possible due to the lack of opposition. Future fights against peer opponents may require the JFACC to be closer to the fight and perhaps even embarked afloat on a carrier, an AEGIS cruiser, or a command ship, such as USS *Blue Ridge* or USS *Mount Whitney*.

In the post-Cold War U.S. combat interventions around the Eurasian landmass, the Air Force has usually been the biggest contributor to the air fight and hence the right choice as the JFACC. That was not usually due to an absence of carrier-based aircraft in those operations. In fact, carriers were often the first U.S. forces on the scene, and flattops provided the initial weight of air support until more numerous Air Force aircraft could deploy to accessible airfields in the region to support the air campaign. The lack of peer competitor opposition to U.S. forces meant that unlike the projected Cold War maritime strategy against the Soviet Union, U.S. carriers could expect to close within fairly short range of potential targets and, in many cases such as Afghanistan and the 2003 Iraq War, face little opposition to strike operations. The lack of a peer competitor

29 Robert S. Tripp, Kristin F. Lynch, John G. Drew, and Edward W. Chan, *Lessons from Operation Enduring Freedom* (Santa Monica, CA: RAND Corporation, 2004), pp. 21-22.

also tended to support the retirement of long-range naval strike aircraft developed in the Cold War without replacement, such as the A-6 Intruder and the F-14 Tomcat.[30]

Overall, the provisions of the 1986 Goldwater-Nichols Act that empowered regional commanders at the expense of the services tended to chain carrier groups to ground combat for long periods of strike operations even when more land-based aircraft could have been a better choice. This also upsets the balance between missions for land- and sea-based aviation. Lumping both together into a JFACC for a low-threat campaign like Afghanistan that is entirely land-based is acceptable, but in cases where there is a maritime component to the fight, sea-based aviation may need to be resident with the Joint Force Maritime Component Command (JFMCC).

The rise of China as a peer competitor and the return of a revanchist Russia calls for a re-evaluation of the joint air component practices developed over the last 30 years. Unlike wars against regional bullies and non-state actors, the defenses of peer opponents will no longer allow the short-range strike operations of the recent past. The geography of the Chinese threat and some aspects of the Russian challenge are also different in that they are positioned in remote maritime locations with a real deficit of suitable, defendable land-based aviation. The wide areas of the Indo-Pacific, the Russian Pacific region, and the emerging Arctic revealed by climate change cannot be patrolled, let alone controlled, by land-based airpower

30 Benjamin S. Lambeth, "American Carrier Air Power at the Dawn of a New Century," RAND Corporation, 2004, p. 5.

from only a few bases in those regions. The improved accuracy and larger numbers of cruise and ballistic missiles available to U.S. peer opponents has also greatly increased the vulnerability of those air bases to attack.

The issue is now not so much a choice between land- or sea-based aviation but how to effectively assign and use both in a variety of geographic and operational environments. While secure land basing has been possible for nearly all U.S. combat operations since 1990, that is not likely to be the case when facing peer competitors China and Russia. Iran, North Korea, and violent extremists also have the capability to threaten U.S. land-based aviation on the ground, something that Saddam Hussein and the Islamic State (ISIS) could not accomplish. In some theaters, such as the Indo-Pacific and the Arctic, carrier-based aviation may provide the bulk of aviation assets, and naval commanders may lead both the Joint Force Maritime and Air components of a joint task force—a situation not seen since the Cold War.

Requirements for Air Power at Sea in the 21st Century

After the end of the Vietnam War, the U.S. Navy undertook a shift from decades of power projection ashore in support of conflicts, such as in Korea and Vietnam, to a focus on sea control against the Soviet Navy. The Falklands War of 1982 was the most significant use of carrier aircraft for sea control missions since the end of the Second World War and highlighted some of the challenges of small aircraft carriers in executing that mission.[31]

Following the end of the Cold War and in the wake of the First Gulf War, national policy returned the U.S. Navy to the role described by Samuel Huntington as "oriented away from the oceans and toward the land masses on their far side."[32] Fleet operations shifted back (again) to one of power projection ashore with both carrier aircraft and cruise missiles. Examples of that include both Gulf Wars, operations in Afghanistan after 9/11, and the Balkan wars of the 1990s. Land-based aviation played an equal role in these operations. Naval aviation provided much of the early coalition airpower that deterred Iraq from continuing its assault into Saudi Arabia in late 1990.[33]

As in 1990, carriers provided the bulk of combat aviation and the initial basing and support for insertion of special operations forces into Afghanistan in 2001 (75 percent) and significant capability from five carriers in the Second Gulf War in 2003.[34] Follow-on carrier deployments to the Middle East through the 2010s continued to provide air strikes in support of continued Iraq and Afghanistan missions, as well as countering the threat posed by ISIS. Carrier-based aircraft were again the first available capability for striking

31 "Lessons of the Falklands, Summary Report," The Chief of Naval Operations Staff, Office of Program Appraisal, February 1983, pp. 4, 29.
32 Samuel Huntington, "National Policy and the Transoceanic Navy," *Proceedings*, United States Naval Institute, May 1954.
33 Richard Halion, *Storm over Iraq, Air Power and the Gulf War* (Washington, D.C.: Smithsonian University Press, 1992), p. 136.
34 Christine Fox, "Carrier H. Operations, Looking Toward the Future—Learning from the Past," The Center for Naval Analyses, May 27, 2009, pp. 8-10.

ISIS in August 2014.[35]

Aircraft carriers have been successful contributors to all of these operations as they do not need status-of-forces agreements, basing rights, and extensive forward bases from which to operate. Nor do they require all of the costly security, facilities, and magazines that go with any shore-based aviation capability. While carriers have been remarkably flexible in these roles, the return of great power opponents with significant adversary capabilities, including active defense systems with significant missile armament, has required the rebuilding of strike-force capabilities to roll back and destroy sophisticated integrated air defense systems.

The Geography of Naval Action

There is a very large overlap in fleet design, weapons mix, and tactical training for blue water sea control and projection of power ashore. The swing in emphasis back from naval operations in support of land campaigns in Southwest Asia to potential clashes of great power rivals' battle fleets at sea in both littoral and deep ocean areas, however, resurfaces some of the important geopolitical theories of the late 19th-early 20th century that influenced maritime strategy. The writings of American naval theorist Alfred Thayer Mahan on achieving "command of the seas" through the defeat of an opponent's battle fleet are again gaining ground in the world's most significant navies. The writings of British geographer Sir Halford Mackinder described the Eurasian super-continent as an "autarkic fortress" from

35 Dave Majumdar, "U.S. Navy Strikes ISIS Targets in Iraq," *U.S. Naval Institute News,* August 8, 2014.

which global power could be exercised against the world's maritime nations.[36] China and Russia, the powers that could potentially dominate that "world island," are enjoying a resurgence after the Cold War. China, in particular, with its Belt and Road Initiative and efforts to command the approaches to Eurasia through military defenses and exclusive economic zones, is determined to dominate the core of Eurasia and its natural wealth.[37] The United States, Western Europe, Japan, Vietnam, Philippines, Indonesia, India, Australasia, and other lands immediately adjacent to Eurasia form what political geographer Nicholas Spykman called the Rimland. Spykman described this geographic middle ground as an area of "marginal and Mediterranean seas," which created a "circumferential maritime highway" that links the whole area together in terms of sea power.[38] As in the great conflicts of the 20th century, Eurasian powers intent on controlling the heartland and surrounding territories again menace the Rimland powers by seeking to build naval and maritime superiority over the geographically blessed Rimland powers, which are dependent on the seas for their trade, communication, and, ultimately, livelihood.

Missions for Airpower at Sea in the 21st Century

Naval power is the key to the mission of defending the Rimland maritime trade and communication routes from Eurasian states

36 Halford Mackinder, "The Geographic Pivot of History," *The Geographical Journal*, vol. 23, no. 4 (April 1904), p. 437.
37 Colin Dueck, "Mackinder's Nightmare: Part One," Foreign Policy Research Institute, October 8, 2019.
38 Nicholas Spykman, *The Geography of the Peace* (New York: Harcourt, Brace and Company, 1944), p. 38.

intent on taking and exploiting them, and sea-based aviation is the core of that effort, as it was during the Cold War. The sea-based aviation missions are control of the air above the operating area, control of the maritime surface and commercial sea lanes, and control of the seas below the surface.

Deterrence through command of the seas—relying on power projection and sea control—remains the most important mission for carrier-based aircraft. The high degree of lethality, mobility, sustained reach, and flexibility of carrier aviation are integral to these missions.[39] Some commentators separate these missions, but, in real life, they are both integrated and integral in naval forces and especially in the carrier airwing. The aircraft carrier at sea is an integral combat unit, but also a flexible one reconfigurable on short notice to conduct any of these operations based on the aircraft it carries and the weapons mounted on those platforms. The Navy's own doctrine states, "We are trained, equipped, and ready to wrest control of the seas, deny the sea to our enemies, project and sustain power ashore, and conduct maritime security operations against a variety of threats. Our versatility ensures we are ready to respond regardless of the nature of the nation's need."[40] Carriers remain capable of conducting any of these operations and can shift from one to another on short notice.

39 David Berger, Michael Gilday, and Karl Schultz, *Advantage at Sea, Prevailing with Integrated All-Domain Naval Power,* Department of the Navy, December 2020, p. 20.
40 Ibid, pp. 1, 5.

The Political Dimensions of Carrier Operations: Assurance, Deterrence, and Compellence

The political/perceptual dimensions of sea-based air power are perhaps the most overlooked carrier capability. Pentagon force planners then and now are more concerned with the costs of carriers than their utility in assuring allies, deterring aggression, and, when necessary, providing force to compel an adversary to U.S. demands. These operations became commonplace in the middle and late Cold War. They accelerated with the end of the Cold War and in the 20 years of Middle East war after the 9/11 attacks.

Following September 2001, deployed carrier battle groups shifted much of their mission focus from direct assurance and deterrence operations to combat strikes in Southwest Asia. Operations *Enduring Freedom* and *Iraqi Freedom*, followed by strikes on the Islamic State, became the primary flattop mission.[41] Carriers provided a great deal of flexibility to these operations by functioning as strike platforms, afloat staging bases for special operations forces (in the case of USS *Kitty Hawk* in early Afghan operations), and hubs for humanitarian service operations. Examples of these include USS *America* and *Dwight Eisenhower's* delivery of and support to the Army's First Cavalry and 82nd Airborne Divisions to Haiti in 1994. They also include relief efforts by USS *Abraham Lincoln* in the wake of the 2003 Indo-Pacific tsunami and support to the Operation *Tomodachi* relief effort in Japan by USS *Ronald Reagan* following the massive

41 Fox, "Carrier Operations, Looking Toward the Future-Learning from the Past," p. 10.

Tohoku earthquake and tsunami in 2011.[42]

Before 1975, U.S carriers deployed to two "hubs": the Western Pacific and the Mediterranean. After the fall of the Shah of Iran, the Middle East became another regular U.S. carrier deployment "hub." As combat commanders demanded more carrier deployments, the shrinking number of U.S. carriers since the Cold War has resulted in the steady decline in the number of flattops deployed per year from 4.5 in 1975 to 2.8 in 2005.[43] As carrier numbers shrink, a maintenance problem on even one flattop can dramatically influence the schedule of the rest. A delay in USS *Harry S. Truman's* 2019 deployment left USS *Abraham Lincoln* deployed for a record 295 days at sea. Six other carriers on the East Coast were in various states of maintenance.[44] The overall result of shrinking carrier numbers over time has been to limit the employment of carriers in other locations due to that focus on two of the three usual deployment hubs. As a result, deterrence declined as China, Russia, Iran, and North Korea judged the United States as a declining power.

Despite this perception, carriers have been part of specific deterrence efforts since the end of the Cold War. These include highly publicized, recent uses, such as the deployment of USS *Harry S. Truman* to the NATO exercise *Trident Juncture* in 2018, the first deployment of carrier aviation above the Arctic Circle since the

42 Ibid; Andrew Feickert and Emma Chanlett-Avery, "Japan 2011 Earthquake: U.S. Department of Defense Response," Congressional Research Service, June 2, 2011, p. 4; and "Carriers Assume New Role in Heat of Haiti Mission, *The Daily Press,* September 16, 1994.
43 Fox, "Carrier Operations, Looking Toward the Future-Learning from the Past," p. 13.
44 Ben Warner, "Top Stories 2019: U.S. Navy Operations," *U.S. Naval Institute News,* December 31, 2019.

Cold War.[45] Other recent carrier deterrence operations featured the three-carrier deployment off North Korea in 2016, ongoing carrier deployments to the Persian Gulf to assure allies and deter Iranian aggression, and, more recently, the deployment of the carriers *Nimitz* and *Ronald Reagan* to the South China Sea in July 2020.[46] USS *Dwight Eisenhower* received tasking to cover the withdrawal of U.S. forces from Afghanistan in April 2021.[47] The deployed carrier and her airwing continue to be the obvious choice for senior U.S. policymakers for deterrence operations.

The problems of the COVID-19 pandemic slowed some of these operations and revealed the vulnerability of large naval crews to viral transmission, as was the case on USS *Theodore Roosevelt.* Carrier deployments have continued despite that temporary setback, with U.S. carriers resuming important assurance port visits to Oman in the first week of September 2020.[48] Given their mobility, sustained reach, and flexibility in operations, the carrier continues to be the most impactful tool of choice for political uses of sea power. Their reduced numbers, however, limit the opportunity for such strengthening of deterrence. With only three currently deployable to cover the world's oceans, presidents must now often be disappointed when in crisis they ask, "Where are the carriers?"

45 Christopher Woody, "A US aircraft carrier is in the frigid waters north of the Arctic Circle for the first time since the Soviet Union collapsed," *Business Insider,* October 19, 2018.
46 Jack Detsch, "U.S. Carriers Send a Message to Beijing Over South China Sea," *Foreign Affairs,* July 9, 2020.
47 Sam LaGrone, "Eisenhower Carrier Strike Group Could Extend Stay in Middle East to Cover Afghanistan Withdrawal," *U.S. Naval Institute News,* April 22, 2021.
48 Sam LaGrone, "U.S. Carriers Resume Port Visits to Oman After 7-Month Gap," *U.S. Naval Institute News,* September 10, 2020.

F/A 18F, Jolly Roger squadron (Courtesy of USNI News)

Power Projection and Sea Control

The carrier's primary use since the end of the Cold War has been power projection ashore through sustained airstrike campaigns in Southwest Asia (Afghanistan and Iraq). While effective in these operations, the carrier's airwing had a shorter range, as Defense Secretary Dick Cheney eliminated replacement long-range carrier aircraft in 1990 in favor of the short-range F/A-18.[49] He canceled all of the Navy's current and future long-range carrier aircraft, including the F-14D Tomcat, A-6F Intruder, A-12 Avenger, and S-3 Viking. His staff persuaded him that with the looming end of the Cold War, they were not needed.[50]

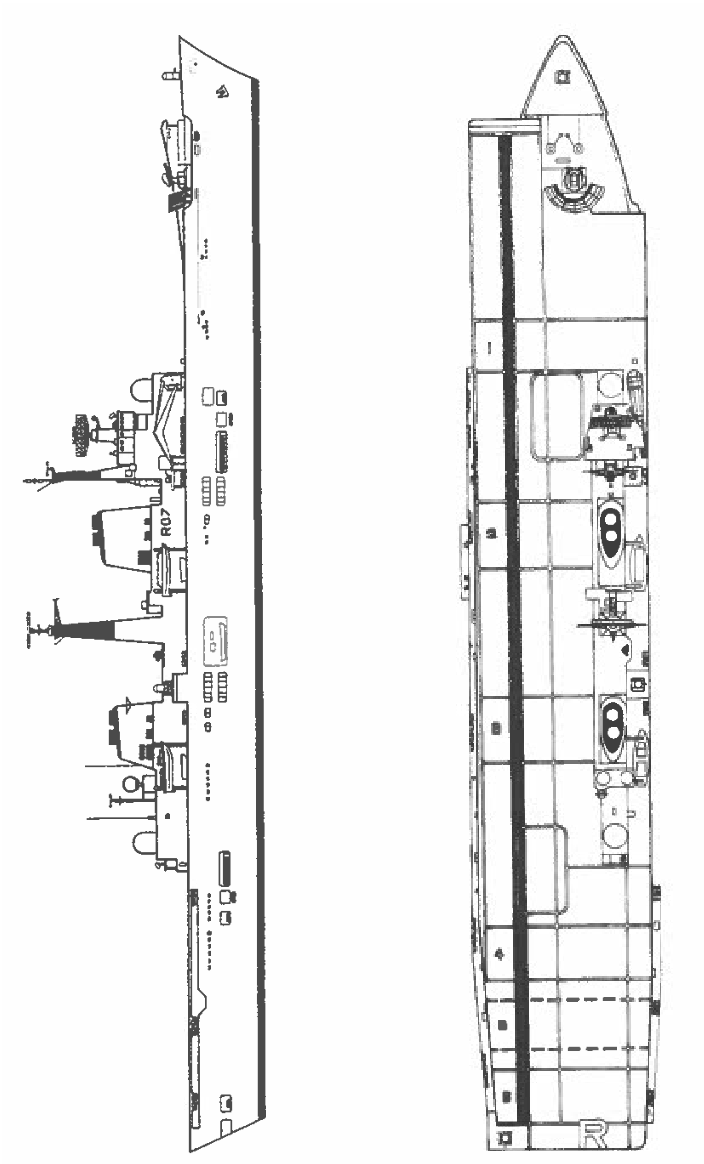
49 Statement of Rep. Randy "Duke" Cunningham, "The Future of Naval Aviation," Statement in the House of Representatives, May 7, 1991, https://fas.org/man/dod-101/sys/ac/docs/910507-f14.htm.
50 Jerry Hendrix, *Retreat from Range, The Rise and Fall of Carrier Aviation,* Center for New American Security, October 2015, p. 45.

While an airwing armed only with F-18 E/F aircraft does have a shorter strike range, the threat to the carrier and its airwing in the post-Cold War era was much less, allowing the flattop and its battle group of surface combatants to operate much closer to target sites. A 1994 General Accounting Office (GAO) report stated this fundamental shift from a long-range, Cold War-era airwing to a much shorter-legged successor as follows:

> Upgraded F-14s generally have greater range than the F/A-18C and could possibly reach targets beyond the Hornet's range. However, this capability may not be needed with the Navy's shift to a littoral warfare strategy. In the Navy's revised strategy, 'From the Sea,' dated September 1992, it announced a need to concentrate on capabilities required to operate near the world's coastlines. The Navy recognized that this direction represented a fundamental shift away from open-ocean war fighting and toward joint service operations conducted from the sea. In defining this change of emphasis, the Secretary of the Navy said: '85% of the Navy's potential (Middle East) targets are within 200 miles of the coast. This is within the F/A-18C's range.'[51]

This "retreat from range" as named by naval historian Jerry Hendrix continued over the post-Cold War period into the 21st century.

51 *Naval Aviation, F-14 Upgrades Are Not Adequately Justified,* United States General Accounting Office, October 1994, p. 3.



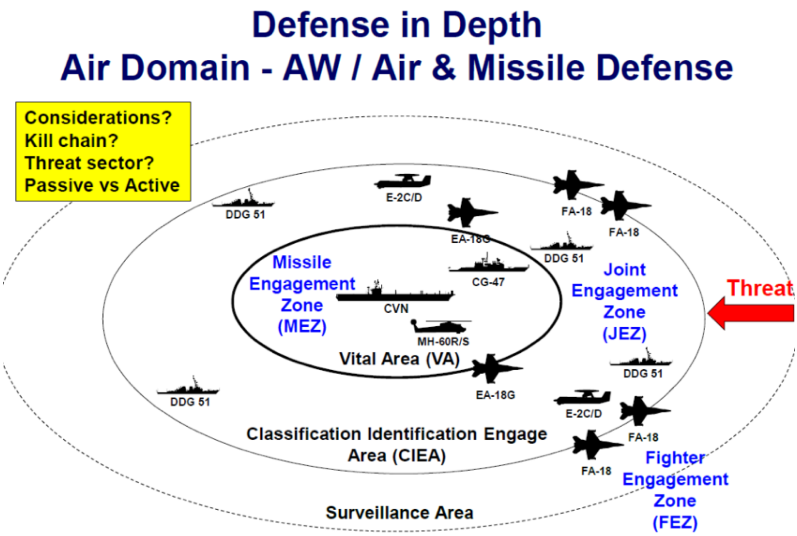
HMS Ark Royal (Courtesy of A.D. Baker III)

According to an assessment by one DC-based think tank, "By 2006, the carrier airwing (CVW) had transformed from a force of long-range interceptors and attack aircraft built for great power conflict to an airwing of relatively short-range multi-role fighters intended for operations in regional conflicts and with irregular adversaries."[52]

The return of great power competition, however, now forces carriers and their escorts back into the business of sea control, which must be achieved and sustained in order to project power ashore. This was an expected requirement during the Cold War and detailed in the 1980s Forward Maritime Strategy. Aircraft carriers "would begin to form into multi-carrier battle forces" and "would seize the initiative, engaging Soviet air attacks as far forward as possible in outer air battles, to cause maximum attrition."[53] The carrier's sea control capability was enabled by the evolution of the "outer air battle" concept that included aircraft like the F-14 able to engage Soviet missile platforms at the outer range of their capabilities. Surface warships were equipped with the AEGIS combat system that allowed them effectively to engage and defeat those missiles and aircraft that penetrated the outer defenses (fighter engagement zone) as detailed in Figure 2.

52 Bryan Clark, Adam Lemon, Peter Haynes, Kyle Libby, and Gillian Evans, *Regaining the High Ground at Sea, Transforming the U.S. Navy's Carrier Airwing for Great Power Competition at Sea,* Center for Strategic and Budgetary Assessments, 2018, p. 53.
53 "The Maritime Strategy," Office of the Chief of Naval Operations, OPNAV 60 P-1-84, 1984, pp. 45, 55.

Figure 2: Defense in Depth in the 2020s, The Air Domain



Source: "Naval Combined Arms and Joint Warfare," Naval War College Joint Maritime Operations curriculum materials, United States Naval War College, 2021, p. 20.

There is no longer a fleet air defense fighter like the F-14, but the AEGIS anti-air system is now the standard for U.S. Navy cruisers and destroyers and soon the FFG-62 frigate that forms the carrier's partners in providing air superiority. While these surface combatants are highly effective in shooting down enemy aircraft, as well as supersonic and hypersonic missiles, they and the Army transports, tankers, merchant ships, and amphibious warfare vessels that surface combatants escort cannot survive for long without air cover. They must have 24-hour-a-day fighter cover. The majority of the earth's surface is out of range of land-based fighters, which cannot provide round-the-clock coverage. Only carrier airwings can provide that capability. The future battle spaces cited by the most recent National

Defense Strategy, where U.S. forces are first likely to encounter opponents, are almost exclusively maritime spaces.[54] Much of those operations are not within the capability of land-based air 24 hours per day for weeks on end. Future conflicts may be missile wars, but the carrier's capacity for sustained operations, flexibility in the air platforms it supports, and survivability still place it in the forefront of complex operations that include both sea control and power projection.

The Operational Warfighting Dimension of Sea-Based Air Power

The airwings assigned to the current *Nimitz* and succeeding carriers will vary in size and composition and can be altered according to the threat and geography of each operation. They generally consist of the following aircraft:

1. Four Strike Fighter (VFA) squadrons (44-48 F-18 E/F Hornet and now including F-35C Lightning) aircraft
2. One Carrier Airborne Early Warning (VAW) squadron (4 E2C Hawkeye or 5 E2D Advanced Hawkeye) aircraft
3. One Airborne Electronic Attack (VAQ) squadron (6 EA-18G Growlers)
4. One Helicopter Sea Combat (HSC) Squadron (8 MH-60S Seahawk) helicopters
5. One Helicopter Maritime Strike (HSM) Squadron (up to 11 MH-60R Seahawk) helicopters
6. One Fleet Logistics Support (VRC) Squadron Detachment

54 James Mattis, *Summary of the 2018 National Defense Strategy*, U.S. Department of Defense, 2018, p. 7.

(2 CM-22B Osprey tiltrotor) aircraft

7. Tanking: currently provided by Air Force aircraft or F/A-18 E/F aircraft in the role of "buddy tanking"[55]

Navy large deck amphibious warfare ships with carrier-like flight decks of the *Wasp* and *America* classes have embarked the AV-8B Harrier and, more recently, have operated small F-35B wings as so-called "Lightning" carriers.[56] Other aircraft that could potentially be embarked on current and/or future large fleet carriers include:

1. The MQ-25A Stingray unmanned tanker. This first unmanned aircraft considered for carrier operations might operate in squadrons of three with the goal of refueling 4-6 aircraft per flight, significantly extending the range of current F-18 E/F aircraft.[57] Initial operating capability is estimated for 2024.[58] (The MQ-25A is a conventional takeoff and landing aircraft and as such could not be embarked on the *Wasp*- and *America*- class "Lightning" carriers.)
2. A future long-range strike aircraft, while currently still in research and development, is badly needed. A carrier's current airwing (including the F-35C) lacks the range necessary to operate outside current adversary land-based missile envelopes. A future carrier-borne strike aircraft

55 Megan Eckstein, "Navy Getting 'Smarter' About Tanking Mission As Super Hornets Approach 6,000 Hours," *U.S. Naval Institute News,* August 12, 2015.
56 Megan Eckstein, "Marines Test 'Lightning Carrier' Concept, Control 13 F-35Bs from Multiple Amphibs," *U.S. Naval Institute News,* October 23, 2019.
57 Sam LaGrone, "MQ-25 Stingray Unmanned Aerial Tanker Could Almost Double Strike Range of U.S. Carrier Air Wing," *U.S. Naval Institute News,* August 31, 2017.
58 David Larter, "If the US Navy isn't careful, its new unmanned tanker drone could face a 3-year delay," *Defense News,* June 10, 2020.

(manned or unmanned) might resemble the stillborn A-12 Avenger aircraft program cancelled in 1991 by the Bush administration.

As was the case in the 1970s and 1980s with the rise of the Soviet Navy, there is no lack of operational level of war missions for the individual carrier strike group and multi-flattop carrier battle force in the new age of great power competition. The emergence of a Chinese carrier force, now totaling three vessels with the potential for up to six carriers by the 2030s, suggests the possibility of carrier duels in blue water like the great Pacific War of the 1940s.[59] There is no doubt that such conflicts will be challenging, especially, if for some unknown reason, the action closes with land-based Chinese assets including the large, land-based missile force detailed in the Defense Department's most recent report on Chinese defense modernization.[60]

As was the case with Cold War maritime strategy, the carrier's first mission might be war at sea against enemy surface, subsurface, and aviation units. Attrition of Chinese surface and air forces, for example, could enhance the implementation of *guerre de course,* targeting Chinese global commerce, including sea-based aviation strikes against Chinese infrastructure and ports, mining of ports and sea lanes, and the closing of straits to Chinese merchant and naval shipping. Carrier-based aviation enforcing blockades would serve

59 Nick Childs, "China's carrier-aviation developments: making a difference," Institute for International Security Studies, June 3, 2018.
60 *Military and Security Developments Involving the People's Republic of China 2020, Annual Report to Congress*, Office of the Secretary of Defense, 2020, p. 16.

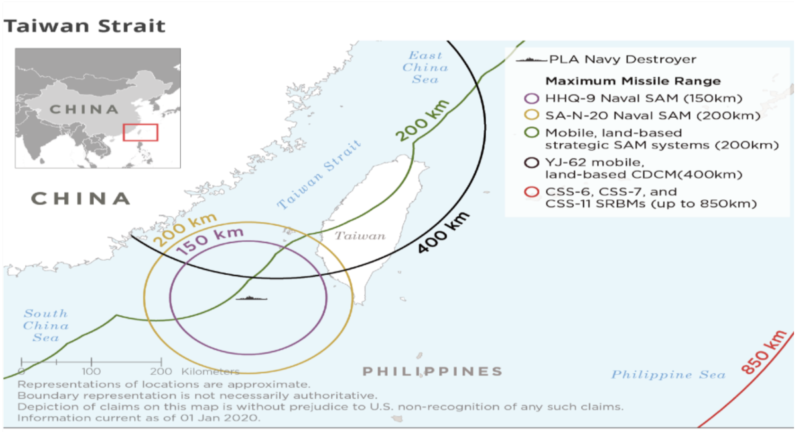
as the likely backbone of global horizontal escalation operations against oversea Chinese military and commercial installations. Such a capability greatly strengthens deterrence, as "a blockade would damage China's economy, deny its leaders access to key resources needed to fight the war, and ultimately compel its leaders to negotiate an end to the conflict. Like deep strikes on the Chinese mainland, the prospect of a blockade could deter China from starting a conflict."[61]

Large and small carriers can participate in these actions, but the 1982 Falklands War highlighted the challenges of small carriers in extended operations. The small UK carriers HMS *Hermes* and *Invincible* lacked the endurance, high-performance aircraft, fixed-wing airborne early warning aircraft, and airwing numbers necessary for sustained operations in the remote Falklands operating area. A 1983 U.S. report on the lessons learned from the Falklands pointedly criticized these limitations and stated that a similar U.S. force built around larger, more capable carriers would have suffered far fewer losses than the British did in the relatively short Falklands conflict.[62]

The Russian Navy is a mere shadow of the former Soviet fleet, but still possesses modern submarines and missiles that can threaten Western targets afloat and ashore.[63] What is similar to the Cold War is that the Russian General Staff greatly fears the power of a U.S. "aerospace blitzkrieg" led in large part by carrier-based aircraft and

61 Fiona Cunningham, "The Maritime Rung on the Escalation Ladder: Naval Blockades in a US-China Conflict," *Security Studies*, vol. 29, no. 4, 2020, p. 732.
62 *Lessons of the Falklands, Summary Report,* Chief of Naval Operations Staff, Office of Program Appraisal, February 1983, pp. 4-7.
63 Steve Wills, "'These aren't the SLOC's you're looking for': Mirror-imaging battles of the Atlantic won't solve current Atlantic security needs," *Defense & Security Analysis*, vol. 36, no. 1, p. 38.

Figure 3: Maximum Missile Ranges in the Taiwan Strait



Source: Office of the Secretary of Defense, "Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2018," United States Department of Defense.

their weapons.[64] Russia's strategic geography is even worse than its Soviet predecessor, and Russian naval forces remain geographically divided and not self-supporting, as has been the case since the Crimean War of the 1850s. Attempts by one fleet to support distant counterparts have been challenging at best, as highlighted by the doomed voyage of the Russian Baltic Fleet to the Pacific during the Russo-Japanese War, climaxing in the disastrous Russian defeat at Tsushima in 1905. U.S. naval aviation is very useful in bridging and controlling these distances that are often devoid of useful land bases for aircraft. In the case of the Russian Northern and Pacific

64 Michael Kofman, "It's Time to Think About A2/AD. Rethinking the Russian Military Challenge," *War on the Rocks*, September 5, 2019.

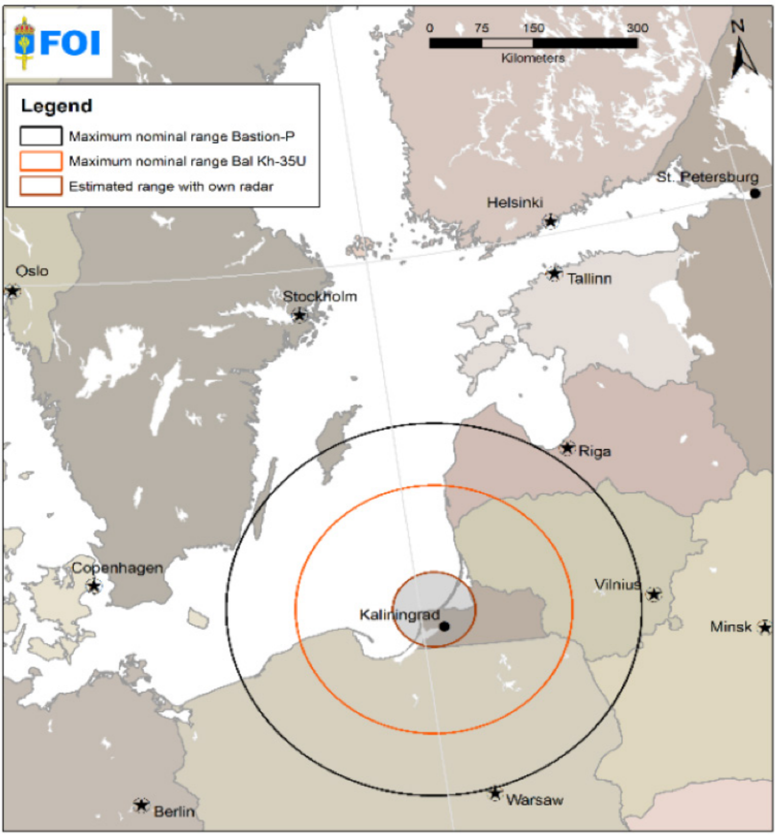
fleets, carrier-based aviation would comprise the largest part of any aerospace campaign against those formations.

Much of Russia's long-range response to sea-based aviation is dependent on land-based systems, including significant aerospace control that might not be possible in the presence of U.S. carriers. A recent Swedish report on Russian long-range, anti-air, and anti-surface weapons details some of the weaknesses in Russia's ability to counter sea-based aviation in the Baltic Sea in the absence of airborne support. The range of the K-300P Bastion mobile surface-to-surface missile system is substantially less if forced to rely on its own radar system for targeting.[65]

Sea-based aviation remains a powerful component of the overall U.S. joint force, especially in remote locations where land-based aircraft are unavailable, through lack of bases or time needed to move them into position to act in an air campaign. The continuing acquisition of carriers by China and a number of U.S. allies, including Great Britain, France, Japan, Italy, and now South Korea, demonstrates that the flattop remains a vital component of diplomacy, power projection ashore, and operational warfare at sea.

65 Robert Dalsjo, Christoffer Berglund, and Michael Jonsson, "Bursting the Bubble, Russian A2/AD in the Baltic Sea Region: Capabilities, Countermeasures, and Implications," Swedish Defense Research Agency, March 2019, p. 35.

Figure 4: Russian Missile Range Rings in the Baltic Sea Ranges for ground-based S-400 radars against targets at different altitudes



3

CAN CARRIERS SURVIVE IN THE MODERN AGE?

"It is often said that the battleship died because it was vulnerable. This is incorrect; it was replaced by the fleet carrier that was much more vulnerable. The battleship died because it was far less capable than the carrier of inflicting damage on the enemy."

– David K. Brown, Royal Navy Constructor, 2000

The aircraft carrier has been the subject of vulnerability concerns since the first Royal Navy flattop, HMS *Argus,* put to sea in late 1918. Combinations of mitigating factors were tried out, from adding cruiser-sized guns to the pioneering American carriers USS *Lexington* and *Saratoga* in the 1920s, to the armored flight decks of British carriers in World War II, and finally the massive size, compartmentation, armor, and side protection of current large U.S. Navy flattops.

Since the end of the Second World War, the U.S. Navy fleet carrier has exceeded the size and cost of the largest battlewagons ever built, but with far more sustained combat capability. Any assessment of carrier "vulnerability" must compete against the carrier's significant ability to inflict damage on multiple enemy targets in the air, on the surface, under the sea, and on land. It also must deal with this critical question: "Compared to what?" Land-air bases? Surface Action Groups with no air cover? Small carriers?

The most recent U.S. Navy survivability document breaks down the concept of warship "survivability" into "susceptibility, vulnerability and recoverability."[66] These three measures provide an excellent framework in which to assess the survivability of the carrier. Many are quick to put the carrier in the same obsolescence bin as the post-World War II battleship without an adequate examination of the facts.[67] The real choice is whether the strategic and operational value of the carrier exceeds its costs and the inherent risks that come with operating an airfield at sea.

Susceptibility

The first category of survivability assessment—susceptibility—is defined by the Navy as "the ability of a warship to avoid and/or defeat an attack and is a function of operational speed, agility, and tactics, signature reduction countermeasures, cover and deception and self-defense system effectiveness."[68] These factors are important to assess the carrier's survivability in that some experts now fear that the deep oceans no longer offer a carrier refuge from enemy attack owing to the increasing

66 "Survivability Policy and Standards for Surfce Ships and Craft of the U.S. Navy," OPNAVNAVIST9070.1B, Office of the Chief of Naval Operations, No. 9, November 17, 2017, pp. 4, 5.
67 Carl Forsling, "The Aircraft Carrier Is in Danger of Becoming the Next Battleship (As in Obsolete)," *The National Interest,* November 30, 2018.
68 "Survivability Policy and Standards for Surface Ships and Craft of the U.S. Navy," p. 4.

capability of land-, air-, and space-based sensors to locate a carrier at significant distance. According to a 2015 study by the RAND Corporation, the Chinese were assessed as capable of long-range, sky wave radar detection out to 2,000 km as of 2017.[69] In addition to the threat from air- and surface-launched missiles, the Chinese have also improved their ability to cue submarine assets to attack carrier strike groups. RAND assessed that over the period from 1996 to 2017 that the number of submarine attacks the Chinese could deploy against a U.S. carrier threat rose from near zero in a seven-day operational period to almost five in the area around Taiwan and the South China Sea.[70]

It seems likely that the ability of the Chinese to threaten U.S. carrier strike forces with missiles and submarines has only grown from those assessments. According to a September 2020 report on Chinese Naval Modernization by the Congressional Research Service, the U.S. Department of Defense assessed that Chinese anti-ship ballistic missiles and conventional cruise missiles could accurately strike naval targets beyond 1,500 kilometers and potentially out to 4,000 kilometers. Its broad-area maritime surveillance and targeting systems "would permit China to attack aircraft carriers, other U.S. Navy ships, or ships of allied or partner navies operating in the Western

69 Eric Heginbotham, Michael Nixon, Forrest E. Morgan, Jacob L. Heim, Jeff Hagen, Sheng Tao Li, Jeffrey Engstrom, Martin C. Libicki, Paul DeLuca, and David A. Shlapak, "Chinese Threats to U.S. Surface Ships: An Assessment of Relative Capabilities, 1996–2017," RAND Corporation, September 14, 2015, p. 2.
70 Ibid, pp. 2-3.

Pacific."[71] Of course, U.S. Navy advances in technology to counter these attacks have grown at least as fast and possibly faster.

While the ability of Chinese forces to identify and potentially track U.S. surface forces has certainly improved over time, the U.S. Navy has not yet fully engaged in the kind of deception operations and advanced technology that it used effectively during the Cold War. These included the use of environmental conditions, emissions control, new technology, cyber, and a busy exercise schedule designed to hone deception skills.

U.S. carriers operating in the Eastern Mediterranean Sea in the later Cold War discovered that some areas of that water space had acoustic conditions that made tracking those ships by submarine a challenging prospect. U.S. Second Fleet Commander Vice Admiral Henry ("Hammerin Hank") Mustin concealed his flattops inside Norwegian fjords and surprised Soviet forces with aircraft that seemed to appear from nowhere.[72] Admiral James "Ace" Lyons used sophisticated electronic deception to mask the movement of 83 U.S. and NATO vessels in a 1981 Norwegian Sea exercise. Lyons used a small group of vessels heading southeast; they "squawked" radars and sonars to mimic naval aids to navigation and used scrambled and clear voice communication to simulate the main

71 Ronald O'Rourke, "China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress," Congressional Research Service, March 9, 2021, pp. 5-6.
72 David Winkler and Henry C. Mustin, *The Oral History of Vice Admiral Henry C. Mustin* (Annapolis, MD: Naval Institute Press, July 2001), pp. 169-171.

force. Meanwhile, the rest of the fleet proceeded north into the Norwegian Sea in complete electronic silence, surprising Soviet forces in the Barents Sea who believed Lyons to be thousands of miles away from Soviet waters.[73]

Victory in the Cold War left the U.S. Navy without an opponent against which to practice such tactics. In the last 30 years—a career lifetime in the past for the young ensigns and lieutenants of the late Cold War now commanding the fleet—such operations atrophied and then vanished into myth and story. There was no need for extensive cover and deception in the wars since 1991, conducted in the words of one naval strategist against "people in the desert who could not shoot back."[74]

The geography of the Indo-Pacific no doubt has similar acoustic dead zones and sea areas masked by terrain as were the cases, respectively, in the Eastern Mediterranean and Norwegian fjords in the 1980s. Technological advances have made emission control, spoofing (transmitting fake signals), meaconing (interception and rebroadcast with different signals), multiplying, and jamming both easier and more complex today. Such tools and skills must be reacquired and fully absorbed into fleet tactics.[75] Submarines that can approach and attack a carrier undetected have always been a

73 Lehman, *Oceans Ventured*, pp. 16-17.

74 Comment to the authors from naval strategist Peter Swartz.

75 Jim Loerch, "Empowering Electronic Warfare To Save Carrier Strike Groups," *AFCEA Signal Magazine,* September 1, 2016.

threat and continue to require vigilant antisubmarine warfare (ASW) technology and operations to defeat. Finally, while it is dangerous to underestimate an opponent, it is equally foolish to endow them with capabilities they do not yet have. The U.S. Navy may have forgotten some of the successful tactics of the Cold War, but its potential opponents are even more bereft of tactical experience. The Russian Navy's financial woes of the post-Cold War era have severely limited its ability to train and exercise. The Chinese PLAN has not engaged in combat operations since its 1979 punitive expedition against Vietnam.

Vulnerability

While all surface vessels are susceptible to attack, the vulnerability of the carrier to multiple new weapons (the hypersonic cruise missile and the anti-ship ballistic missile, as well as an arsenal of other arms, including submarine torpedoes, mines, and drones) is again at the center of the debate on the large carrier's viability. The Navy survivability instruction defines vulnerability as "a measure of the capability of the ship, mission-critical systems and crew to withstand the initial damage effects from conventional, chemical/biological/nuclear (CBR), or asymmetric threat weapons or accidents, and continue to perform assigned primary warfare missions and protect the crew from serious injury or death."[76]

76 OPNAVINST 9017.1B, November 2017, p. 5.

Often missed in the conversation about carrier vulnerability is that the vessel's combat mission is largely responsible for its perceived weakness. Huge, open hangar decks, large stores of flammable aviation fuel, and high explosive weapons certainly make for an inviting target.[77] While vulnerable to crippling damage based on these characteristics, the record of the larger U.S. carriers taking serious battle damage and continuing to conduct flight operations is impressive. U.S. Navy damage control has always been exemplary and remains proficient even in the present when other Navy capabilities have atrophied.[78] Consider these examples of carrier survivability in the face of vulnerable characteristics:

World War II-era incidents: On October 30, 1945, USS *Franklin* (CV 13) was unexpectedly attacked by a Japanese kamikaze suicide plane carrying a 550-pound bomb that penetrated the ship's unarmored flight deck, igniting dozens of other weapons on the aircraft parked on the ship's hangar deck.[79] Less than six months later, on March 19, 1945, *Franklin* was hit again by two 500-pound bombs from Japanese attackers using kamikaze tactics. *Franklin* suffered more than 800 dead out of 2,600 personnel aboard at the time of the attack.[80] *Franklin* suffered

77 U.S. Navy Facts and Figures, USS *Theodore Roosevelt*, https://www.public.navy.mil/airfor/cvn71/pages/factsandfigures.aspx.
78 Robert E. Schmidle and Mark Montgomery, "A report on the Culture of the United States Navy Surface Fleet," The Congress of the United States, 2021, p. 15.
79 "USS Franklin CV-13 War Damage Report No. 56," U.S. Navy Bureau of Ships, September 15, 1946, pp. 8-9.
80 Norman Friedman, *U.S. Aircraft Carriers: An Illustrated Design History* (Annapolis, MD: U.S. Naval Institute Press, 1983), pp. 153-156, 232.

the worst wartime losses of any surviving U.S. Navy ship.[81] The official U.S. Navy damage report on *Franklin* highlights both the enduring vulnerability of the carrier as a weapon system, but also the robust design and survivability of the large flattop in action. The report noted, "The major damage sustained in each of the actions of October 30, 1944 and March 19, 1945 demonstrates the effectiveness of bomb hits when received by aircraft carriers during the extremely vulnerable period just prior to and during periods of launching strikes."[82] The *Franklin* report also states, "The latter two cases of damage to *Franklin* illustrate thoroughly the ability of modern U.S. aircraft carriers to survive extensive damage from plane crashes, fire and heavy bombs."[83] Despite the vulnerability, carriers can survive heavy damage and remain afloat, if not operational. When *Franklin's* fires were finally under control, the ship resumed steaming under her own power and was able to leave the operating area under control. The damage to the *Franklin* was important in that it helped set new design parameters for post-World War II flattops, beginning with USS *Midway* (CV 41) that emphasized armor and improved protection for the carrier.[84] During the Okinawa campaign, the Japanese launched an estimated 1,900 kamikaze sorties against the Allied fleet.[85] Of

81 "USS Franklin (CV-13) Big Ben, National Medal of Honor Museum website, https://mohmuseum.org/ussfranklin/, 2019.

82 "USS Franklin CV-13 War Damage Report No. 56," pp. v-vii.

83 Ibid.

84 Ibid, pp. 21-22.

85 Nicolai Timenes, Jr., *Defense Against Kamikaze Attacks in World War II and its Relevance to Antiship Missile Defense*, Center for Naval Analyses Operations Evaluation Group, November 1970, p. 54.

the 793 kamikazes that actually found targets, 181 hit ships and another 95 crashed close enough to cause damage.[86] Most aircraft were very agile fighters using very effective tactics, often superior to modern anti-ship missiles. During 1945, kamikazes and another six bombers using kamikaze tactics hit six large carriers. None were sunk or damaged beyond repair.[87]

Vietnam-era accidents: USS *Oriskany*, *Forrestal*, and *Enterprise*. The lessons learned from *Franklin* and other World War II carriers influenced the design of subsequent Cold War flattops with positive results. Three cases in particular emphasize the survivability of the big carrier across the Cold War.

A fire occurred aboard the USS *Oriskany* on October 26, 1966, while the carrier was conducting airstrikes against Vietnamese targets. The fire was caused by the accidental ignition of a signaling flare that a sailor threw into a flare locker inside the ship's aircraft hangar. Several planes caught fire, ordnance on those aircraft detonated causing further damage, and a number of sailors were trapped by the blaze. Forty-two sailors were killed. Despite damage, *Oriskany* returned to its Philippine base under its own power.

On July 29, 1966, the carrier USS *Forrestal* was operating in the Gulf of Tonkin conducting air strikes on Vietnamese

86 Shawn Woodford, "The Most Difficult Antiaircraft Problem Yet Faced By the Fleet: U.S. Navy vs. Kamikazes at Okinawa," U.S. Navy History and Heritage Command, June 18, 2020, https://www.history.navy.mil/browse-by-topic/wars-conflicts-and-operations/world-war-ii/1945/battle-of-okinawa/antiaircraft-problem.html.
87 Ibid.

targets. While preparing to launch aircraft, she suffered a major fire due to the accidental launch of a Zuni ground attack rocket attached to one of the aircraft.[88] Initial damage control efforts to smother fires and prevent the explosion of ordnance failed, killing nearly all of the ship's aviation firefighting specialists. Future Senator John S. McCain, Jr., barely escaped death while dismounting from his bomb-laden A-4 *Skyhawk* engulfed by the fires. The damage to the ship was significant and summarized in one historical account as follows: "One 500-pound bomb, one 750-pound bomb, seven 1000-pound bombs, and several missile and rocket warheads were exposed to the heat from the fire and exploded with varying degrees of violence. It took about 10 hours to extinguish all of the fires on the ship. This disaster resulted in 134 deaths, 161 injured, 21 aircraft destroyed, and 39 aircraft damaged."[89] While the ship was rendered non-operational because of the explosions and fires, she was able to steam under her own power to the U.S. Naval Air Station, Cubi Point (the Philippines) for temporary repairs before returning to the United States for overhaul. One of the improvements stemming from the *Forrestal* fire was the addition of deck-edge foam sprayers to better blanket the ship's flight deck and smother fires.[90]

The first nuclear-powered carrier USS *Enterprise* suffered the third major carrier fire of the Vietnam era on January 14, 1969,

88 *Investigation of Forrestal Fire,* Chief of Naval Operations Staff, August 21, 1969, pp. 1-3.
89 Raymond Beauregard, *The History of Insensitive Munitions,* (Wordpress Publishing, 1994); and *Investigation of the Forrestal Fire*, p. 86.
90 *Investigation of the Forrestal Fire*, p. 113.

while conducting flight training near Oahu, Hawaii.[91] Again, a Zuni rocket was responsible for the accident; this time, its ignition was caused by the hot exhaust gas of a tractor-pulled aircraft starting- motor parked adjacent to an F-4 aircraft with Zuni rocket launchers. At least 18 distinct explosions (most from 500-lb. bombs) blew five holes and three major dents in the ship's flight deck, causing major damage and the death of 34 sailors.[92] Sixteen aircraft were also destroyed in the fire. Despite major damage, all fires on the ship were out in 4 hours, and she returned to Pearl Harbor under her own power and served another 45 years. Despite significant numbers of high-order explosions, the ship's nuclear power plant remained safe and the damage well contained to the area of the blasts.[93]

Crew training and proficiency, especially in firefighting, played a role in the survivability in each of the three Vietnam-era carrier fires. *Enterprise* in particular was a larger flattop than the other carriers damaged by accidents and hence more survivable. She also benefitted from lessons taken from the *Forrestal* fire in terms of flight deck firefighting. There is no doubt, however, that the large carrier is a very survivable platform despite her inherent vulnerabilities stemming from unique mission requirements. *Enterprise* was later assessed as surviving the equivalent force of six heavyweight Soviet cruise missile strikes in the course of her accident but could have

91 *Investigation of the USS Enterprise Fire, 14 January 1969,* Naval Judge Advocate General's Office, 1969, p. 1.
92 Ibid.
93 Ibid, p. 26.

continued flight operations had they been required.[94]

Recoverability

The third piece of the survivability triad is recoverability, defined by the Navy's survivability instruction as "a measure of the capability of the ship and crew, after initial damage effects, whatever the cause, to take emergency action to contain and control damage, prevent loss of a damaged ship, minimize personnel casualties, and restore and sustain primary mission capabilities."[95] The ability of *Franklin, Oriskany, Forrestal,* and *Enterprise* and their crews to recover from those combat actions/ accidents and get back underway on their own power in a few hours testifies to the big flattop's robust construction. It also says something about U.S. Navy sailors and the commitment of the service to constant improvements in damage control. While tragic and unnecessary, the 2017 collision between the destroyers USS *Fitzgerald* and *John S. McCain* that claimed the lives of 17 sailors could have been much worse had the sound damage control principles forged during the Cold War not been present.[96]

Carrier Survivability in the Present

Vietnam War-era cases in carrier survivability and destroyer

94 John Lehman, *Aircraft Carriers: The Real Choices,* Center for Strategic and International Studies, 1978, p. 41; and *Investigation of the USS Enterprise Fire; 14 January 1969,* p. xxi.

95 OPNAV 9070.1B, p. 5.

96 Gerry Roncolato, "Fitzgerald Delivers Damage Control Lessons and Questions," *Proceedings Today,* U.S. Naval Institute, vol. 143/8/1,374, August 2017; and "USS John S. McCain suffered flooding after collision: U.S. Navy," *Reuters*, August 21, 2017.

USS America CV 66 sinkex (U.S. Navy)

collisions in the present offer some valuable insight into carrier survivability, but two more recent events further inform decision making about the current and future survivability of the big flattop and potential, smaller air-capable ships. The former *Kitty Hawk*-class flattop USS *America* (CV 66) was the subject of four weeks of extensive survivability testing in May 2005 before her scuttling by evaluators.[97] The tests were designed to support the development of the future, large nuclear carriers.[98] Reports remain classified but indicate that *America*, with a double hull and more than a thousand watertight compartments, resisted sinking until being deliberately sent to the bottom. Then-Vice Chief of Naval Operations Admiral

97 Jason Dearen, "Navy's Practice of Sinking Ships Raises Red Flags," *Norfolk Virginian-Pilot*, March 5, 2012.
98 *Department of the Navy Fiscal Year 2007 Budget Estimates Submission: Justification of Estimates,* Department of the Navy, Research, Development, Test and Evaluation, February 2006, p. 234.

John Nathman said of the tests, "We will conduct a variety of comprehensive tests above and below the waterline collecting data for use by naval architects and engineers in creating the nation's future carrier fleet. It is essential we make those ships as highly survivable as possible."[99] A controlled sinking exercise is not a combat test, but it does suggest that the current *Nimitz*- and *Ford*-class carriers that were built as improved versions of the *America* are very survivable.

The other, unintended recent test of aviation ship survivability was the July 12, 2020, fire aboard the USS *Bonhomme Richard*, an aircraft carrier-like, large amphibious warfare ship while she was moored at Naval Station San Diego, California. The ship was undergoing upgrades to allow her to operate F-35B Lightning aircraft as one of the so-called "Lightning" carriers, such as the most recent USS *America*, a similar large amphibious warship that deployed with 13 F-35B Marine Corps Lightning aircraft.[100]

Bonhomme Richard suffered severe damage as a result of a fire that affected 11 of the ship's 14 decks, buckled segments of her flight deck, damaged her vehicle storage area, and gutted the command-and-control spaces located in the ship's "island," a tower structure projecting above her flat landing deck.[101] The Navy declared the damage was so severe that *Bonhomme*

99 Letter to the USS *America* Veterans from VCNO ADM John Nathman, 2005.

100 Megan Eckstein, "Marines Test 'Lightning Carrier' Concept, Control 13 F-35Bs from Multiple Amphibs," *U.S. Naval Institute News*, October 23, 2019.

101 David Larter, "US Navy's top officer reveals grim new details of the damage to *Bonhomme Richard*," *Defense News,* July 22, 2020.

Richard was beyond economical repair and ordered scrapped.[102]

The ship was in port at the time of the fire and only a small component of her crew was on duty to combat the fire. Perhaps, a full crew as the ship has at sea might have put out the fire more rapidly, but the blaze demonstrates the vulnerability of large amphibious ships acting as light carriers. While ships like *Bonhomme Richard* and *America* look like aircraft carriers and are in fact larger than World War II flattops like the *Franklin*, they are not built to the same survivability standard as full-size carriers.[103] They have little armor or compartmentation and have large open spaces, including well decks for landing craft and large storage parks for vehicles as key components of their mission to transport and land Marines. These characteristics add to the overall vulnerability of amphibious ships as opposed to purpose-built aircraft carriers.

Do Operational Advantages Outweigh Vulnerabilities?

The question of carrier vulnerability versus the value of the flattop in a variety of operations has been a recurring one since carriers went to sea at the end of the First World War. They replaced the battleship as a capital vessel because of their ability to deliver sustained combat power against opponents rather than because of a lack of vulnerability. Do the carrier's current susceptibility to detection, its vulnerability to cruise

102 Meghan Eckstein, "Navy Will Scrap USS Bonhomme Richard," *U.S. Naval Institute News,* November 30, 2020.
103 Scott Truver, "When it Comes to Ship Survivability, Prayer Isn't Enough," *U.S. Naval Institute News*, February 4, 2016.

and ballistic missiles, and the doubts about its recoverability from heavy damage outweigh the advantage of sustained combat power from sea-based aviation? The carrier faced these challenges in the Cold War and overcame them in the 1980s through emission control; speed, maneuver, and deception; better air defenses in the form of the F-14, Phoenix missile, and AEGIS weapon system for ships; and lessons learned from past carrier fires.

The geography of conflict does not always offer easy access to air bases ashore. In Korea in 1950, the invading communists captured every single air base on the peninsula. Only carrier-based air provided the saving air support to allied forces until the Inchon landing took back some land bases. The Falklands War represents a prime example of balancing carrier vulnerability with combat capability. British Task Group Commander Rear Admiral Sandy Woodward said, "I realized perhaps more than most that one mishap, a mine, an explosion, a fire, whatever, in either of our two aircraft carriers would almost have certainly proved fatal to the whole operation."[104]

Large carriers remain the hardest ships to disable or destroy. Damage can limit their ability to perform aviation operations for periods proportional to the amount of damage they receive. Large carriers are susceptible to detection, yet are superior to much smaller flattops in every other description. Finally, the

104 John Woodward, *One Hundred Days: The Memoirs of the Falklands Battle Group Commander* (Annapolis, MD: U.S. Naval Institute Press, 1992), p. xviii.

mobile flattop is less politically and militarily vulnerable than an air base ashore that cannot move and is not sovereign U.S. territory.[105]

105 Lehman, *Aircraft Carriers: The Real Choices,* p. 44.

4

FOUR OPTIONS FOR CARRIER SIZE AND CAPABILITY

"The aircraft carrier presents the naval constructor with some of the most difficult problems encountered in warship design. On a hull possessing most normal warship features, provisions must be made for the operation and maintenance of several squadrons of aircraft. If operated ashore, a carrier's aircraft would require an airfield extending over several square miles with air control, hangar, maintenance shops, petrol storage, bomb dumps, barrack blocks, messes, transport, and runways thousands of feet in length. In a carrier, this has to be compacted into a ship from 800 to 1100 feet long with a flight deck of less than three acres."

– Quoted in David K. Brown, in Nelson to *Vanguard: Warship Design and Development, 1923–1945*

The opening quote from J.H.B. Chapman, a 1960s-era Royal Navy constructor, listing the challenges in designing a mobile air base at sea remain much the same today. There are infinite varieties of potential carrier designs that include all of these requirements now as there were in the 1970s during an earlier carrier debate. Then, as now, it is still useful to reduce that variety to four basic models for consideration. They include:

1. Continued construction of the current *Ford* (CVN 78)-class carriers (the replacement for the current *Nimitz*-class CVNs)
2. A new medium aircraft carrier (CVM) about the size of the conventionally powered USS *Midway* (CV 41)
3. A European conventional or nuclear carrier design (HMS *Queen Elizabeth* or FS *Charles De Gaulle*)
4. The "Lightning Carrier," a large deck U.S. amphibious ship serving as a carrier, such as USS *America* (LHA-6 class)

These four options represent the full breadth of choices available in carriers that support fixed-wing aircraft.

All four designs evaluated here are large ships (over 40,000 tons and 800 feet in length), but with widely varying aircraft capacities, combat endurance, propulsion, and survivability ratings. Deck length is an issue determining whether a carrier can support catapult-assisted takeoff and arrested landing (generally, 900 feet or more in length) or short takeoff and vertical landing (800 feet or more in length).[105] Carrier option evaluations are based on five criteria: (a) types of aircraft required, (b) airwing size, (c) magazine and aviation fuel capacity, (d) propulsion, and (e) cost, which is covered in a later chapter.

Finally, while many critics continue to discuss the vulnerability of the large flattop and its potential replacement by smaller platforms armed with cruise missiles, historical evidence suggests this alternative is dubious. One large *Nimitz*-class carrier has been

105 John Lehman, *Aircraft Carriers: The Real Choices,* pp. 54-55.

Naval Air Crewman (Helicopter) 1st Class Caleb Rausch, from Durham, North Carolina, conducts carrier strike group integrated operations in an MH-60S Seahawk attached to the Golden Falcons of Helicopter Sea Combat Squadron (HSC) 12 with the U.S. Navy's only forward-deployed aircraft carrier USS Ronald Reagan (CVN 76) and guided-missile cruiser USS Shiloh (CG 67). (U.S. Navy)

assessed by the Navy as capable of delivering (via airstrikes) the equivalent weight in firepower of 5,000 cruise missiles over a 30-day continuous air campaign.[106] Historical cruise missile use has been much smaller, with 288 cruise missiles being expended in the First Gulf War, 325 in the 1998 Operation *Desert Fox* against Iraq, and just 88 in Operation *Enduring Freedom*. These relatively low numbers versus those of the carrier airwing highlight again the necessity of preserving a significant U.S. Navy carrier force.

106 "Why a Big Deck Carrier?" Briefing to the United States House of Representatives Armed Services Committee, July 16, 2006.

Table 3: Carrier Choices

	Ford-class CVN	New CVM	*Charles de Gaulle small* CVN	*Queen Elizabeth* CV	*USS America* LHD/LHA carrier
Total Aircraft	75+	45-50	36	45	26-30
Total Strike Aircraft	46-48 (4 squadrons)	30-34 (3 squadrons)	18-20 (1.5-2 squad-rons)	24-36 (up to 3 squadrons or 4 F35B squadrons)	24 (2 squadrons)
Sorties per Day	160 to 270 (surge)	175	60-100	60-100	40-70
Displacement	100,000 tons	55,000-65,000 tons	42,000 tons	65,000 tons	45,000 tons
Propulsion	Nuclear	Conventional	Nuclear	Conventional	Conventional
Speed	30+ knots	30+ knots	27 knots	25-28 knots	22 knots
Operational Range	Unlimited (nuclear)	14,000 nautical miles at 13 knots	Unlimited (nuclear)	10,000 nautical miles at half speed	9,500 nautical miles at 18 knots
Aviation Fuel	3 million gallons	1.3 million gallons	1.3 million gallons	793,000 gallons	1 million gallons
Aviation Ordnance	375,000 square ft.	225,000 square ft.	2,100 tons	10% less than Ford*	16,000 square ft.

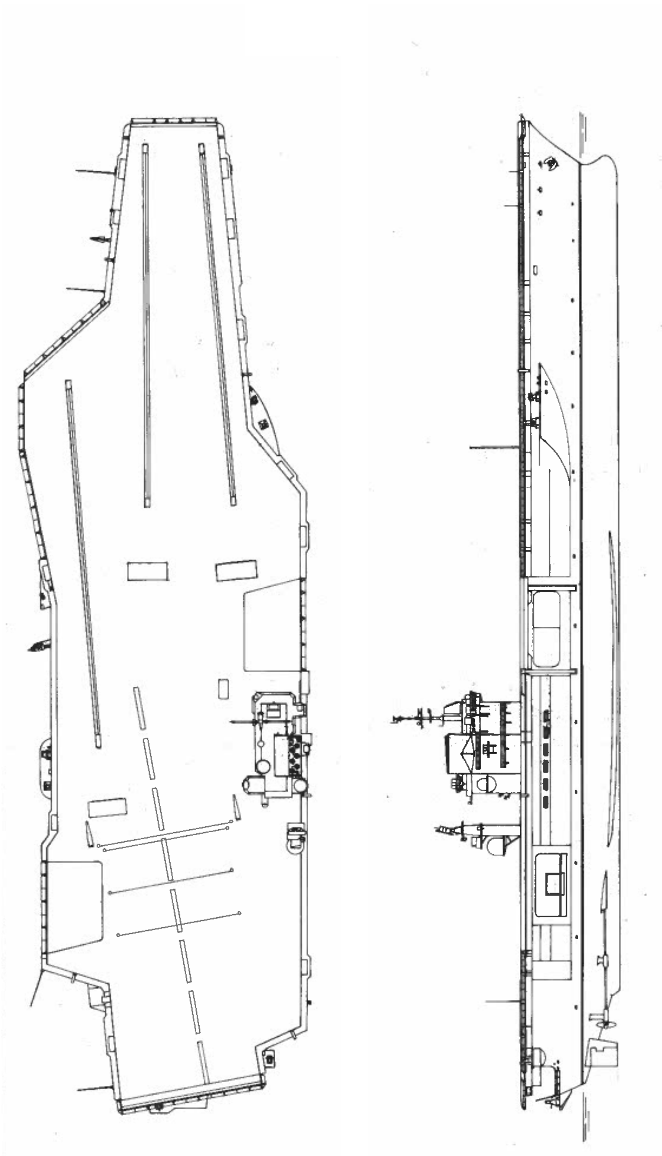
*Seth Cropsey, Bryan G. McGrath, and Timothy A. Walton, *Sharpening the Spear: The Carrier, the Joint Force,and High-End Conflict*, Hudson Institute, 2015, p. 87.

Proposed carrier choices:

1. *Ford*-class CVN: The current *Ford*-class carrier (CVN 78) is in serial production with a current goal of at least six ships. She is the first carrier designed under the post-Goldwater-Nichols joint bureaucratic process. While the *Ford* has essentially the same hull as the *Nimitz*, changes in the *Ford* from *Nimitz* class originated with Navy participation, but without Navy final decision authority. Those key joint decisions include a new type of reactor, electromagnetic catapults, arresting gear, and weapon elevators. The latter notional systems were hoped to provide improved efficiency and reliability, better flight deck aircraft handling through positioning the island structure further aft, and a smaller crew. These advantages have yet to be found. It was hoped that all of those changes might reduce the ship's lifecycle costs and improve the ship's sortie generation rate.[107] The *Ford* class has 23 major changes over the previous *Nimitz* class, but many are based on undeveloped technology and have been the source of billions of dollars of cost overruns and years of delay.[108] They include engineering challenges with the electromagnetic catapults (EMALS), advanced arrestor gear and elevators, and inability so far to meet the contracted sortie rate. There is a more fundamental question whether there is any need at all for the ability to produce a higher number of sorties than *Nimitz* flattops. That higher number of sortie requirement came from a joint requirement committee based on the old Vietnam War-era Alpha Strike, "aluminum cloud" operations that are no longer in use. The *Ford* catapult system has not yet been able to match the *Nimitz* sortie generation capability that approached 120-130 sorties per day during the initial part of the 2003 Iraq War.[109] A more serious problem beyond mere reliability yet unsolved is that if one electromagnetic catapult goes down, all are down. The FY2021 Director of Operational Test and Evaluation annual report stated,

> The crew cannot readily electrically isolate EMALS components during flight operations due to the

107 Ronald O'Rourke, "Navy Ford (CVN-78) Class Aircraft Carrier Program: Background and Issues for Congress," Congressional Research Service, March 25, 2021, pp. 4, 5.
108 Ibid, pp. 31-33.
109 Lambeth, "American Carrier Air Power at the Dawn of a New Century," p. xi.



CVN with gas turbine/electric propulsion (Courtesy of A.D. Baker III)

> shared nature of the Energy Storage Groups and Power Conversion Subsystem inverters on board CVN 78. The process for electrically isolating equipment is time-consuming; spinning down the EMALS motor/generators takes 1.5 hours by itself. This inability precludes EMALS high power maintenance during flight operations.[110]

Delays caused by these new unproved technologies mandated by the joint bureaucracy have increased the cost of the first unit to $13.3 billion so far, an increase of over $3.3 billion from original estimates and double the cost of the last *Nimitz*.[111] We have used throughout this report the costs provided by the Defense Department to Congress, but knowledgeable officials involved with the program now estimate the final cost to be $17.8 billion, and that number is before the full ship shock trials (FSST) of the *Ford*, which could have a significant cost impact. The *Ford* class, like the *Nimitz*, can be built in only one shipyard (Newport News Shipbuilding), effectively a monopoly, thus making it difficult to obtain cost savings in construction.

Types of Aircraft Required: The *Ford* class supports all current and planned U.S. Navy carrier aircraft.[112]

110 Robert F. Behler, *Director, Operational Test and Evaluation FY2020 Annual Report,* U.S. Department of Defense, January 2021, p. 136.
111 Author Note: The last *Nimitz*-class ship USS *George H.W. Bush* cost $6.2 billion in 2009; just 10 years later, USS *Gerald R. Ford's* expected cost was double that of the *Bush.*
112 John Schenk, *Modernizing the U.S. Aircraft Carrier Fleet, Accelerating CVN 21 Production Versus Mid-Life Refueling* (Santa Monica, CA: RAND Corporation, 2005), p. 77.

Airwing Size: The *Ford* class fully supports the current U.S. Navy airwing (about 75 total aircraft), as does the previous *Nimitz* class. Its "operational density" (OD)—those parts of the carrier that include the fraction of the hangar bay and flight deck occupied by aircraft, support equipment, and other miscellaneous items—is 75 percent, which is 5 percent better than that of *Nimitz*.[113] During the 1990s and early 2000s, OD decreased due to the retirement of A-6s and S-3s. Carrier density is rising again, however, due to the replacement of the four-plane Prowler squadron with a five-plane squadron of the larger Super Hornet Growler and older Hornets with Super Hornets that are 23 percent larger.[114] Density will increase further with the addition of the MV-22 Tiltrotor to the airwing. This full capability of *Ford* and *Nimitz* is in contrast with the two smaller carriers examined below. Neither the Royal Navy *Queen Elizabeth*-class carrier nor the U.S. Navy "Lightning carriers," such as USS *America,* have catapult and arresting gear and cannot operate fixed-wing airborne early warning E-2D, electronic warfare EA-18 *Growlers,* or the emerging, fixed-wing unmanned aircraft, such as the MQ-25 *Stingray* tanker. These aircraft are all vital to operations at sea against other naval forces. The British ships and the U.S. LHA/LHD conversions are limited to helicopters and F-35B aircraft with shorter range and less armament capability than the F-35C.

113 Interview with OPNAV staff source, October 2020.

114 *Navy Aircraft Carriers; Cost-Effectiveness of Conventionally and Nuclear-Powered Carriers*, United States General Accounting Office, August 1998, p. 64.

Magazine Capacity and Sustainment: Magazine capacity matters in terms of a carrier's ability to conduct combat operations over an extended period. This feature of the large nuclear carrier remains one of its chief advantages over systems that would replace the flattops, such as a mass of cruise missile-armed ships (manned or unmanned). The refueling and replenishment of such smaller ships, especially in missile weapons, under sustained combat conditions could prove difficult. *Ford* has a capacity of 375,000 cubic feet of aviation ordnance, and three million gallons of usable jet fuel storage for 14 days of sustained operations.[115] The larger size of the *Ford* and *Nimitz* also contributes to a variety of other benefits, including increased survivability, compartmentation, armor and firefighting, better operational sea keeping in bad weather, and a lower historic accident rate owing to a larger flight deck.[116]

Sortie Rate: Future carrier missions, especially those with a "war at sea" component where the adversary is another blue water naval force, will demand longer, more specific strike and fighter-cap missions as opposed to mass delivery of ground attack munitions. A 2017 RAND study on carriers captured this problem with sortie demands saying, "Increased standoff distances, and hence longer sortie durations, are the characteristics of future planning scenarios. As a result of longer sortie durations, a lower sortie generation rate

115 USS Ford characteristics, U.S. Navy fact file, September 17, 2020, https://www.navy.mil/Resources/Fact-Files/Display-FactFiles/Article/2169795/aircraft-carriers-cvn/.
116 A 1998 GAO report identified only 10 carrier deck mishaps from 1986 to 1996, of which only 4 were on nuclear-powered carriers (*Enterprise* and *Nimitz*-class ships).

is required, all else being equal."[117]

2. New *Midway*-sized CVM: The *Midway*-class carriers of the immediate, post-World War II era were developed for many of the same reasons as *Nimitz* and *Ford*, including a preference for increased size as a means of generating greater strike capacity. The *Midway* went on to serve a 46-year career from 1945 through the 1991 Gulf War. *Midway* could not support all U.S. naval aircraft, notably the F-14 Tomcat, and her airwing was smaller at 56 aircraft than contemporary, larger post-war conventional and nuclear-powered carriers with 75 or more embarked aircraft.[118] While a new *Midway*-sized carrier would operate fewer aircraft than *Ford/ Nimitz*, her catapult and arrested landing configuration would allow her to operate all current and planned U.S. naval aircraft.

Changes in oil prices, including the U.S. transition from net oil importer to exporter, would make a new conventionally powered 65,000-ton carrier much less costly to build and operate than a *Ford*-class flattop. There are several options for proven low-risk conventional propulsion systems from gas turbine to combined gas turbine and diesel systems. Nuclear power is also an option, especially using existing, proven submarine power plants.

Types of Aircraft Required: A new *Midway* design might embark an airwing from 45-60 aircraft depending on the mission. With its steam catapults and arresting gear, it would be able to operate all

117 Bradley Martin and Michael McMahon, *Future Carrier Options* (Santa Monica, CA: RAND Corporation, 2017), p. 14.
118 *Cost-Effectiveness of Conventionally and Nuclear-Powered Carriers*, GAO, pp. 142-146.

USS Midway in 1990/1991 around the time of Operation Desert Storm (Courtesy of Seaforces.org)

current and projected carrier aircraft, including AEW, electronic warfare, and the MQ-25A unmanned tanker aircraft that carriers lacking catapults and arresting gear cannot support. Such a flattop and its airwing might not operate "alone and unafraid" in very high-threat areas, but it could do so in many medium- and low-threat environments as well as supplementing the airwings of *Nimitz* and *Ford* in high-end combat.

Airwing Size: Current *Nimitz/Ford* airwing totals about 75 aircraft of all types, with a core of four strike fighter squadrons that represent the bulk of the flattop's strike and air superiority weight. The airwing for a new CVM might be tailored depending on the flattop's mission. Three strike fighter squadrons of 30 to 34 F-18E/F or F-35C aircraft might be carried in a strike-heavy configuration. The former USS *Midway* carried 30 F/A-18 Hornets during Operation *Desert Shield/*

Storm.[119] A *Midway*-size might also work in a support capacity with multiple, five-plane EA-18G electronic warfare aircraft, multiple unmanned tanker squadrons, and additional E-2D Hawkeye AEW aircraft. Such subsidiary carrier roles existed during the early and middle Cold War when World War II-era, but modernized, *Essex*-class flattops served as antisubmarine carriers (CVS) with aircraft and helicopters configured to the ASW mission. These ships aged out of the fleet in the mid-1970s, forcing larger carriers to carry a mixed wing of both strike and ASW aircraft. The return of a *Midway*-size might again allow for such divisions in warfighting specialization among the fleet's flattops.

Magazine Capacity and Sustainment: A modern CVM would not carry the same weapons and aviation fuel load as *Nimitz/Ford*, but might still support more than 80 sorties per day with 368,000 square feet of weapons storage and 1.48 million gallons of aviation fuel for at least a week of sustained operations.[120] Selecting a smaller carrier comes with additional challenges in terms of accidents. The *Midway's* smaller size was linked to her 1970s accident rate that was double that of the incoming *Nimitz* class flattops.[121] The Royal Navy and Royal Air Force lost ten Harrier aircraft in the 1982 Falklands War operating from small carriers, with half of those losses due to accidents.[122] While these examples suggest smaller carriers have a higher accident rate and are less operable in higher seas, improved

119 Ibid, p. 142.
120 "CVV," *Naval Aviation News,* July 1979, pp. 10-12.
121 Lehman, *Aircraft Carriers: The Real Choices,* p. 57.
122 *Lessons of the Falklands: Summary Report, February 1983,* Department of the Navy, Office of Program Appraisal, February 1983, p. 5.

technology in both carriers and their aircraft can overcome these challenges. Finally, while smaller than succeeding conventional and nuclear-powered, post-Cold War flattops, the *Midway* class benefitted from the experience of the Second World War and had not only three-inch flight deck armor, but also a seven-inch armor belt on her hull as well.[123] A future CVM would incorporate extensive watertight compartmentation and much more effective and lighter weight side protection than heavy belt armor, and incorporate the far more effective firefighting of the latest technology.[124]

Sortie Rate: Upwards of 80 sorties per day could be maintained, and perhaps more, depending on the number of catapults fitted and the range and types of missions undertaken. Any discussion of a smaller airwing must consider these factors when considering their mission capability. *Midway* maintained 89 sorties per day during Operation *Desert Storm* in 1991.[125]

3. A Current European Design CV (*Queen Elizabeth or Charles de Gaulle*): The United States is by no means the only designer and builder of first-rank flattops. The French carrier *Charles de Gaulle* and the new British Royal Navy *Queen Elizabeth*-class carriers represent existing designs that the U.S. Navy might produce domestically under license in lieu of continued building of the expensive *Ford*-

123 Scot McDonald, "Evolution of Aircraft Carriers, CVB's, The Battle Carriers," *Naval Aviation News,* U.S. Navy History and Heritage Command, https://www.history.navy.mil/content/dam/nhhc/research/histories/naval-aviation/evolution-of-aircraft-carriers/car-10.pdf.

124 Thomas B. Grassey, "Retrospective: The Midway Class," *Proceedings*, U.S. Naval Institute, vol. 112/5/999, May 1986.

125 *Cost-Effectiveness of Conventionally and Nuclear-Powered Carriers*, GAO, p. 62.

class carriers. Like the *Midway*-size CVM, the nuclear-powered *De Gaulle* and conventional *Queen Elizabeth* could be produced competitively in at least four shipyards, including Newport News, as a more affordable successor to the *Ford* class. Under this plan, the *Fords* would be limited to two or three units, as was the case with the very expensive U.S. *Seawolf*-class submarines and a more numerous but less expensive successor. This type of flattop could serve as the new U.S. carrier design for the 2020s and beyond. In the case of the *Queen Elizabeth* design, the United States would likely desire the pre-2012 variant of the ship that featured a catapult and arrested landing design, or a proposed French catapult and arresting variant of the *Queen Elizabeth* called the "PA-2 that was ultimately cancelled in 2013."[126] Both designs (*De Gaulle* and *Queen Elizabeth)* support nominal, mid-sized airwings of 35-40 aircraft, though the larger *Queen Elizabeth* design is credited with a surge-size airwing of up to 60 aircraft.[127] The catapult/arresting configuration of the PA-2/*Queen Elizabeth* and the *Charles de Gaulle* would both allow for the operation of the full range of current and proposed U.S. naval aircraft, while the existing *Queen Elizabeth* would be limited to the F-35B variant and rotary-wing aircraft.

Types of Aircraft Required: The *De Gaulle* supports a variety of French fixed-wing aircraft and is fitted with modified versions of the same steam catapults found on USS *Nimitz*-class flattops that have allowed her to operate U.S. Navy F/A-18 Hornet, E2C Hawkeye,

126 Antoine Philippe, "Why France needs a second aircraft-carrier," *Question Defense Info (FR),* 2007.
127 George Allison, "What will the Queen Elizabeth class carriers carry?," *U.K. Defense Journal*, December 6, 2016.

and C-2 Greyhound aircraft.[128] The *Queen Elizabeth,* as introduced, is limited to the F-35B Lightning, but recently deployed with 25 of these aircraft (one Royal Air Force and one U.S. Marine F-35B squadron). The *Queen Elizabeth* might also support other U.S. rotary-wing aircraft, such as the MV-22 Osprey, but the British government has not yet considered such an addition.[129] The French variant of the *Queen Elizabeth* (the PA-2) would have been similarly outfitted with catapults like those of the *Charles de Gaulle,* with the ability to support a mix of aircraft types from both the current French and British flattop designs.[130] The current *Queen Elizabeth* design remains unable to operate a full fixed-wing airwing that U.S flattops have carried for decades.

Airwing Size: A European carrier variant will not support a full, four strike fighter airwing while simultaneously allowing for the airborne early warning, electronic warfare, and antisubmarine warfare aircraft necessary for independent carrier operations. *Charles de Gaulle* generally supports the equivalent of two strike fighter squadrons when deployed but has sailed with a reinforced wing of 26 strike aircraft when it conducted strikes against ISIS in 2015.[131] *Queen Elizabeth,* as introduced, is limited to the short-range F-35B aircraft. *Queen Elizabeth* can support three full squadrons of strike fighters

128 David Cenciotti, "French Rafale fighter jets operate from U.S. aircraft carrier," *The Aviationist,* January 15, 2014.
129 Thomas Nedwick, "Behold a British Carrier Carrying the Most Stealth Fighters of Any Warship to Date," *The Drive,* September 23, 2020.
130 Antoine Philippe, "Why France Needs a Second Aircraft Carrier."
131 "French Carrier Strike Group to Deploy to Eastern Mediterranean with Largest Air-wing Ever," *Naval Recognition,* November 16, 2016.

Queen Elizabeth (Courtesy of navyrecognition.com)

Charles de Gaulle (Courtesy of navyrecognition.com)

New French Carrier (Courtesy of A.D. Baker III)

and additional helicopter-based capabilities in AEW and ASW. The British government has so far committed to only two squadrons for each vessel for a total of 48 F-35B aircraft for shipboard operations.[132]

Magazine Capacity and Sustainment: Charles de Gaulle's nuclear propulsion puts her in a class by herself in terms of non-U.S. nuclear-propelled flattops. She regularly supports three-month deployments and is credited with 2,100 tons of magazine storage and a maximum storage of 1.3 million gallons of jet fuel.[133] *De Gaulle* had a number of challenges from commissioning through her first overhaul in 2007 that included a loss of one of her propellers and reactor problems

132 Nigel Walker and Tim Robinson, *Carrier strike strategy and its contribution to UK defence,* Westminster, House of Commons Library, February 28, 2019, p. 3.
133 Eric Wertheim, *Combat Fleets of the World, 16th Edition*, (Annapolis, MD; U.S. Naval Institute Press, 2016), p. 196.

as she spent less than 900 days at sea in her first six full years in commission.[134] The proposed PA-2 design was significantly larger and featured much larger facilities, including 1.4 million gallons of fuel storage.[135]

The *Queen Elizabeth* class features conventionally powered ships with a nominal range of 10,000 nautical miles. They boast a 793,000-gallon aviation fuel capacity and an improved ordnance handling system design to support a higher aircraft sortie rate.[136] Both *Queen Elizabeth* and her sister ship *Prince of Wales* have proved successful in the early stages of their first commissions. The Royal Navy, however, decided to do without the electromagnetic catapults that have plagued the USS *Ford* and have a 16 percent space/weight reserve for incremental improvements over their lifetime under the philosophy that a larger ship would be "cheaper to build in costs per ton, but also have lower maintenance costs" over its service life.[137] Former British First Sea Lord Admiral Sir Michael Boyce stated that Royal Navy studies had decisively concluded that in terms of a larger design, "Air is free, and steel is cheap."[138]

Sortie Rates: *Charles de Gaulle* and *Queen Elizabeth* both have

134 "Entretien et Modernisation du Charles de Gaulle," French Navy Press Release, May 22, 2008.

135 "Porte Avions 2," *Naval Technology,* October 1, 2009.

136 "Logistics Team Rises to the QE Refueling Challenge," Royal Navy Official Website, August 18, 2017.

137 Peter Roberts, "The Queen Elizabeth Class: How Innovative is the Design?" *RUSI Defence Systems,* September 9, 2014; and "Development of the Queen Elizabeth class aircraft carrier – a design history," savetheroyalnavy.com, October 2, 2018.

138 "Development of the Queen Elizabeth class aircraft carrier – a design history," savetheroyalnavy.com, October 2, 2018.

significantly lower sortie rates as compared to the current USS *Nimitz*- and *Ford*-class carriers. *De Gaulle* is nominally credited with the ability to launch 100 aircraft sorties per day when equipped with a full complement of 40 aircraft.[139] *Queen Elizabeth*-class ships are credited with a maximum 72 aircraft per day sortie rate.[140] The Royal Navy achieved high sortie rates in past conflicts with relatively small numbers of aircraft. During the Falklands War, 28 Sea Harrier aircraft operating from HMS *Hermes* and *Invincible* completed 1,335 combat sorties over a 45-day period for an average sortie rate of 1.41 sorties per aircraft per day.[141]

4. U.S. Navy LHD/LHA *Lightning* carrier: One of the other, oft-mentioned candidates for light carriers, or as an augment to the current carrier force since they already exist, is the U.S. "big deck" amphibious force of *Wasp*-class landing helicopter docks and the new *America*-class landing helicopter assault ships. The eight ships (soon to be seven, with the retirement of USS *Bonhomme Richard* due to fire damage) of the *Wasp* class and the current three *America* class (one of which, the USS *Bougainville,* is under construction) are amphibious warfare ships designed for helicopter assault and well-deck-based landing operations with embarked U.S. Marines or other ground forces. Weighing in at over 45,000 tons and almost 850 feet in length, they are nearly the size of the carrier USS *Midway* when

139 Dave Majumdar, "France's Charles De Gaulle Aircraft Carrier: The Good, the Bad and the Nuclear," *The National Interest,* November 18, 2015.
140 George Allison, "HMS Queen Elizabeth launches 4 jets 'in quick succession,'" *U.K. Defence Journal,* November 15, 2019.
141 Kelvin Kurnow, "Royal Navy big deck carriers from 1960 to today – A Commentary," *UK Defence Journal,* June 2, 2020.

she commissioned in 1945 and currently larger than nearly all of her foreign carrier contemporaries. The *Wasp*-class' size and aircraft carrier-like flight deck has allowed the vessel to operate the AV-8B Harrier II ground attack aircraft for decades in a secondary role as an air/ground attack element of Marine Corps Amphibious and later Expeditionary Forces. An earlier LHA class ship, USS *Nassau,* acted as a carrier during Operation *Desert Storm* in 1991, and, later, USS *Kearsarge's* small force of six Harriers played an outsized role in the 2011 Operation *Odyssey Dawn* against Muammar Gaddafi's Libyan forces.[142] USS *America* recently deployed with 13 F-35Bs embarked to test the idea of the "Lightning carrier" concept.[143] While large and carrier-like in many ways, they are built to a much lower standard of survivability than conventional flattops and are much slower with a best speed of 24 knots.[144] The fire and subsequent decision to scrap USS *Bonhomme Richard* (LHD 6) further demonstrates that the big-deck amphibious ship is not a viable carrier design.

Types of Aircraft Required: Like the current *Queen Elizabeth* class, the Lightning carrier would be restricted to the F-35B aircraft in terms of fixed-wing assets, but could also accommodate the full range of rotary-wing aircraft, including MV-22 Osprey tiltrotor. While both the current LHA and previous LHD ships were built to allow for AV-8B Harrier operations, *America* and her sister *Tripoli*

142 Fred Allison, "26th MEU at Operation ODYSSEY DAWN Small MAGTF, big punch," *Marine Corps Gazette,* May 2020.
143 Meghan Eckstein, "Marines Test 'Lightning Carrier' Concept, Control 13 F-35Bs from Multiple Amphibs," *U.S. Naval Institute News,* October 23, 2019.
144 Norman Friedman, "USS America (LHA 6) A different kind of gator," *Defense Media Network,* December 19, 2019.

both required flight deck refits to allow for the extra heat generated by F-35B and MV-22 operations.[145] The ships of the LHD class will need to be back-fitted to support F-35B operations because their decks are also ill-suited to the extreme heat generated by that aircraft's engines. USS *Bonhomme Richard* was undergoing such a refit when she was all but destroyed by fire.[146]

Airwing Size: The Lightning carrier features the smallest airwing of the four carrier choices with room for fewer than 25 F-35Bs. It also lacks the catapults and arresting gear necessary for existing U.S. AEW and EW aircraft. That might at best equal two strike fighter squadrons, but if operating without a fleet carrier, it would have limited strike capacity because one of those squadrons would be dedicated to protecting the lightning carrier itself and its surface escorts. A maximum load of strike fighters will also limit the Lightning carrier's ability to embark those rotary-wing assets needed for ASW, as well as larger aircraft like the MV-22 for carrier on board delivery.

Magazine Capacity and Sustainment: In addition to having the smallest embarked airwing of the four carrier choices, the Lightning carrier is the slowest in terms of speed, operational range, and magazine capacity. The LHD/LHA's top speed approaches just 24 knots as opposed to the 30+ knot speeds of current U.S. nuclear carriers and

145 Carlo Munoz, "SNA 2014: Heat From F-35, MV-22 Continue to Plague Big Deck Amphibs," *U.S. Naval Institute News,* January 14, 2014.
146 David Larter, "The Bonhomme Richard fire deals a blow to the Navy's designs in the Indo-Pacific," *Defense News,* July 13, 2020.

venerable *Midway* class, the 26 knots of *Charles de Gaulle,* and the 28 knots of the *Queen Elizabeth*. The LHD class has limited magazine space that would likely support only 3-4 days of sustained fixed-wing air operations. Its operational range exceeds 9,800 nautical miles, but its low speed means limited tactical maneuverability compared with faster, purpose-built carriers. Economy of scale plays a role as well. While present threats suggest a larger and more distributive carrier force than currently in service, carriers below the size of *Midway* and *Queen Elizabeth* are much less cost effective.[147] Finally, airplanes require maintenance like any other vehicle, and combat operations take a toll on aircraft availability. The Royal Navy maintained a 90 percent availability rate for their Sea Harrier aircraft during the Falklands campaign, but Argentine attacks were erratic and uncoordinated, allowing for a more measured response than would be possible in combat with a peer competitor force.[148] A much smaller flattop like the *America* looks good on paper until its airwing rapidly degrades under combat conditions to a point where the ship is unusable for operations beyond self-defense.

Sortie Rates: While rated for upwards of 24 F-35B aircraft to date, the USS *America* has embarked fewer than 14 in a 2019 deployment of a Marine F-35B squadron aboard the ship. While high sortie and availability rates were reported, the relatively small number of aircraft and the F-35B maintenance cycle may combine to reduce sortie rates over the course of a long operation, such as the Falklands

147 Ibid.
148 Sandy Woodward, "Lessons of the Falklands: Summary Report, February 1983," Chief of Naval Operations Staff, Office of Program Appraisal (OP 090), February 1983, p. 5.

campaign. A 2017 RAND Corporation study estimated that a wing of 24-25 F-35Bs might sustain 50-55 sorties per day.[149] The longer the range at which these aircraft must operate will decrease this rate, and while F-35Bs operating within 100 nautical miles of the flattop on local ops might attain a full 50-55 sorties per day, those operating at 300 nautical miles might achieve only 30 or fewer.[150]

149 Martin and McMahon, *Future Carrier Options,* p. 30.
150 2006 HASC briefing on carrier options.

5

NUCLEAR VS. CONVENTIONAL PROPULSION

"I don't know why anyone would expect to get the tremendous increase in military capability provided by nuclear propulsion without paying for it."

– Admiral Hyman G. Rickover, House Armed Services Committee testimony on the Naval Nuclear Propulsion Program, April 27, 1977

"I do not feel that all carriers and cruisers should be nuclear powered, but only enough carriers and cruisers to constitute all nuclear task forces, and then only enough nuclear task forces to provide a strategically segment of the U.S. Fleet that could be used for rapid response."

– Chief of Naval Operations Admiral James Holloway, House Appropriations Subcommittee testimony, February 17, 1977

The discussion on whether U.S. aircraft carriers ought to be nuclear, conventional, or a mix of such propulsion dates from the inception of the first nuclear carrier USS *Enterprise* in 1965. The U.S. Navy has not built a non-nuclear-powered aircraft carrier since the first USS *John F. Kennedy* commissioned in 1968.[151] The last conventionally powered carrier, USS *Kitty Hawk*, decommissioned

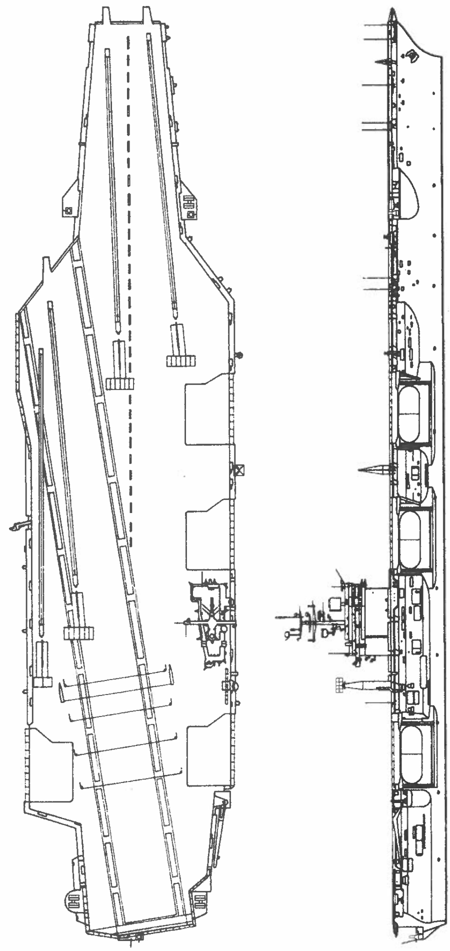
151 Ronald O'Rourke, "Navy Aircraft Carriers: Retirement of USS John F. Kennedy - Issues and Options for Congress," Congressional Research Service, 2007, p. 4.

in 2009.[152] Periodically, the issue of whether a conventional carrier could be suitable returns to public discussion with prominent examples of such in the early 1970s, late 1970s, and late 1990s. Congress has walked back from earlier legislation mandating that all carriers be nuclear-propelled. Finally, a new issue not fully realized in the late 1970s is that of nuclear carrier refueling and ultimate disposal.

Current Navy Policy

The U.S. Navy has been committed to nuclear propulsion for aircraft carriers. Current plans include four and up to a total of six nuclear-powered *Ford*-class carriers as the replacements for the present *Nimitz*-class flattops, of which the first and namesake was commissioned in 1975.[153] The *Fords* feature an improved nuclear reactor, the Bechtel A1B, with 25 percent more generating power than the previous A4W reactors of the *Nimitz*-class flattops.[154] The Navy's official statements have been supportive of continued nuclear propulsion. The Director of Naval Nuclear Propulsion Admiral James Caldwell said in 2019 congressional testimony: "Since *Nautilus*, follow-on classes of ever more capable nuclear-powered submarines and aircraft carriers have ensured our warfighting edge over potential adversaries."[155] Nuclear power has clearly become the

152 "USS George Washington to Replace USS Kitty Hawk as U.S. Navy's Forward Deployed Carrier," *U.S. Navy News*, December 2, 2005.
153 O'Rourke, "Navy Aircraft Carriers: Retirement of USS John F. Kennedy," p. 4.
154 "Statement of Admiral James F. Caldwell Deputy Administrator for Naval Reactors, National Nuclear Security Administration, U.S. Department of Energy on the Fiscal Year 2020 President's Budget Request," House Committee on Appropriations, Subcommittee on Energy and Water Development, April 2, 2019.
155 Ibid.



Nimitz (Courtesy of A.D. Baker III)

Navy's choice in propulsion regardless of congressional or other mandates.

Congressional Views of Conventional and Nuclear Power

Congress has backed away from the provisions of past decades that mandated nuclear propulsion for both aircraft carriers and large surface combatants. The last such statement was made in the FY2008 Defense Authorization Act, Section 1012 (H.R. 4986/P.L. 110-181) of January 28, 2008, and stated, "U.S. policy is to construct the major combatant ships of the Navy, including ships like the CG(X), with integrated nuclear power systems, unless the Secretary of Defense submits a notification to Congress that the inclusion of an integrated nuclear power system in a given class of ship is not in the national interest."[156] The cancellation of the CGX (cruiser) program made this provision a moot point.[157]

Cost

Apart from the operational advantages of nuclear power, there are significant cost differences with conventional options. Some quick comparisons illustrate this point:

- Acquisition: Current estimated cost of nuclear plant of 260,000-to-280,000 shaft horsepower is \$9.7 billion.[158]

156 Ronald O'Rourke, "Navy Nuclear-Powered Surface Ships: Background, Issues, and Options for Congress," Congressional Research Service, 2010, p. 3.
157 Observation by Congressional Budget Office naval analyst Dr. Eric Labs to the authors.
158 David A. Perin and John B. Newman, *CVX Analysis of Alternatives, Final Results for Part 2,* Center for Naval Analyses, November 1998, p. 33 (CNA methodology for calculating 280,000 shaft horsepower power costs for nuclear and conventional carriers adjusted for inflation to 2021 values).

Current estimated cost of conventional plant of same horsepower is $8.7 billion.[159]

- Refueling: A complete mid-life refueling overhaul for the *Ford* class has been estimated at $5.56 billion dollars at 2018 figures.[160]
- Defueling: The current estimated cost of defueling and recycling a nuclear carrier at retirement is $750 million to $1.5 billion (depending on the use of a military or commercial shipyard).[161]
- Personnel: The current estimated annual additional cost of nuclear-trained personnel over the carrier's lifetime is $8.4 billion for nuclear carrier versus $7.4 billion for a conventional carrier.[162]
- The current estimated annual cost of fueling a conventional carrier (older *Kitty Hawk/Kennedy* class) that requires 500,000 barrels per year at an October 2020 price per barrel of F-76 Distillate Fuel Marine (DFM) of $100.38 is roughly equal to $50,190,000.[163]
- The lost availability due to nuclear refueling overhaul vs. conventional overhaul is two years.

159 Ibid.
160 Martin and McMahon, *Future Aircraft Carrier Options,* pp. 54, 59.
161 *Aircraft Carrier Dismantlement and Disposal Options Warrant Additional Oversight and Raise Regulatory Questions*, Government Accountability Office, August 2018, p. 33.
162 *Navy Aircraft Carriers, Cost-Effectiveness of Conventionally and Nuclear-Powered Carriers,* United States General Accounting Office, August 1998, p. 81 (personnel costs methodology for 1998 adjusted for inflation to 2021).
163 Ibid, p. 84; and Thomas W. Harker, "Fiscal Year (FY) 2021 Standard Fuel Price Change," memorandum, Office of the Under Secretary of Defense, September 17, 2020, p. 2.

The most significant concerns thus remain acquisition cost and life cycle cost of conventional versus nuclear propulsion. When assessed in the late 1970s and late 1990s, the general conclusion was that while the overall cost of nuclear carriers was greater than that of conventional counterparts, the costs of fuel oil over the life of the conventional carrier versus periodic nuclear refueling were in favor of the nuclear flattop. In 1978, the acquisition cost of a large nuclear carrier was 30 percent greater than a large conventional flattop, and 30-year lifecycle costs were within two to three percent.[164] Added to that were the operational advantages of a nuclear warship that was not dependent on vulnerable replenishment ships for propulsion fuel over long-distance steaming (such as across the Indian Ocean), and the added benefit of avoiding annoying stack gases that can disturb pilots on final approach to the ship.[165] The Sea-Based Air Platform Study of 1978 and other analysis suggested that these attributes made the nuclear flattop the correct choice, and the U.S. Navy constructed 10 *Nimitz*-class flattops.

In the early 1990s, when carriers again were assessed against the backdrop of the end of the Cold War and the need to continue forward presence operations, the same equation prevailed. The Clinton administration's Bottom Up Review confirmed the continued construction of nuclear carriers to replace the aging conventional flattops with initial funding of CVN 76 (*Ronald Reagan*) and CVN 77 (*George H. W. Bush*) in FY1995 and FY1999, respectively.[166]

164 Lehman, *Aircraft Carriers: The Real Choices*, p. 52.
165 Ibid.
166 Peeks, *Aircraft Carrier Requirements and Strategy, 1977 to 2001,* p. 130.

A 1998 GAO study on the cost effectiveness of nuclear and conventional carriers found a similar gap in operating costs over the lives of conventional and nuclear-powered flattops estimating these at $14.1 billion and $22.2 billion (in FY1997 dollars), respectively.[167] The report cited the aging conventional flattop force structure and with it the rise in more difficult to procure parts and infrastructure to support conventional flattops. It also noted that the underway refueling advantage enjoyed by nuclear carriers had been significantly reduced when nuclear cruisers were retired, thus returning nuclear carrier battle group escorts to dependence on tankers. In addition, Atlantic Fleet officials in 1997 stated that, "It would be easier to surge the conventionally powered carrier because additional workers could easily be assigned to complete the work more quickly by completing work tasks in parallel. In contrast, nuclear-powered carrier work is sequential and there are a finite number of nuclear-certified workers."[168] Overall, the GAO report portrayed a mixed picture, citing the benefits and limitations of each type of flattop.

Fast forward to the present and some considerations have changed. First, technology has vastly increased the availability of fossil fuels in the United States. The average cost today is a small fraction of what it was in the 1990s. Another significant difference is now the rising cost of the *Ford*-class carrier relative to the rest of the shipbuilding budget. In the words of a 2019 RAND study, "Continuing the *Ford*-class carrier program imposes high acquisition cost and might unduly

167 *Cost-Effectiveness of Conventionally and Nuclear-Powered Carriers*, United States General Accounting Office, August 1998, p. 5.
168 Ibid, p. 183.

USS Gerald Ford (Courtesy of USNI)

affect the whole of the Navy shipbuilding budget."[169] A number of technical challenges associated with the *Ford* class' undeveloped technology continue to cause rising cost and delay at this writing. While the ship was commissioned and in theory accepted by the Navy in 2017, continuing serious technical deficiencies mean the Navy still requires more funding and more time to complete this ship.[170] Her sister ships—the future USS *John F. Kennedy* (CVN 79) and USS *Enterprise* (CVN 80)—have continued the trend in cost overruns. The Congressional Budget Office reported in 2020 that *Kennedy's* potential for further cost growth over 2020 was 64 percent and *Enterprise's* was 80 percent.[171]

169 Martin and McMahon, *Future Aircraft Carrier Options,* p. 9.
170 Ibid, pp. 15, 30.
171 Eric Labs, "The 2020 Outlook for Navy Shipbuilding," Presentation to the Bank of America Merrill Lynch Defense Outlook Forum, Congressional Budget Office, January 8, 2020, p. 21.

Finally, non-nuclear marine propulsion technology is significantly more advanced than it was in the late 1990s when the last significant comparisons of conventional and nuclear propulsion were conducted. For example, the 65,000-ton displacement HMS *Queen Elizabeth*-class carriers are powered by a combined diesel and gas turbine (CODOG) plant that feeds an overall, integrated electrical propulsion and distribution system.[172] *Queen Elizabeth's* integrated system delivers just over 100 megawatts (mw) of electrical power.[173] This is far less than that of the overall generation capacity of the nuclear-propelled USS *Ford*-class carrier that is rated at upwards of 700 megawatts.[174] It takes 80mw just for the propulsion of the *Queen Elizabeth*, leaving just 20mw for other shipboard systems, a figure close to that of the preceding U.S. *Nimitz*-class carriers with 30mw of electrical power.[175] The *Queen Elizabeth* lacks conventional catapults to launch aircraft and arresting gear to recover them, and any new conventional carrier would need an auxiliary steam system necessary to produce the 450-to-520° Fahrenheit steam needed to support the type of steam catapult currently in service.[176]

The *Ford*-class electrical generation capacity (outside propulsion)

172 "Powering the *Queen Elizabeth* Class Aircraft Carriers," Rolls Royce Corporation, 2014, pp. 4, 5.

173 "HMS Queen Elizabeth," Wartsila Marine Engineering, https://www.wartsila.com/marine/customer-segments/references/view/hms-queen-elizabeth.

174 Robert Farely, "China Wants Its Very Own Nuclear Aircraft Carrier (And Wants Russian Help)," *The National Interest,* December 21, 2019.

175 Sam LaGrone, "Underway on USS Gerald R. Ford: Navy Marks Progress on Carrier as Scrutiny of Program Grows," *U.S. Naval Institute News,* December 9, 2019; and "GE's Electric Propulsion Powered Royal Navy Aircraft Carrier Successfully Completes Sea Trials," *MI News Network,* January 9, 2020.

176 "Phase I Final Rule and Technical Development Document of Uniform National Discharge Standards (UNDS), Appendix A, Catapult Wet Accumulator Discharges: Nature of Discharge," Environmental Protection Administration, 1999, p. 3.

has been tested at 2.7 times that of the *Nimitz* class, so it has over 80 megawatts just for internal consumption separate from propulsion.[177] Much of the extra electrical generation capacity on the *Ford* class supports the EMALS catapults, arresting gear, electromagnetic weapons elevators, and other systems not present on other carrier classes. The *Queen Elizabeth* is not a *Ford*-class flattop, but her design suggests that a conventionally powered carrier of medium size with catapult and arresting wire upgrades could operate a robust airwing in the absence of nuclear power.

Other challenges to the conventional flattop remain in the replenishment of not only her propulsion fuel but that of her escorts. The nuclear carrier force has relied on conventional escorts since the retirement of the last of the nuclear-powered guided missile cruisers in the 1990s. In some cases, those escorts were reliant on the nuclear-powered carrier for propulsion refueling, especially when purpose-built combat logistics force ships have not been present in the carrier strike group. While this was sustainable in the immediate, post-Cold War era when U.S. ships faced no sea control challenges, it seems incredulous now to confine high-value units like the large carrier to long, straight refueling courses for escorts that leave them vulnerable to submarine attack. The lack of a large and effective enough combat logistics force to support warships of all sizes is a conversation for another work, but neither conventional nor nuclear carriers should be regular gas stations for their escorts in a period of strategic competition.

177 "CVN 78 Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78)," U.S. Department of Defense, Selected Acquisition Report (SAR), December 2019, p. 19.

6

HOW MANY CARRIERS? AT WHAT COST?

"The Navy does not need a 4th nuclear-powered aircraft carrier. It can maintain a twelve-carrier fleet and the fighting capability it needs from a conventionally-powered carrier which I shall request in my budget for next year, at a saving of $1 billion for that single ship."

– Defense Secretary Harold Brown, August 1, 1978

"Senator, we need 15 carriers for peacetime operations. We need 20 or more for war."

– Vice Admiral Henry Mustin to Senator Edward M. Kennedy, Senate Armed Services Committee testimony on a two-carrier block buy, March 17, 1987

Not surprisingly, the Washington debate over how many carriers are needed has waxed and waned according to world events and perceived threats coming from maritime or continental powers. In the immediate post-WWII years, the U.S. government failed to recognize the global nature of the Soviet threat and ordered the scrapping or mothballing of all but seven of the 110 Navy carriers.[178] That radical action helped to bring on the invasion of South Korea.

178 Michael M. McCrea, Karen N. Domaby, and Alexander F. Parker, *The Offensive Navy Since World War II: How Big and Why, A Brief Summary*, Center for Naval Analyses, August 30, 1989, p. 12.

The Korean War brought an immediate reversal by the Truman administration, which trebled the Navy budget and ended the war with 19 carriers with the first "supercarriers" under construction.[179]

The decade between the Korea and Vietnam conflicts saw the launch of the first nuclear-powered supercarrier, the USS *Enterprise*. During the Vietnam War, the Navy maintained an average of 14 carriers, and continued building nuclear *Nimitz*-class carriers starting in 1975.[180] In the search for a "Peace Dividend" after the war and a new administration that was focused on the huge imbalance of land forces in the central front of Europe (some 88-125 Warsaw Pact divisions facing 26 NATO divisions), Navy budgets were cut deeply and carriers were reduced to 12.[181] As often happens after major defense cuts, America's adversaries became more aggressive: declaring the Brezhnev Doctrine, which asserted the right to intervene wherever communist regimes were threatened; invading Afghanistan; and fomenting communist insurgencies in Latin America and Africa.

As to be expected, these events drew a strong reaction from the administration's opposition. Ronald Reagan campaigned in 1980 on rebuilding the Navy to 600 ships, including 15 supercarriers, and upon winning the election, he proceeded to build and deploy them.[182]

179 "US Ship Force Levels, 1886-present," U.S. Navy History and Heritage Command, November 17, 2017, https://www.history.navy.mil/research/histories/ship-histories/us-ship-force-levels.html#1951.

180 Ibid.

181 Edward C. Keefer, *Harold Brown, 1977–1981: Offsetting the Soviet Military Challenge*, Office of the Secretary of Defense, p. 357; and James Blaker and Andrew Hamilton, *Assessing the NATO/Warsaw Pact Military Balance,* Congressional Budget Office, December 1977, pp. xvi, 2.

182 Gerhard Peters and John T. Woolley, "Republican Party Platform of 1980," American Presidency Project, https://www.presidency.ucsb.edu/node/273420.

With the end of the Cold War in 1991, the search for a "Peace Dividend" began anew, and defense budgets were cut some 30 percent.[183] Aircraft carriers were reduced again to 12 in General Colin Powell's Base Force concept developed by the Joint Staff.[184] Clinton administration Defense Secretary Les Aspin's Bottom Up Review of 1993 added further defense cutbacks totaling up to one-third of the late Cold War force, including the trimming of the carrier fleet to just 11 active vessels.[185] This number was later reduced in law to 10 to allow for the extended period needed to commission USS *Gerald R. Ford.*[186] Congress then grew concerned that Navy cuts were too deep and put into law the requirement for at least 12 carriers.[187]

In the public debate today, the usual reason for cutting carriers is budgetary, with vulnerability in second place and strategy rarely mentioned. Whether it was the $3 billion for the fourth *Nimitz*

183 Eric V. Larson, David T. Orletsky, and Kristin Leuschner, *Planning in a Decade of Change, Lessons from the Base Force, Bottom-Up Review, and Quadrennial Defense Review* (Santa Monica, CA: RAND Corporation, 2001), p. xviii.

184 Lorna Jaffe, *The Development of the Base Force 1989-1992,* Office of the Chairman of the Joint Chiefs of Staff, July 1993, p. 44.

185 Les Aspin, *The Report on the Bottom Up Review,* U.S. Department of Defense, 1993.

186 Section 126 of the FY2006 National Defense Authorization Act (H.R. 1815/P.L. 109-163 of January 6, 2006), which set the number at 12 carriers. The carrier force dropped from 11 ships to 10 between December 1, 2017, when *Enterprise* (CVN-65) was inactivated, and July 22, 2017, when CVN-78 was commissioned into service. Anticipating the gap between the inactivation of CVN-65 and the commissioning of CVN-78, the Navy asked Congress for a temporary waiver of 10 U.S.C. 8062(b) to accommodate the period between the two events. Section 1023 of the FY2010 National Defense Authorization Act (H.R. 2647/P.L. 111-84 of October 28, 2009) authorized the waiver, permitting the Navy to have 10 operational carriers between the inactivation of CVN-65 and the commissioning of CVN-78. Reported by Congressional Research Service analyst Ron O'Rourke in his October 7, 2020, report on the *Ford*-class carrier.

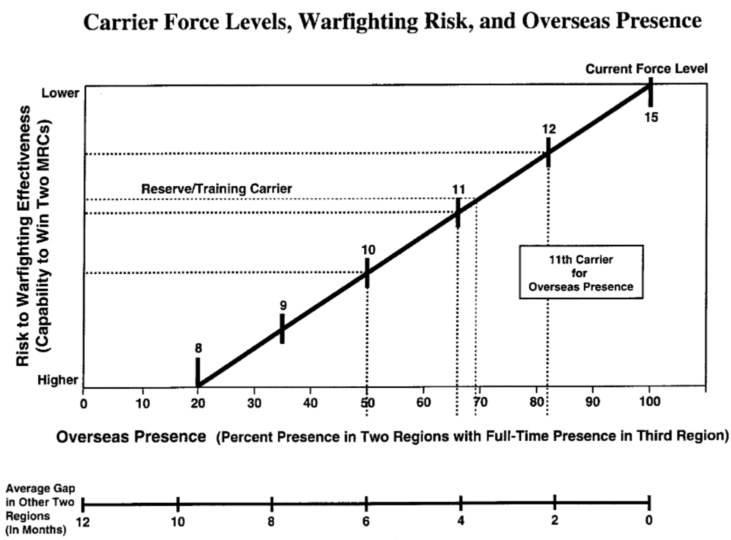
187 The John S. McCain National Defense Authorization Act for Fiscal Year 2019, 115th Congress, Second Session, August 15, 2018, p. 29.

Naval vessels from five nations move in parade formation for a rare photographic opportunity at sea. In four descending columns, from left to right: ITS Maestrale (F 570), De Grasse (D 612); USS John C. Stennis (CVN-74), Charles de Gaulle (R91), Surcouf (F 711); USS Port Royal (CG-73), HMS Ocean (L12), USS John F. Kennedy (CV-67), ITS Luigi Durand de la Penne (D560); and HNLMS Van Amstel (F 831). (U.S. Navy)

class (later named the USS *Theodore Roosevelt)* in 1980, or the $13.3 billion USS *Gerald R. Ford* in the present day, the cost of carriers makes them a natural target for budget hawks seeking to free funds for other projects.

The Navy challenge today is to make the case for the right number of carriers needed for global operations in peace and war, while at the same time understanding that the runaway cost of the new *Ford* class makes it unaffordable unless significantly reduced. The decisions on carrier numbers over the last 30 years have been driven by the public perception that there is very little threat. The return, however, of great power enemies with global reach requires the Navy to recommend carrier numbers based on those emerging threats. Carrier maintenance cycles must also be considered along with the

Figure 5: The 1993 Bottom Up Review Illustration of Carrier Requirements for Forward Presence in three distinct geographic areas (Western Pacific, Mediterranean Sea, and Persian Gulf regions)*



*Source: Aspin, *The Report of the Bottom Up Review,* p. 50.

total number of carriers. The number that can be forward deployed in peacetime is a smaller number than can be surged in war because the readiness of the force requires thorough maintenance on a regular cycle. The calculus of the carrier estimate for the 1993 Bottom Up Review remains useful today given the Navy's requirement to maintain forward deployed, combat credible naval forces. It remains very much the case of a 10- or 11-carrier navy in a 15-carrier world.

Carrier Costs

Since WWII, the aircraft carrier has been the single most expensive platform in the U.S. military. The cost of the *Ford* class, however, is out of proportion to any of its predecessors. There are several reasons for this. It is the first carrier procurement managed by the joint Pentagon bureaucracy established by the Goldwater-Nichols reforms rather than by the Navy itself. The Joint Requirements Oversight Committee's input into the design of the *Ford* class put too much emphasis on sortie numbers because of lessons from the Gulf Wars rather than from the Cold War, where carriers were employed in a diversity of missions. The result of that process added 12 undeveloped technologies to the design, including electronic catapults, arresting gear, and elevators, along with new radars and other fundamental infrastructure of the ship, none of which existed at contract time and some of which have not been successfully completed or tested at this writing.[188] Some skeptics have described it as a sea-going camel designed by a committee. The ship was authorized in FY2008. Now, 13 years later, the cost so far in 2008 dollars is over $13 billion and climbing as all of its systems have yet to be fully certified.[189] By contrast, the first *Nimitz* class (roughly the same size as *Ford*) took nine years from contract (1967) to deployment (July 1976) and cost $4 billion adjusted for inflation in 2008 dollars (*Nimitz* cost about $1 billion in 1975 dollars).[190]

188 *FORD-CLASS AIRCRAFT CARRIER Follow-On Ships Need More Frequent and Accurate Cost Estimates to Avoid Pitfalls of Lead Ship*, Government Accountability Office, June 3, 2017, pp. 11-13.
189 Ron O'Rourke, "Navy Ford (CVN-78) Class Aircraft Carrier Program: Background and Issues for Congress," Congressional Research Service, March 25, 2021, p. 6.
190 "Bringing the Federal Budget Closer To Home," *New York Times,* November 23, 1975.

Another reason for such a large increase is that the Pentagon must deal with a monopoly supplier, as Newport News Shipbuilding is the only company that has facilities able to build such a large, nuclear-powered ship, and monopolies have little incentive to reduce costs or to innovate in construction technology.

Other carrier choices are less costly but deliver less capability. The Royal Navy's two *Queen Elizabeth*-class conventionally powered flattops nominally support about two-thirds the aircraft of larger U.S. carriers, and were built as a single programmatic effort for about $10 billion.[191] *Charles de Gaulle* was built for £3 billion in 2001, which equates (from inflation alone) to $6.5 billion in today's dollars.[192] The United States' own large amphibious ship LHD and LHA-6 classes are relatively low cost, with LHA-6 USS *America* at $3.4 billion in 2015 dollars.[193]

Smaller, conventionally powered carriers do cost less. It has been over two decades since the Navy carrier force contained a number of conventional carriers, and the USS *John F. Kennedy* (CV 67) was the last to be commissioned in November 1968.[194] The GAO estimated in 1998 that a nuclear-powered aircraft carrier ($8.1 billion in 1997 dollars) would cost double what a conventionally powered counterpart did and that its 50-year lifespan costs were 58

191 "Major Projects Report 2019," United Kingdom Ministry of Defence, 2019.
192 David Bartocinni, "The Charles De Gaulle Aircraft Carrier, France's Naval Power," *InsiderOver,* February 7, 2020.
193 *Defense Acquisition: Assessments of Selected Weapon Programs,* Government Accountability Office, 2015, p. 113.
194 Naval Vessel register (NVR) ex-USS *John F. Kennedy,* December 12, 2017, https://www.nvr.navy.mil/shipdetails/shipsdetail_CV_67.html.

percent higher than those of a conventional flattop were over the same time.[195]

Carrier Maintenance and Overhaul

While carrier acquisition is often the first dollar value questioned by Congress and others, the periodic overhauls and continued maintenance of carriers are a much larger cost issue. Many of the *Ford*-class' innovations, especially its new reactors, revamped flight deck design and electromagnetic catapults, and weapons elevators, were intended to reduce both crew complement and maintenance over the life of the ship and hence lower overall lifecycle costs, if they are successful. The ship's A1B reactor cores have an estimated fuel life of 25 years between fuelings.[196] Given the ship's 50-year expected service life, the reactors should need refueling once over the course of the ship's service life, as has been the case with the *Nimitz*-class ships.[197] As of June 2021, the Navy estimates that these improvements will reduce the lifetime costs of the *Ford* class by $4 billion.[198]

A snapshot of U.S. Navy carrier readiness from January 2020 suggests the amount of maintenance and support needed to keep U.S. flattops ready for both their regular turns at oversea deployment as well as unplanned surge operations that bring carriers in port forward at

195 *Navy Aircraft Carriers: Cost-Effectiveness of Conventionally and Nuclear-Powered Carriers,* United States General Accounting Office, 1998, p. 8.
196 Martin and McMahon, *Future Aircraft Carrier Options*, p. 26.
197 Ibid.
198 Ronald O'Rourke, "Navy Ford (CVN-78) Class Aircraft Carrier Program: Background and Issues for Congress," Congressional Research Service, June 7, 2021, pp. 4, 5.

short notice in crisis response missions.[199]

Table 4. U.S Navy Carrier Readiness as of January 17, 2020

USS Nimitz (CVN 68)	Underway training at sea
USS Dwight D. Eisenhower (CVN 69)	In port, upkeep and maintenance
USS Carl Vinson (CVN 70)	Limited availability while waiting for docking for maintenance
USS Theodore Roosevelt (CVN 71)	Preparing to deploy in late January 2020
USS Abraham Lincoln (CVN 72)	Just returned from deployment and preparing to change homeports
USS George Washington (CVN 73)	Complex overhaul (includes refueling) with the ship out of services for up to three years.
USS John C. Stennis (CVN 74)	Preparations to begin Complex overhaul
USS Harry S. Truman (CVN 75)	Deployed overseas
USS Ronald Reagan (CVN 76)	In a regularly scheduled maintenance period of upwards of 4 months in length (Reagan is the forward deployed U.S. carrier in Japan)
USS George H. W. Bush (CVN 77)	Limited availability while waiting for docking for maintenance
USS Gerald R. Ford (CVN 78)	Post-delivery test and trials period (up to 11 months or more as Ford continues to work out equipment issues)

This snapshot of carrier readiness in January 2020 shows two carriers (*George Washington* and *John Stennis*) either out of service or about to leave service for regular complex overhaul of 44 months. Another, *Ronald Reagan*, was in a selected restricted availability (SRA), a period not as long as a complex overhaul but one where many key systems are offline for maintenance. The number of carriers available at any given time to deploy and operate is restricted by these maintenance efforts and even a dozen supercarriers cannot meet the demands of

199 Charles Ehnes, "Surface Navy Association, National Symposium 2020, In-Service Aircraft Carriers Program," Naval Sea Systems Command (PMS 312), January 2020, p. 5.

the regional combatant commanders. The Goldwater-Nichols Act of 1986 gave the regional commanders authority to force the Navy to provide more carriers even when they are ill-prepared to deploy in the absence of required maintenance and training.

Required Numbers

There is the hope that the *Ford* class may eventually improve the overhaul process for nuclear-powered carriers, but the regular complex overhauls of the *Nimitz* class will continue to take those ships offline for four years at a time, thus limiting at given points the number of carriers the U.S. can actively deploy. Other than one American carrier based in Japan, these vessels are exclusively homeported in the United States, which means they have long transits from the continental United States to forward deployed assurance of allies, deterrence, and/or war-fighting locations. The Korean War demonstrated the calculus remaining to the present day that for every deployed flattop, the Navy must possess three, with one in the shipyard undergoing refit and one in the training cycle preparing to deploy in addition to the carrier on station.[200]

According to the Navy History and Heritage Command, "Since the 1970s, these [carrier] deployments have been concentrated in three 'hubs': the Mediterranean Sea, the western Pacific Ocean, and the Arabian Sea."[201] The forces required to maintain combat credible power in those regions have been a prominent part of both the

200 Seth Cropsey, Bryan G. McGrath, and Timothy A. Walton, *Sharpening the Spear: The Carrier, the Joint Force, and High-End Conflict*, Hudson Institute, October 2015, p. 73.
201 Peeks, *Aircraft Carrier Requirements and Strategy,* p. 12.

numbers of carriers required and with them the size of the rest of the fleet.

With the end of the Cold War and the collapse of the Soviet Union, the number of required flattops reverted to 12. A dozen carriers could provide the appropriate global deterrent, Middle East war-fighting missions, and one other region for two hubs. The Pentagon described the need for the carrier in the post-Cold War fleet in the 1993 Bottom Up Review of defense capabilities as:

> Without the Soviet Navy, no one challenges us for control of the seas. Now our naval forces must focus on projecting conventional power ashore in regional conflicts, particularly during the critical opening phase of a major conflict. In addition, they must 'show the flag,' that is, help maintain a significant U.S. presence overseas to uphold our international commitments. In this context, aircraft carriers are the centerpiece of our naval forces.[202]

The 12-carrier number lingered until *Enterprise,* the first nuclear carrier, was retired in December 2012.[203] Since its intended replacement, the *Ford,* was and still is way behind schedule, the Navy has had to limp along with 11, even as the theater commanders demand even more than during the Cold War as Russia, China, North Korea, and Iran became more and more truculent. The Navy devised schemes, such as the Optimized Fleet Response Plan

202 Les Aspin, *The Bottom Up Review.*
203 Mark Faram, "This is how the Navy plans to break the Big E," *Navy Times,* June 6, 2019.

(OFRP), to try to stretch the 11-carrier force to cover the demands of the regional combatant commanders supporting the three "hubs" of deployment.[204] The Navy has learned and relearned the hard way that the service cannot do more with less. The tried-and-true system of three carriers in rotation keeping one forward deployed was sufficient to provide two out of three in the emergency circumstances of wartime, but cannot be maintained in peacetime without severe damage to morale, maintenance, and readiness. That is where we are today. The Navy needs more ships.

The smaller number of carriers means that they deploy more and remain deployed for longer periods. The Navy recently testified that despite a goal of seven-month-long deployments for carriers, the average deployment length went from 6.5 months in 2011 to 8.2 months in 2014.[205] Some deployments went very long. In the years 2014 and 2015 in particular, "*Nimitz* and *Harry S. Truman* completed 8.5-month deployments in fiscal year 2014. *George H.W. Bush* completed a 9-month deployment, *Carl Vinson* completed a 9.5-month deployment, and *Theodore Roosevelt* will complete an 8.5-month deployment this year."[206] Despite strenuous efforts by a succession of Navy Secretaries and Chiefs of Naval Operations to reduce the lengths of carrier deployments, they have failed. Since the Goldwater-Nichols reforms, the Navy service chief has no

204 Meghan Eckstein, "U.S. Fleet Forces: New Deployment Plan Designed to Create Sustainable Naval Force," *U.S. Naval Institute News,* January 20, 2016.
205 "Military Readiness: Progress and Challenges in Implementing the Navy's Optimized Fleet Response Plan," United States Government Accountability Office, May 2, 2016, p. 7.
206 Multiple *U.S. Naval Institute News* reports from 2015 covered these long carrier deployments. Meghan Eckstein and Sam LaGrone, "Top Stories 2015: U.S. Navy Operations," *U.S. Naval Institute News,* December 28, 2015.

authority over the ships once they deploy in response to a combatant commander request. Combatant commanders are naturally unwilling to give up their authority and want to hold onto naval forces for as long as they can.

While carrier deployments dropped to a 25-year low in 2018, due in large part to a lull in global crises, they quickly rebounded in the following years.[207] In January 2020, the carrier *Abraham Lincoln* set a dubious record in making a year-long deployment, the longest of any flattop since the Vietnam War.[208] *Dwight Eisenhower* and *Theodore Roosevelt* made additional nine-month deployments in 2020.[209] The year 2020 became the busiest year for Navy carrier operations since the Arab Spring of 2011, with a net increase in carrier operations of 40 percent from 2019.[210] The Fleet Response Plan and Optimized Fleet Response Plan efforts by the Navy have not been able to reduce the length or number of deployments in the carrier force. These regional demands are being met at the cost of grinding down the ships and sailors.

The COVID-19 pandemic has made the deployment of the smaller number of carriers a greater challenge. The Navy maintained an ambitious deployment schedule for all of its ships during

207 Megan Eckstein, "No Margin Left: Overworked Carrier Force Struggles to Maintain Deployments After Decades of Overuse," *U.S. Naval Institute News,* November 12, 2020; and Sam LaGrone, "U.S. Aircraft Carrier Deployments at 25 Year Low as Navy Struggles to Reset Force," *U.S. Naval Institute News,* September 26, 2018.
208 Gidget Fuentes, "Lincoln Strike Group CO: Record Deployment Marks New Uncertainty for Fleet," *U.S. Naval Institute News,* January 20, 2020.
209 Geoff Ziezulewicz, "Another week, another spate of nine-month ship deployments," *Navy Times,* October 14, 2020.
210 Megan Eckstein, "No Margin Left: Overworked Carrier Force Struggles to Maintain Deployments After Decades of Overuse," *U.S. Naval Institute News*, November 12, 2020.

the pandemic, but the support structure for this effort has been seriously tested. Current Chairperson of the Senate Armed Services Committee Subcommittee on Seapower, Mazie Hirono (D-HI), stated, "With our shipyards and the impact of COVID on the shipyards, it's going to take longer for the ships to be adequately rehabilitated."[211] That delay includes the carrier force, and it is already seeing COVID impacts beyond the USS *Theodore Roosevelt* outbreak. The pandemic forces deployed ships to remain at sea or anchor out rather than moor pier-side during deployments. This extra time and associated wear-and-tear on ship systems has an impact on when the ship returns from deployment and enters post-deployment shipyard repair and upgrade periods. A smaller number of carriers creates smaller margins for failure in terms of completing maintenance and getting the ship back to sea for its next operational employment. Any problem could mean back-to-back deployments for carriers. The last time the USS *Dwight Eisenhower* had close, consecutive deployments, the ship's post-deployment maintenance period ballooned from 14 to 23 months in the shipyard.[212]

These kind of endless deployments with very short breaks between them characterized the "hollow force" of the 1970s, where the Navy's retention of sailors past initial enlistments plummeted to record low levels. In 1970, for example, Navy carriers spent 91 days in homeport per year, suggesting long deployments and lots of time spent at sea

211 Andrew Clevinger, "Navy conquered COVID-19 on ships, but pandemic has a long tail," *Roll Call,* March 11, 2021.
212 Eckstein, "No Margin Left: Overworked Carrier Force Struggles to Maintain Deployments After Decades of Overuse."

away from family.[213] Then-Chief of Naval Operations Admiral Elmo Zumwalt described the effects of such long deployments on the Navy as follows,

> Our surveys have shown consistently that family separation is a key factor in the career decisions of most Navymen. This slide shows the average number of days spent by our ships in their home ports last year. Some of our career men in deprived ratings are at sea for more than 7 years at a stretch on schedules such as these.[214]

Long deployments combined with low pay severely affected Navy retention of qualified sailors. According to naval historian Ronald Spector, "As early as 1971, an article in the U.S. Naval Institute's *Proceedings* referred to the personnel situation in the nuclear navy as a 'crisis.' During the 1960s and 1970s almost two-thirds of nuclear-qualified officers left the service at their earliest opportunity."[215]

Today's long carrier deployments—including recent ones over 200 days in length by USS *Dwight Eisenhower* and USS *Nimitz* due to operational requirements and the need to quarantine for the COVID-19 pandemic ahead of deployment—may equally reduce sailor retention and weaken the overall force. A fleet with 12 and growing to 15 carriers, all properly maintained with shorter

213 John Hattendorf, *U.S. Naval Strategy in the 1970s,* (Newport, RI: U.S. Naval War College Press, 2007), p. 23.
214 Ibid.
215 Ronald Spector, "U.S Navy Sea Changes," *Quarterly Journal of Military History*, Winter 2012.

deployment cycles as was the case in the 1980s, improves both readiness and retention. The Navy can pay now with more ships, or pay later in terms of repairs, reduced retention, and poor readiness for combat.

There has been scant effort to reduce long, "double pump" deployments by increasing the size of the carrier force. The last Trump administration Secretary of Defense, Mark Esper, did not support adding carriers to the fleet. He suggested that only 8-to-11 carriers were needed, and called instead for replacing them with alternate force structures, including unmanned surface and subsurface units.[216] In defending this reduction in carriers, Esper stated that, "Nuclear powered carriers will remain our most visible deterrent, with the ability to project power and execute sea control missions across the globe," but implied their numbers should be reduced.[217] Reductions seem a dubious choice as the oldest carrier, USS *Nimitz,* returned from an 11-month deployment on March 4, 2021.[218]

Effect on Personnel

Despite hopes of other platforms for these missions, many of the notional low-end platforms suggested as carrier replacements and the logistics needed to support large numbers of such units in a distributed deployment remain aspirational or experimental. The Navy has so far struggled to get the littoral combat ship (LCS),

216 David Later, "Defense Department study calls for cutting 2 of the US Navy's aircraft carriers," *Defense News,* April 20, 2020.
217 John Harper, "Esper Calls for 500-Ship Navy to Counter China," *National Defense,* October 6, 2020.
218 Megan Eckstein, "USS Nimitz Returns Home After 11 Months Total Away," *U.S. Naval Institute News,* March 5, 2021.

the first of the products of this new reformed joint multi-service procurement system, to work. The relatively low-end LCS relies on high speed, short range, small crew, automated systems, and a great deal of shore-based maintenance. The Navy has provided the Indo-Pacific Command with a two-ship LCS deployment to Singapore in recent years, with one of those vessels armed with eight surface-to-surface cruise missiles. The challenges of LCS, the delays in developing the combat system on the *Zumwalt*-class destroyer, and the aforementioned challenges with the *Ford*-class carrier's systems have soured congressional opinion on Navy shipbuilding.[219] It is hoped that unmanned units—if they are successfully developed in the future—might help to reduce some of the costs associated with combat-credible forward presence, but they would still need to be refueled, repaired, and re-armed at sea, a capability that remains theoretical and experimental at best.[220] While experimentation might continue, the Navy—after three consecutive troubled ship classes (LCS, *Zumwalt,* and *Ford)*—cannot afford the time needed to travel the bureaucratic road of troubled Joint Requirements Oversight yet again, when a rapid expansion of fleet capability is now needed.

An 11 Carrier Navy in a 15 Carrier World?

Given the current commitments of U.S. naval forces to multiple deployment hubs, the strain those deployments have placed on the current carrier fleet, and the relatively immature and experimental

219 Megan Eckstein, "White House-Led Navy Shipbuilding Plan Set to Push Boundaries of Pentagon Budgets, Industry Capacity," *U.S. Naval Institute News,* December 10, 2020.
220 Hunter Stires, "CNO Announces the Return of Vertical Launch System At-Sea Reloading," *The National Interest,* July 5, 2017.

status of any replacements, it would seem prudent to build a larger carrier fleet than the present 11-12 flattop force. The carrier is not the only U.S. Navy offensive platform for striking targets ashore; surface ships and submarines provide significant capability in terms of missile firepower. However, only the carrier is able to provide a mobile dome of 24/7 air superiority, anywhere over 72 percent of the earth's surface. Whether naval or military supply ships, commercial tankers, and transports, nothing can survive on the surface of the sea without air superiority above them.

The post-World War II U.S. Navy and its Cold War successor embodied a mix of capabilities in both high- and low-end units. Both, however, were built around the carriers, as combat from the 1940s to the 1980s Falklands War proved surface combatants cannot operate in the absence of sea-based air superiority. The carriers exist to protect the missile shooters as much as to conduct strikes themselves.[221] It is the logic of the mad hatter to suggest that we have to buy escorts to protect the carriers. Distributed, low-end missile shooters (manned or unmanned) will require air superiority, and considering the geography of the Indo-Pacific with limited land bases, it is clear that more aircraft carriers are needed. It does not mean that they all must be nuclear super-carriers. Given the geography of current great power competition in at least three major geographic areas, it seems clear that an increased level of sea-based aviation is a paramount requirement.

221 John Lehman to Senator Edward M. Kennedy, March 17, 1987, testimony on the two-carrier buy for that FY87, CSPAN, https://www.cs-span.org/video/?56752-1/aircraft-carrier-replacement.

7

UNMANNED CARRIER AIRCRAFT: MISSIONS AND MYTHS

"Through June 30, 1969, the Navy spent over a quarter of a billion dollars for the development and acquisition of the Drone Anti- Submarine Helicopter Weapon System that provides delivery of torpedoes by drone helicopters, and operates from surface ships for the purpose of attacking and destroying enemy submarines. Although this weapon system provided the Navy with a capability it did not previously have, the system suffered from a high rate of loss of the drone helicopters. Of the 750 drones purchased by the Navy, 362 have been lost. GAO believes that the difficulties experienced with the system resulted, in large part, from the Navy's ordering the drone helicopters into production before they were fully developed and tested."

– General Accounting Office Report on the Drone Antisubmarine Helicopter, April 1970

In the 1970s, before the arrival of combat-ready unmanned aircraft, much attention was given to the emerging V/STOL concept and the prospects for its future employment on warships of different sizes. This technology developed successfully beyond the early AV-8A Harrier V/STOL aircraft and was the key weapon of the Royal Navy in the Falklands War of 1982 for defending its ships once they arrived at the Argentine-occupied islands. While V/STOL became a successful component of sea-based aviation in limited roles, it never supplanted conventional takeoff and landing (CTOL) carrier aircraft in the U.S. Navy. The reason is simple: The amount of fuel required by a combat aircraft to take off on its own power and to land vertically on a ship severely limits the range and weapons payload of that aircraft, while CTOL aircraft get their launch and recovery energy free of charge, which means much greater range and payload. The limited range and payload of V/STOL aircraft mean that most missions at sea cannot be conducted by those aircraft.

With its missions primarily close to or on shore, the U.S. Marine Corps successfully operated Harrier AV-8B aircraft in combat until their recent replacement by the F-35B V/STOL variant of the F-35 family of aircraft, but V/STOL aircraft did not achieve their promise in the U.S. Navy because of their range/payload limitations. Thus, there was no role for a large number of small V/STOL carriers with a few aircraft per ship, despite the recommendations in some academic studies in the late 1970s.[223]

In the current era, there is a new actor on the flight deck: unmanned combat aircraft. They appear to be an equally promising addition to the carrier airwing in the future, but, like proposed surface and subsurface unmanned systems, the unmanned autonomous aircraft has been endowed with a fair amount of mythology in what it can do in the present. The development of the MQ-25A *Stingray* aircraft as a tanker for the carrier airwing has been a useful experiment and has highlighted the requirements needed to operate unmanned

223 "Department of Defense Appropriations for 1979," 95th Congress, Second Session, February 7, 1978, p. 682.

aircraft at sea. Future unmanned aircraft may operate in a variety of roles, including strike operations. Some significant challenges must be overcome, however, in order to reach that capability. Realization of that vision will take time, a new generation of technology, and substantial congressional funding.

The MQ-25A Stingray Experience

The Navy began development of an unmanned, carrier-based aircraft with the creation of the Unmanned Carrier-Launched Airborne Surveillance and Strike (UCLASS) program in 2006.[224] Its mission was defined as "a long-range surveillance and strike asset . . . of the future."[225]

In 2011, however, the Navy was directed by the Defense Department to alter the mission of the UCLASS to one of light strike against terrorists rather than as a full-fledged carrier airwing strike asset.[226] In January 2016, the Defense Department directed the Navy to change the program from developing an unmanned aircraft with strike as a primary function to one focused on an unmanned carrier-based aerial refueling system, which "represented a significant shift in requirements."[227]

224 Randy M. Forbes, "Unmanned Carrier-launched Airborne Surveillance and Strike (UCLASS) Requirements Assessment," House Armed Services Committee, Seapower and Projection Forces Subcommittee, 113th Congress, Second Session, July 14, 2014, p. 3.
225 Ibid.
226 Sam LaGrone, "Pentagon Altered UCLASS Requirements for Counterterrorism Mission," *U.S. Naval Institute News,* August 29, 2013.
227 *Navy Unmanned Aerial Refueling System, Acquisition Addresses Validated Requirements and Reflects a Knowledge-Based Approach,* United States Government Accountability Office, September 2017, p. 3.

MQ-25A drone (Courtesy of The National Interest)

F-35B (Courtesy of The National Interest)

E-2D Hawkeye (Courtesy of ainonline.com)

F-35C (U.S. Navy)

CVM-22B Osprey (Courtesy of military.com)

The Navy has not had a dedicated, carrier-based tanker since the retirement of the KA-6D in 1997 and has since been marginally supported by FA-18 aircraft in "buddy tanking" missions.[228] The use of the expensive, complex, and scarce F/A-18 strike fighter as a tanker is a very poor use of this resource as an auxiliary rather than as a combat aircraft.[229] Conformal fuel tanks once thought possible of extending the F/A-18's range now appear problematic as they may put unneeded stress on the airframe and may also increase the maintenance burden on carrier flight deck maintainers.[230]

Lacking organic tanking, the Navy has become dependent on joint Air Force-controlled land-based tanking since Operation *Desert Storm* and in the post-9/11 conflicts around the Eurasian rimland. It would be much more efficient for the Navy to again possess its own tanking capability, especially when the fight moves to contested waters in the Indo-Pacific, where land-based aviation lacks land bases, and the few that exist are extremely vulnerable to attack from a major enemy. A new tanker is the right choice rather than burdening existing aircraft.

The progress of the MQ-25A to full operational capability has been slowed by a general lack of Department of Defense support. The FY2021 Defense Department budget request cut development funding for the unmanned tanker in half, from $600 million to $300

228 Bryan Clark, Adam Lemon, Peter Haynes, Kyle Libby, and Gillian Evans, *Regaining the High Ground at Sea: Transforming the U.S. Navy's Carrier Air Wing for Great Power Competition,* Center for Strategic and Budgetary Assessments, 2018, pp. 53-4.
229 Megan Eckstein, "Navy Getting 'Smarter' About Tanking Mission As Super Hornets Approach 6,000 Hours," *U.S Naval Institute News,* August 12, 2015.
230 Caleb Larson, "The U.S. Navy's F/A-18 Super Hornet Might Be in Trouble," *The National Interest,* February 2, 2021.

million.[231] The MQ-25A is expected to achieve interim operational capability in 2024.[232] A recent Congressional Budget Office report suggested the Navy would buy 69 MQ-25A aircraft at an overall cost of $8 billion.[233] The initial squadron of 20 aircraft will be based at Naval Base Ventura County in Point Mugu, California.[234] The Navy is also gearing up to select 450 warrant officers as "aerial vehicle operators," suggesting that the new tanking aircraft will be flown as a drone for the foreseeable future and not operate on its own artificial intelligence, or at least not all of the time it is aloft.[235]

The projected MQ-25A component of the U.S. Navy carrier airwing will likely be five unmanned tanking aircraft.[236] While this may seem a modest, unmanned contribution to the carrier airwing, it has major implications, especially in terms of aircraft density and the overall airwing size that a single flattop can accommodate. Just five MQ-25 aircraft will account for almost 6 percent of the overall airwing strength carried on a *Nimitz*-class carrier.[237] Those 5 MQ-25s are also expected to drive the overall operational density on the *Nimitz*-class ships to an 89 percent fill, where the Navy's desired operational

231 *United States Department of Defense Fiscal Year 2021 Budget Request,* U.S. Department of Defense, May 15, 2021, p. 4.2.
232 Megan Eckstein, "Pentagon Wants a Process to Field Unmanned Systems, AI Faster," *U.S. Naval Institute News,* September 22, 2020.
233 R. Derek Trunkey, David Arthur, Edward G. Keating, and John Kerman, *The Cost of Replacing Today's Naval Aviation Fleet*, Congressional Budget Office, January 2020, p. 9.
234 Gina Harkins, "Navy Reveals Basing Plans for New MQ-25 Stingray Tanker Drones," *Military.com,* November 2, 2020.
235 Diana Stacy Correll, "Navy unveils warrant officer specialty to operate MQ-25 Stingray refueling drones," *Navy Times,* December 15, 2020.
236 Internal OPNAV N98 assessments.
237 Ibid.

density fill for that class is just 80 percent.[238] Operational density is in effect a calculation of the size and complexity of an aircraft; the people, equipment, and maintenance time and effort needed to operate any given aircraft (manned or unmanned) on a carrier; and is represented by a circular "spot" on the flattop's hangar and flight decks.[239] As stated earlier, aircraft operational density is an important factor in determining what types of aircraft and how many of each can be effectively carried by a given aircraft carrier. The Navy does not like to operate its flattops in peacetime with more than 80 percent of their overall aircraft capacity, as overloading them tends to reduce efficiency of flight deck operations. If a non-combatant, unmanned aircraft takes up more than a one-to-one ratio in overall airwing strength, what is the expected footprint of a much more complex unmanned strike aircraft? Any calculation of the unmanned component of a carrier airwing must take into account the challenge of aircraft density.

In addition to technological, logistical, and density issues, unmanned aircraft add a new faction to carrier critics. Human Rights Watch and other humanitarian organizations have mounted a near-decade-long campaign against automated, weaponized platforms. Their 2020 report states that many nations, including the United States, "are investing heavily in military applications of artificial intelligence (AI) with the goal of gaining a technological advantage in next-

238 OPNAV N98 documents suggest this.
239 Eric S. Ryberg, "The Influence of Ship Configuration on the Design of the Joint Strike Fighter," Naval Surface Warfare Center Dahlgren Division, February 26, 2002, p. 4.

generation autonomy on the battlefield."[240]

Many speculate that so-called "killer robots" of all types, including surface, submarine, and air, will soon populate the ranks of the U.S. military and challenge long-standing military ethics on human control of force. However, unmanned aircraft development to date has focused on remote-piloted rather than autonomous vehicles. The U.S. Navy has been a pioneer in such efforts going back to the 1960s with the Drone Antisubmarine Helicopter (DASH) program. This remote-piloted helicopter drone could carry two Mk44 antisubmarine torpedoes for a 25-minute-long mission at a speed of 80 knots.[241] The DASH was a concept ahead of its time with great potential for success as a standoff antisubmarine warfare platform. Unfortunately, the technology needed to make DASH successful was not yet mature. The drone had significant datalink, maintenance, and training issues that caused its eventual withdrawal from service in 1971.[242]

Since the 1960s, drone aircraft have continued to develop toward what DASH first aspired to do. During the Vietnam War, the Navy pursued development of an unmanned surveillance drone and an unmanned armed decoy drone. Both were cancelled by the Defense Department because they were not multi-service, joint programs. Both types were selected and used by the Israeli Defense Forces

240 Brian Stauffer, "As Killer Robots Loom, Demands Grow to Keep Humans in Control of Use of Force," Human Rights Watch, 2020.
241 Shannon A. Brown, ed., *Providing the Means of War: Historical Perspectives on Defense Acquisition, 1945–2000,* U.S. Army History Center and the Industrial College of the Armed Forces, 2005, p. 5, 113.
242 Ibid, pp. 113-114.

with great success during the Bekaa Valley conflict in 1982.[243] The U.S. Navy was so impressed that they purchased ten complete surveillance drone systems, now called RQ-2A *Pioneer*, and large numbers of the armed decoy drones, now called *Sampson*. The Navy and Marines used both in *Desert Storm*, with great success. *Pioneer*, now in the Smithsonian, was made famous for the Iraqi division that surrendered to it after launch from the battleship USS *Missouri*.[244] That success resulted in a chastened Defense Department developing the fully weaponized MQ-1 *Predator* and MQ-9 *Reaper* drones of the War on Terror era. The MQ-9 is a significant leap ahead from the original MQ-1 with 15 times the weapon capacity of the original, including up to four AGM-114 *Hellfire* missiles or two 500-pound laser-guided bombs.[245]

While this is a significant capability against low-threat unconventional forces, it is very different from Cold War and current manned strike aircraft. The MQ-9 supports a payload of about 3,800 pounds, flies at a maximum speed of 300 mph, and has a combat radius of 500 nautical miles (nm).[246] The F-35C is credited with a combat radius of 600nm, but allows for only a minimal weapons load. The F-35B manages only 450nm with just two bombs and two air-to-air missiles and gun pod. This is nowhere near the capability of

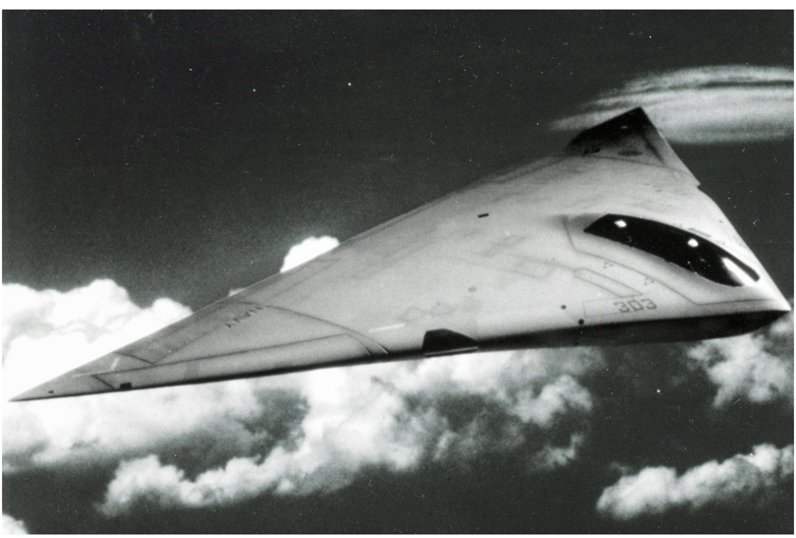
243 Rebecca Grant, "The Bekaa Valley War," *Air Force Magazine,* June 1, 2002; and Lawrence Newcome, *Unmanned Aviation: A Brief History of Unmanned Aviation* (Reston, VA: American Institute of Aeronautics and Astronautics, 2004), p. 96.
244 "Pioneer RQ-2A UAV," Smithsonian Institute, https://airandspace.si.edu/collection-objects/pioneer-rq-2a-uav/nasm_A20000794000.
245 "MQ-9 Reaper Hunter Killer Armed Unmanned Aircraft System (UAS)," Defense Operational Test and Evaluation Annual Report, 2008, pp. 229-230.
246 "MQ-9 statistics," United States Air Force, September 23, 2015, https://www.af.mil/About-Us/Fact-Sheets/Display/Article/104470/mq-9-reaper/.

Cold War aircraft, such as the F-14D and A-6E. The F-14D could carry four Joint Direct Attack Munitions (JDAMs) or six Phoenix missiles at a combat radius of 550nm, and the A-6E could carry twelve 1000-pound laser-guided bombs and still have a combat radius of 878nm. All this goes to highlight again that, for operations in the near future, the carrier airwing urgently needs a fighter-attack aircraft with at least the range and payload in excess of the F-14D and A-6E.[247]

The MQ-25 *Stingray* carries 15,000 pounds of fuel, suggesting a high capacity for strike missions with a delivery radius of at least 500 nautical miles from its carrier base.[248] A lot more, however, goes into the creation of a strike fighter capability than just range and ordnance load. The F-35 has a large enough electronics surveillance and warfighting suite that one informed engineer called it a "flying frigate."[249] All that electronic computing power makes for more density, more maintenance crew, larger supply and logistics tail, and less space for aircraft on even a large flattop like the *Nimitz*- and *Ford*-class ships. For example, only 44 F/A-18 E/F Super Hornets occupy the same density aboard ships as 54 older F/A-18C jets. An actual artificial intelligence-equipped airframe deployed in squadron-sized numbers would likely cause a significant rise in overall aircraft density on a carrier and further limit the number of strike/air superiority aircraft that the flattop could embark.

247 *The F-35 Selected Acquisition Report (SAR),* U.S. Department of Defense, April 17, 2019, pp. 15-17.
248 Sam LaGrone, "Navy Folding MQ-25A Tanker into Larger Unmanned Campaign; Test Flights to Resume This Summer," *U.S. Naval Institute News,* July 30, 2020.
249 Discussion with retired U.S. Naval War College scientist James O'Brasky, 2019.

EF-18G Growler (Courtesy of Dayton International Air Show)



A-12 Avenger II (Courtesy Norman Polmar/Navy History Magazine)

The problem of aircraft density as applied to unmanned, autonomous aircraft employed on carriers may be the most significant operational impediment to their greater usage, but the scope of this undeveloped capability needed by an artificial intelligence-enabled combat aircraft to operate in the physical world remains daunting. Consider the problems associated with the driverless automobile operating in the two-dimensional space of roads. A 2019 *Wall Street Journal* article described the differences between people and AI as ones where, "We are sentient beings, and we have the ability to reason from first principles, from scratch if you will, while AI on the other hand is not conscious, and doesn't even understand what it means that there's a physical world out there."[250] This fundamental lack of AI understanding continues to limit the wider employment of automated automobiles. Many cannot recognize changes in the roadway brought about by weather, or comprehend that a water-filled pothole is a potential danger to safe navigation. Electric car maven Elon Musk boasted in March 2020, "The fighter jet era has passed. . . . Locally autonomous drone warfare is where it's at, where the future will be."[251] Despite this rosy assessment, in 2019, live use of Tesla vehicles using their "autopilot" feature resulted in three crashes: "One ran a red light, and the collision resulted in the death of two people. Another hit a parked firetruck with fatal results, and the third hit a police car on a highway."[252]

250 Christopher Mims, "Self-Driving Cars Have a Problem: Safer Human-Driven Ones," *Wall Street Journal,* June 18, 2019.
251 Douglas Birkey, "Sorry, Elon, fighter pilots will fly and fight for a long time," *Defense News,* March 2, 2020.
252 Ibid.

In an August 2020 Defense Advanced Research Projects Agency (DARPA) test, an AI in control of an Air Force F-16 fighter defeated a human pilot in five of five tests.[253] The only weapon available in these tests were the aircraft's gun weapons. Missiles were not included in the test. While impressive, what was not simulated in this evaluation is perhaps more important than what was. The AI did not have to monitor the operations of a physical aircraft; it did not have to transit the aircraft from its base to the combat zone, avoid or navigate weather, or face jamming or other electronic warfare countermeasures. The limited battlespace of an aerial dogfight with gun weapons, such as featured in the DARPA trial, is not enough to evaluate any AI combat system.[254]

Fifth-generation fighter aircraft, such as the F-22 Raptor and F-35 Lightning, already feature numerous autonomous support functions to pilots, and unmanned aircraft will likely provide direct support to manned ones in "manned and unmanned teaming." The Navy and Boeing have experimented with this concept in the EA/18 Growler electronic warfare aircraft with one manned aircraft controlling two automated ones.[255]

The future holds the prospect for unmanned aircraft assuming more roles in carrier-based aviation and that emerging capability is certainly no myth. The promise, however, of unmanned, automated combat aircraft superseding human-piloted ones as seen in science

253 Brian Everstine, "Artificial Intelligence Easily Beats Human Fighter Pilot in DARPA Trial," *Air Force Magazine,* August 20, 2020.
254 Ibid.
255 Mike Ball, "Manned-Unmanned Teaming Demonstrated with Navy EW Aircraft," *Unmanned Systems Technology,* February 7, 2020.

fiction remains far in the future. The example of DASH suggests that good ideas sometimes need decades of technological advances to catch up and make the concept viable for service. The increasing density of all combat aircraft and especially that of unmanned aircraft suggests that limited numbers of the latter will be carried on aircraft carriers for the mid-term future.

8

CONCLUSIONS

Nine key questions provide a framework on which to evaluate the modern aircraft carrier. Aircraft carriers represent a significant expenditure of national treasure, and American citizens must have confidence that the naval systems purchased with their tax dollars represent a sound investment in proven combat capability. This book confirms the value of sea-based aviation in the form of the carrier, and again "tees up" the choices in that platform. A robust carrier force is required so that the U.S. Navy can do its part in assuring allies and partners of its credibility and deterring and, if necessary, compelling opponents to cease hostile actions and support war termination on terms favorable to the United States and its allies and partners.

1. **What are the missions for airpower going forward?**

The missions for airpower at sea in the third decade of the 21st century remain robust and varied as the Navy returns to great power competition with China and Russia. The Indo-Pacific and Arctic regions offer few locations for land-based aviation. Regions more familiar from recent U.S. combat action such as the Eastern Mediterranean and Persian Gulf still offer land-based aviation, but shifting political climates can limit access and improved ballistic and cruise missile technology threatens all fixed installations. These geographic and political issues suggest that carrier-based aviation will be a vital component of U.S. joint force action in forward locations at not only the beginning of—but also throughout—any sustained conflict. The carrier and its embarked aircraft are agile in their missions and can shift at short notice from sea control to power projection ashore to humanitarian service operations. The need for robust airpower at sea will remain a constant for the near future.

2. Can land-based aviation replace sea-based aircraft?

That was not the case in the Cold War or even the post-Cold War era when carrier-based aviation was often the only available U.S. strike capability at the outset of a campaign, such as in the Afghanistan and Iraq missions. Land-based aircraft followed but are always at a degree of risk, given status of forces agreements and the threat of terrorist attack on U.S. air bases. The current geography of great power competition requiring aviation to support sea control and strike in the maritime Indo-Pacific and Arctic limits the role of land-based aircraft making carrier aviation even more important than in recent years. Land-based aircraft are also vulnerable to advanced, more accurate, and longer-range cruise and ballistic missiles.

3. How survivable is the carrier under modern conditions of combat?

No surface warship is more survivable than the large aircraft carrier. Dispersal of forces among smaller flattops may reduce susceptibility to attack, but any flattop smaller than 50,000-ton displacement will be more vulnerable and less able to recover from damage. The return to active competition with the Soviet Navy in the 1970s led to innovations in operations that reduced carrier vulnerability, and the new Chinese and returning Russian threats will likewise spur a return to a more aggressive carrier posture at sea with more deception operations that reduce vulnerability. Just as threats have increased, so have the carrier's defenses in the form of its attack submarine escorts, its anti-submarine helicopters, and the constantly improving technology in its AEGIS escorts. Finally, if successfully attacked, the accidents of the 1960s and recent SINKEX of the ex-USS *America* suggest that large carriers can still survive tremendous punishment. The recent *Bonhomme Richard* fire, however, tells us that ships not purpose-built as fleet carriers are vulnerable to even moderate damage and lack the ability of larger flattops to return to flight operations after taking heavy damage. Amphibious warfare ships like the *Bonhomme Richard* can support Marine aviation in a ground support role and might serve as auxiliary carriers in low-threat regions, but they should not be called on to be fleet carriers. Finally, aircraft carriers of all sizes have always been vulnerable due to the nature of their mission, but that should not deter national decision makers from aggressively fielding naval aviation at sea from carrier flight decks.

4. How many carriers does the U.S. Navy need to carry out its global operations?

Adversaries may change, but geography does not. Analysis from diverse periods (the 1980s, the 1993 Bottom Up Review, and 2015) suggest that the U.S. Navy needs at least 15 carriers to effectively cover three deployment hubs and not prematurely exhaust both ships and the sailors who crew them in the process. Actual wartime operations would likely require more flattops. Cruise missiles launched by surface ships are an important component of naval power, but it would take dozens of those ships, as well as a currently non-existent re-arming and re-supply force, to keep enough of them at sea to serve as an effective deterrent or sustained strike capability. Even then, they would require an escorting carrier to protect them from aerial attack.

5. **Can carrier costs be reduced from the runaway figures of the current *Ford*-class ships?**

As with the *Zumwalt*-class destroyer and the Littoral Combat Ship (LCS), the *Ford*-class ships tried to force too many new technologies and concepts through a huge defense acquisition bureaucracy and test and evaluation system not designed to support so many changes in one new class of vessel. The *Ford* class is also based on the now-dated lessons of the First Gulf War that demanded a high sortie rate for power projection campaigns ashore and not for sea control, which remains the carrier's primary mission. A smaller, conventionally powered flattop that is large enough to support a 65-plane airwing will take advantage of the new U.S. status as an oil producer to operate at lower cost than a nuclear flattop.This size carrier can be built competitively in multiple yards by more than one builder, and as a result of that competition, improve innovation and drive down costs. Restoring competition in the marketplace of ideas and defense products is essential to control current runaway costs.

6. **What are the options for carrier size and capability?**

One finds compelling arguments for any of the four carrier choices presented in this book. The Navy needs fully capable, nuclear-powered carriers as represented by the *Nimitz* class, but half of the operational lifespan of those vessels is already behind them. The *Ford* class, encumbered with immature technologies and a rising price tag, cannot be the only carrier solution going forward into the next decade. Increasing threats from peer competitors and regional powers demand a mix of carrier capabilities. The existing U.S. Navy "big deck" amphibious warships of the *Wasp* (LHD) and *America* (LHA) have been adapted as "Lightning carriers" with upwards of two strike fighter squadrons. These vessels, however, remain too slow, lack survivability, and, in the absence of catapults, cannot support the vital early warning and electronic warfare aircraft crucial to the success of strike/air defense aircraft.

7. What are the choices for propulsion?

A new 21st century design of the size of the very successful USS *Midway* (CV 41)—competitively built in more than one shipyard and supporting an airwing of 60-65 aircraft—can complement the larger nuclear flattops while still being survivable and capable of independent operations.

A smaller conventional flattop can be designed and built in far less time than the *Ford* class, and at a far lower cost. Even if for industrial base reasons it is to be nuclear-powered, such a ship might use reactors developed for the U.S. submarine fleet. The choice of propulsion in 1978 was clearly nuclear, not only in terms of operational superiority but also economically as the United States still reeled from the oil embargoes led by the Organization of Petroleum Exporting Countries (OPEC). Today, the U.S. is an oil exporter and is largely immune to the oil challenges of the late 20th century. Nuclear carriers still have superior operational performance, but the nuclear escorts that once enabled all-nuclear task groups are now retired. Nuclear carriers are dependent on conventionally powered surface warships for screening and resupply. There has not been the opportunity for direct comparison in combat operations since the 1991 Gulf War, but, in that conflict, conventionally powered carriers conducted only slightly fewer sorties per day than did the sole nuclear carrier assigned to Operation *Desert Storm*, the USS *Theodore Roosevelt*. Given the higher costs of sustaining nuclear flattops over time as opposed to their conventional counterparts, there seems again room in the carrier battle line for conventional ships.

8. What is to be the role of unmanned aircraft?

The "new actor on the flight deck" in the form of the unmanned aircraft promises to take on refueling and potentially some support to manned strike missions in the coming years. A fully automated unmanned strike fighter, however, with the ability to operate unattended by human control on independent missions is still decades ahead in the future. Naval aviation can continue to embrace the benefits of unmanned aviation in the form of the MQ-25A for refueling and perhaps as a human-controlled, unmanned strike platform to augment manned aircraft.

9. What is to be done about the lack of long-range fighter and attack aircraft on our carriers?

The range of past and existing carrier aircraft has been discussed throughout the book. While the current airwing has some issues with range, the addition of the F-35C variant and the MQ-25A tanker can mitigate some of those and restore some range to the carrier airwing's striking power. The threat posed by peer competitor land-based defenses is real, but as was the case with the Cold War maritime strategy of the 1980s, the Navy is not preparing to sail within aircraft-striking distance of a peer competitor's coastline on day one of a conflict and assume that it can launch attacks with impunity. Whoever said, "A ship is a fool to fight a fort" (Lord Nelson, Sir John Fisher, or Wayne Hughes) was correct, but ships can and have helped to neutralize forts over time through raids and consistent combat action. The carrier airwing needs range to conduct attacks that cause attrition in land-based air forces after a 30-year pause in facing competent peer opponents. It is time for a new strike aircraft that is a real successor to the A-6E. The A-12 Avenger was perhaps ahead of its time and was stillborn, but the need for such an aircraft has returned with the need for carrier airwings to conduct long-range operations for sea control and power projection.

Final Thoughts

The aircraft carrier's roles and missions have remained controversial in the 100 years since the vessel's introduction to world navies. Critics declared that they could not survive bombs from dirigibles, battleship guns, dive-bombers, kamikazes, submarine torpedoes, cruise missiles, sea-skimming supersonic missiles, ballistic missiles, and hypersonic missiles. The ageless "see-saw" of offense vs. defense has consistently proved carrier critics wrong.

Since WWII, the U.S. Navy has faced existential questions on the future of the flattop on three distinct occasions (1949, the late 1970s, and the early 1990s) in addition to the current carrier choices debate. All of those were eventually resolved in favor of the carrier's continued role in naval operations. It remains clear that the carrier should continue as the centerpiece of U.S. Navy combat power. The submarine- and surface-launched missile is also an important component of naval combat power, but it cannot replace the carrier. The ships discussed here represent a complete set of practical candidates, but endless debate and continued "drift" among the carrier choices presented by the executive and legislative branches, as well as the Navy itself, will only cause further erosion of national security and naval capability.

In our judgment, the best choice is the *Midway*-size medium aircraft carrier. It is big enough to carry a full three-dimensional airwing and include all the survivability of the *Ford/Nimitz.* Such a carrier would have speed well above 30 knots; modern technology, including close in, electronic, cyber, and kinetic defenses; multiple hulls and side-protection; full watertight compartmentation and armored decks; and the latest firefighting technology. Finally, such a carrier is small enough to be built in at least four American shipyards at competitive costs, and at a fraction of that of the *Ford* class. It is time to make a choice and proceed to construction.

ABOUT THE AUTHORS

John F. Lehman was Secretary of the Navy in the Reagan administration and a member of the 9/11 Commission. His latest book is *Oceans Ventured: Winning the Cold War at Sea*.

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WHERE ARE THE CARRIERS?

U.S. National Strategy and the Choices Ahead

Since the carrier's adoption over 100 years ago, policymakers and service members have argued over the ship's mission, size, vulnerability, and—of course—cost. These arguments have become increasingly more pointed as the armed services compete over diminishing financial resources. Former Secretary of the Navy John Lehman, with the assistance of Center for Naval Analyses Analyst Steve Wills, evaluates aircraft carrier options as he has done numerous times in the past. These choices include:

- *Gerald R. Ford*-class nuclear-powered, large carrier
- Light carriers based on amphibious warfare ships of the *Wasp* and *America* class
- French nuclear-powered carrier *Charles de Gaulle* or conventionally powered British *Queen Elizabeth*-class carrier
- A new medium carrier the size of the Cold War *Midway*-class ships

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