Chapter Two

AIRCRAFT CARRIERS AND THE CARRIER INDUSTRIAL BASE

In this report, we take as a baseline a fleet of 12 aircraft carriers whose primary role remains as it has been,[1] and we assume that the basic design features of the current class of carriers will apply to CVN 77, the last ship of that class. The past and potential future evolution of carrier force structure, roles, and design thus do not much affect our analysis of industrial-base issues. Nevertheless, some knowledge of that evolution provides an important context for our industrial-base analysis and the implications to be drawn from it. In this chapter, we offer background on the role, force structure, and design of carriers and on the carrier industrial base.

THE CARRIER'S ROLE

As with the rest of the U.S. military, aircraft carriers exist to support the National Military Strategy of the United States—a strategy that has, of course, evolved over the past 50 years, as have perceptions of threats to U.S. national security. The result has been a sorting out of roles among elements of the force structure.

The Early Days[2]

In the early part of this century, the Navy's primary offensive weapon was the battleship's heavy guns. The first carriers—those built before World War II—operated as an adjunct to the battle fleet, providing the battleships with such vital services as reconnaissance and spotting, and controlling the air over the

[1]The Navy has been aggressive in thinking about new paradigms for aircraft carriers. For a thorough discussion, see Jacquelyn K. Davis, *CVX: A Smart Carrier for the New Era*, Washington, D.C.: Brassey's, 1998.

[2]The United States has produced (i.e., built or converted and launched) a total of 64 carriers in 15 different classes. See Appendix A.

gunnery engagement. The strike power of a carrier was, at first, very much a secondary asset.[3]

This situation began to change as carrier forces were modernized. The new carrier emphasis was demonstrated by the British at Taranto and the Japanese at Pearl Harbor. The first carrier battles in the Coral Sea and northwest of Midway Island finalized this reorientation in thinking. In the Midway battle in particular, the Japanese carrier force was smashed without a heavy gun being fired.[4] Within three weeks, the Japanese canceled battleship construction and implemented a new construction and conversion program that emphasized carriers.[5] The United States already had 23 carriers under construction; within one month after Midway, Congress authorized 13 more, and 10 of those were ordered from shipyards within 30 days.

Postwar Adaptation

Following World War II, the Navy was forced to adapt to a changing world environment. Whereas wartime experience had centered on defeating the Japanese fleet in blue-water engagements, the Soviet Union was a classic Continental power that presented no significant naval threat. This difference left the Navy carrier leadership in search of a mission. To this end, the service tried to assimilate the new nuclear-strike role. The outcome of the resulting debate has shaped the aircraft carrier's function to this day.

The Navy's solution to the strategic nuclear-strike problem—a carrier that could conduct a heavy, primarily nuclear, bombing attack against land targets—was USS *United States* (CVA 58), construction of which was started in 1949.[6] Envisioned as the platform for the heaviest long-range jet aircraft that could practicably operate from a carrier deck, *United States* was to be dramatically larger than previous carriers and was designed for this new strike role. Because of that role, she would not replace existing carriers but would form the centerpiece of strike groups including conventional carriers operating multirole air wings—a specialization representing a departure from the aircraft

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[3]For a detailed discussion, see Norman Friedman, *U.S. Aircraft Carriers: An Illustrated Design History*, Annapolis, Md.: Naval Institute Press, 1983.

[4]Karl Lautenschlager, *Technology and the Evolution of Naval Warfare 1851–2001*, Washington D.C.: National Academy Press, 1984.

[5]The Yamato class was planned to consist of seven battleships. *Yamato* was commissioned just after the start of the Pacific War in 1941, *Musashi* in the middle of 1942, and work on *Shinano* and *No. 111* ceased at the outbreak of World War II. After the Battle of Midway, *Shinano* was redesigned as an aircraft carrier. *No. 111* and the remaining three ships were canceled.

[6]Roger Chesneau, *Aircraft Carriers of the World, 1914 to the Present: An Illustrated Encyclopedia*, Annapolis, Md.: Naval Institute Press, 1984.

carrier's major strengths of flexibility and effectiveness over a wide range of warfighting scenarios.

At the time, the Navy was willing to sacrifice this flexibility to gain a major share of the dominant nuclear-strike mission. This role was controversial because it directly opposed Air Force development of a large force of intercontinental bombers, which, for many political, technical, and budgetary reasons, won out in the end.[7] *United States* was canceled by Secretary of Defense Louis Johnson in April 1949, eight days after the keel was laid. Ironically, the Navy did not lose a nuclear-attack capability; it gained one by developing such heavy-attack aircraft as the AJ-1 Savage, A-3 Skywarrior, and A-5 Vigilante. Thus, although the role of operating nuclear-strike aircraft was assigned primarily to the Air Force, the Navy gained a limited carrier-based strategic-strike capability.

The cancellation of *United States* led the Navy to de-emphasize the specialized, heavy-attack carrier and focus on acquiring and employing more-flexible and more-adaptable carriers, aircraft, and doctrine: "Between 1946 and 1950, the concept of future carrier operations shifted from strategic strikes by a small number of carrier-based heavy bombers to tactical air strikes by a much larger group of smaller aircraft."[8] The outbreak of the Korean War soon confirmed the value of this tactical orientation.

Because of geography and the rapid advance of the communist forces, allied airpower early in the conflict was primarily carrier-based: Carriers provided rapid response and the ability to generate a high number of sorties while remaining relatively immune to land-based threats. The Korean experience thus provided the model of the multirole, tactically oriented, forward-deployed carrier strike force, a force that was to be called upon repeatedly in the coming decades.

Carriers provided a major portion of U.S. airpower during the Vietnam conflict; they have performed combat operations many times since, most notably in Grenada and Lebanon (1983) and Libya (1986), and in Operation Desert Storm (1991). Despite the lack of a credible, ocean-going naval threat to American interests, carrier-based tactical airpower came of age during the Cold War as the major, and sometimes sole, instrument of American power projection.

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[7]Of course, the Navy did acquire a strategic nuclear-strike role through submarine-launched ballistic missiles.

[8]Friedman, 1983, p. 255.

Forward Presence and Crisis Response[9]

The current National Military Strategy stresses overseas presence and power projection, to enable promotion of stability and, when necessary, defeat of adversaries:

> Forward deployed naval expeditionary forces can respond immediately to a crisis . . . and through prompt action help halt an enemy offensive and enable the flow of follow-on . . . contingents. By ensuring freedom of the seas and controlling strategic choke points, naval forces provide strategic freedom of maneuver and enhance deployment and sustainment of joint forces in theater. Air forces maintain control of the skies, helping to destroy the enemy's ability to wage war, providing sustained, precise firepower, and numerous tactical and operational advantages while facilitating land and naval maneuver.[10]

The aircraft carrier combines peacetime engagement, deterrence, and warfighting capabilities in one integrated package. It is often the initial power-projection and enabling asset when hostilities threaten or occur. Short of hostilities, the presence of an aircraft carrier makes a powerful political statement and presents a credible military threat to enemies, along with offering support for allies.[11] As was made clear in the 1991 Gulf War, crisis deployments of land-based air and ground forces to allied countries are necessary; however, positioning them takes time and obviously requires the host nation's cooperation.[12] To a government whose populations or neighbors may be opposed to the operations of U.S. land-based aircraft from its territory, carrier battle groups stationed offshore in international waters can satisfactorily balance the demands of internal politics and external defense.

DESIGN EVOLUTION

Despite its cancellation, the *United States* program shaped the design of future carriers. Relative to the carriers built in the first half of the century, *Forrestal* and ships that followed were distinguished by

- increased size, including the ability to operate increasingly fast, heavy, and capable aircraft throughout the life of the ship

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[9]Data on U.S. military crisis response are presented in Appendix B.

[10]John Shalikashvili, *National Military Strategy of the United States*, Washington, D.C.: Joint Chiefs of Staff, 1995, p. 14.

[11]*Independence*, which is conventionally powered, is homeported in Tokyo Harbor, the only U.S. carrier to be based permanently outside the United States.

[12]The United States has built 172 overseas bases since World War II. It has access to 24 of those today. (Davis, 1998, p. 8.)

- enlarged capacities to store fuel, ordnance, and other supplies, increasing the carrier's ability to sustain long periods of combat operations
- improved survivability
- improved all-weather operations and seakeeping ability
- increased longevity.

Forrestal—The First Modern Aircraft Carrier Class

The Korean War of 1950–1953 was a sharp reminder that conventional military conflict could erupt and challenge U.S. interests. The war saw extensive use of carriers and prompted construction of a new class of larger vessels: the Forrestal class.[13] The increased size of this class was a result of prudently modifying *United States*' design to take into account rapidly evolving jet-aircraft development. Four ships of this class were authorized in successive years beginning in FY52.

Before the Forrestal class was constructed, the evolving performance of aircraft had been outstripping the carrier's ability to handle them safely. Techniques of shipboard launch and recovery represented a major obstacle to the introduction of modern jet aircraft. It was not until 1955, when the United Kingdom's HMS *Ark Royal* went into service, that all three features essential for jet-age aviation appeared on a carrier:[14]

- Steam catapults that could accelerate heavier, swept-wing jets to the higher airspeeds they required to become airborne
- An angled flight deck, which permitted safe recovery of jet aircraft
- An optical landing system to show the pilot the proper glide slope for a safe landing.[15]

Later that same year, *Forrestal* was commissioned with these same characteristics. *Forrestal* could store 1,800 tons of ordnance and 750,000 gallons of aircraft fuel. It was also the first carrier in which the flight deck was an integral structural member of the hull. This design allowed the deck to support 75,000-lb A-3 heavy-attack jets. Twenty years later, this structure was sound enough to

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[13]During the 1950s, World War II–era Essex-class ships were also brought out of retirement and modified by installing new flight decks to handle jet aircraft. However, these carriers were increasingly relegated to anti-submarine warfare operations that did not require handling jet fighter aircraft.

[14]For a list of carriers currently in operation by all the world's navies, see Appendix C.

[15]Lautenschlager, 1984, p. 49.

handle the even-heavier F-14. By contrast, the ships of the 1940s-era Midway class were incapable of operating F-14s and, because of their smaller size, were often restricted by inclement weather.

The enhanced survivability of larger vessels is epitomized by *Forrestal* herself. Although seriously damaged by the famous fire and explosions that occurred on board in July 1967 off Vietnam, "the carrier survived. Whether a ship of smaller dimensions would have done so is open to speculation."[16] Finally, their size and the forethought with which these ships were constructed enabled them to spend their service lives without major modifications. Neither the Forrestals nor subsequent U.S. carriers have undergone structural alteration as significant as that affecting the Midway and Essex classes.[17]

Nuclear Propulsion

Introduction of nuclear power was the next defining step in carrier evolution. Envisioned originally in the late 1940s, nuclear-power-plant technology was not sufficiently advanced to be incorporated in the Forrestals. Finally authorized in 1956, the first nuclear-powered carrier, USS *Enterprise* (CVN 65), was significantly larger, more complex, and costlier than previous vessels. Her displacement was a maximum 94,000 tons—compared with the 81,000 tons characteristic of the "improved" Forrestal-class ships (CVs 63, 64, 66)—and allowed room for approximately 90 percent more aviation fuel (up to 2.75 million gallons) and 50 percent more ordnance (up to 2,500 tons).

The main advantage of nuclear power was virtually unlimited endurance, as displayed through *Enterprise*'s highly publicized round-the-world cruise. The power plant thus permitted *Enterprise* to sustain operations even longer than had previous large carriers. It demonstrated such sustainment initially off Vietnam and again during 1979–1981 deployments to the Indian Ocean in response to crises in Iran and Afghanistan. The latter operations are notable because they were accomplished with little logistics support in a region rarely visited by U.S. forces until then.

The Nimitz class included improvements over the one-of-a-kind *Enterprise*. By substituting two more-efficient nuclear reactors for *Enterprise's* eight, the Nimitz class achieved even greater storage for aviation fuel, ordnance, and spare parts.

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[16]Chesneau, 1984, p. 268.

[17]Chesneau, 1984, p. 267.

Nuclear-powered carriers offer advantages besides storage and endurance, but those advantages may not be so obvious at first. Two of the most significant are speed and acceleration. Nuclear reactors can quickly impart high speed to the carrier's massive hull, permitting great operational flexibility; the ability to sustain that speed heightens the ship's responsiveness. Increased speed and endurance also make the nuclear-powered carrier more difficult to locate and target, and thus make it less vulnerable to modern submarines and cruise missiles. Another set of advantages accrues from the electrical and steam-power reserves of a nuclear plant. The substantial amounts of steam power required to launch increasingly heavy aircraft with safety can be had much more reliably with nuclear power than with fossil fuels. And the electrical demand of a carrier, already huge, will only increase with the increasing importance of electronics, computers, and radars.[18]

Although at the outset technically difficult and expensive to achieve,[19] the use of nuclear propulsion on aircraft carriers has proven its worth militarily and has generated significant economies over the life of the ships.

The Next Class and the Disadvantages of the Nimitz

The next carrier to be built after CVN 77 is planned to be the first ship of a new class, designated CVX.[20] The design of the CVX has yet to be determined, even in broad outline. It may well include only evolutionary improvements to the tested, long-prevailing design concept of large nuclear carriers. However, Nimitz-class carriers are not without their disadvantages, and the Navy may consider smaller, nonnuclear designs—although, historically, warship types have not been scaled back in size.

We do not wish to speculate here about whether historical precedent will apply. Instead, we take this opportunity to point out some of the issues concerning large, Nimitz-class carriers. Cost is, of course, chief among the disadvantages. Whereas the calculus of cost-effectiveness is complex and may favor the Nimitz class, there is no question that periodically replacing large Nimitz-class carriers with newer, similar ships takes a big bite out of the Navy's ship-construction resources. (Typically, a ship is funded in large part, and often completely, from a

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[18]For a full discussion of the various advantages of nuclear power for carrier design and operations, see Friedman, 1983, p. 309.

[19]Building nuclear-powered vessels for the Navy is far different from building ships to standards for conventional power.

[20]For an interesting discussion of this design in relation to aviation at sea, see Reuven Leopold, *Sea-Based Aviation and the Next U.S. Aircraft Carrier Design: The CVX*, Cambridge, Mass.: Massachusetts Institute of Technology, Center for International Studies, MIT Security Studies Program, January 1998.

single year's construction budget (except for advance procurement [AP] of nuclear components.)

Of course, Nimitz-class carriers also provide greater military capability, so a trade-off must be reached between cost and military value. Also, as will become apparent in Chapter Three, construction of large, Nimitz-class ships with ship funding confined to one year limits the Navy's flexibility in spreading work over shipyards and over time.

Other disadvantages of Nimitz-class carriers may be more perceived than real; they fall into three categories: (1) the disposal of radioactive waste (including spent nuclear fuel) produced during ship operation, (2) the acceptance of nuclear-powered warships in foreign ports, and (3) the potential environmental impacts if a naval reactor accident occurs. We deal briefly with each in turn here.

The Navy has a long history of safely disposing of the nuclear waste it produces from nuclear-powered warship operation and servicing. Indeed, the amount of low-level radioactive waste it generates constitutes less than 10 percent of what is produced by commercial nuclear-power plants in the United States. Existing and projected disposal capacity, required for commercial nuclear-power-plant operation, is more than sufficient for the Navy's needs.

With respect to spent nuclear fuel, a Nimitz-class carrier generates several metric tons over its lifetime—a very small amount compared with what commercial nuclear reactors produce: a projected 85,000 metric tons (heavy metal) by the year 2035. By that same point, the Navy expects to have generated about 65 metric tons of spent fuel from all of its nuclear-powered warships. All spent fuel is planned for disposal in a geologic repository. While the final costs of disposal have not yet been established, the Navy expects the disposal costs for the spent fuel created by a Nimitz-class carrier over its lifetime to be less than $20 million—a very small fraction of the life-cycle cost of the ship.

The Navy's nuclear-powered warships have a long history of gaining access to foreign ports, owing to their long-standing record of safety and environmental protection. Nuclear-powered warships visit over 150 ports in 50 foreign countries and dependencies, including major industrialized countries such as Japan, Germany, Great Britain, France, and Canada. While it cannot be denied that a reactor accident may adversely affect the Navy's ability to enter some foreign ports, the Navy is keenly aware of that potential. Its record demonstrates that avoiding such a problem is the focal point of its "safety-first" mentality.

The likelihood of a reactor accident—the release of fission products from the reactor—is extremely small, because the reactors in Nimitz-class carriers are designed to military standards for shock, battle damage, and reliability. Navy

nuclear-powered warships have accumulated over 4,800 reactor-years of operation, and have steamed over 110 million miles, without such an event occurring.

Even if an accident occurs, the impacts on the environment and on the public are expected to be small, for four reasons:

- The power of a Nimitz-class reactor is rated at less than 20 percent that of a typical commercial nuclear power plant.
- Unlike commercial plants, which typically operate continuously at their maximum-rated power to generate revenues from electrical-energy production, naval reactors usually operate much below their maximum power ratings, since there is no need to proceed continuously at maximum speed. (The amount of radioactive material available to be dispersed in the event of an accident is much lower if the reactor is operating at low power before the accident.)
- When a carrier is in port, its reactors are usually shut down or are operating at very low power; the ship uses shore power for its "hotel" functions—housing, laundering, food preparation, etc.
- Unlike a land-based power plant, a ship is mobile: It can be moved away from populated areas if a problem occurs.

FORCE STRUCTURE

The structure of a carrier force is now largely determined by the ships' role in supporting America's national security objectives and takes into account the design of the ships currently in the force. (Figure 2.1 traces U.S. carrier force structure from 1950 to 1997, by hull number and class.[21]) When the United States began building a carrier force, this was not the case. Force size was determined, instead, by the 1922 Washington Naval Treaty. Freed from treaty limitations by World War II, the carrier force quickly expanded. Most carriers built during World War II were of the 35,000-ton Essex class. Extensively modified, many of these served through most of the Cold War as both attack (CVA) and anti-submarine (CVS) carriers alongside the larger Midways, Forrestals, and *Enterprise*. However, as early as 1947, a Cold War policy-

[21]Full service lives are shown for all ships operating since 1950, so the figure extends back to 1943 to accommodate these. However, the figure is not an accurate representation of force structure in the 1940s, because some ships in that force structure were no longer operating in 1950 and are thus not included. If a ship was commissioned by June 30 or decommissioned after June 30, it is counted as being in operation for that year.

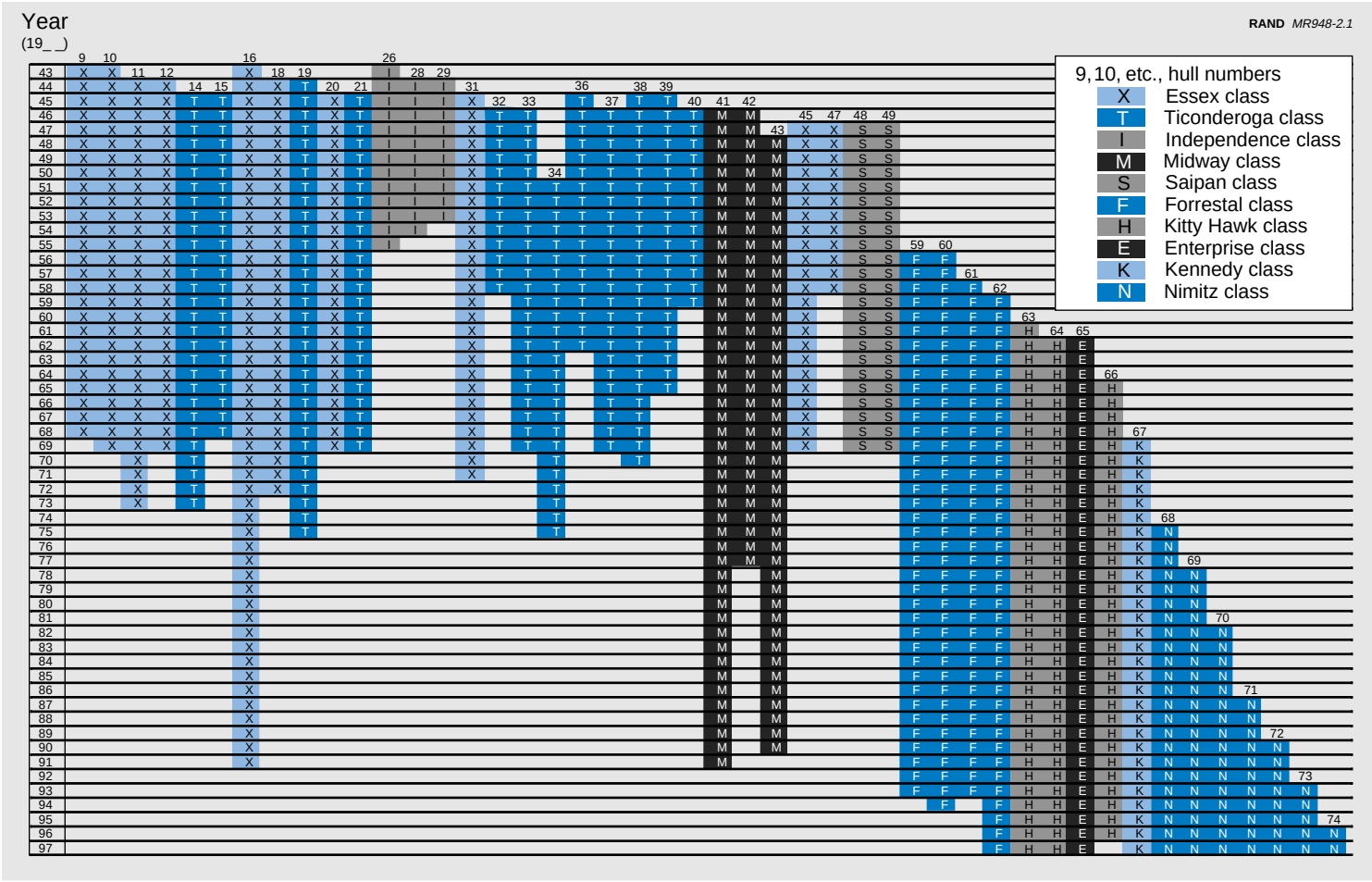

Figure 2.1—Service Lives of U.S. Aircraft Carriers in Operation Since 1950, by Hull Number and Class

planning document called for 12 CVAs, and the number of fleet carriers—those deploying fighters and strike aircraft—has generally held between 12 and 15 (Figure 2.2). Thus, although there was an apparent surfeit of carriers in the 1950s and 1960s, many were less capable than the larger, newer ships.[22]

With the prospect of large-scale deactivations and new-carrier construction in the late 1960s, carrier force structure became an issue. In light of the Vietnam War experience, Secretary of Defense Robert McNamara in 1966 increased the 1970s force structure from a proposed 13 attack carriers to 15.[23] This number remained relatively constant until post–Cold War restructuring brought the number down to 12. All along, as more-modern ships replaced aging ones, the carrier force changed in composition as well as in number (see Figure 2.1).

Why a 12-ship fleet? Currently, carrier force structure is based primarily on support of the commanders in chief of U.S. forces in the Western Pacific Ocean, Europe/Mediterranean Sea, and Indian Ocean/Persian Gulf. Maintaining a continuous carrier presence in each of these three areas would require approximately 15 ships—the rationale for the Cold War policy. This 5-to-1 ratio allows for maintenance, training and predeployment exercises, and personnel time in home port,[24] and it accounts for transit time to operational areas from the West Coast of the United States. In the post–Cold War era, limited gaps in carrier presence are deemed acceptable, so current national security objectives are regarded as satisfied with 12 aircraft carriers. (Table 2.1 delineates the coverage gaps experienced with fleets smaller than 15 ships.)

Note that, in discussing the adequacy of a 12-ship fleet, we have been assuming normal peacetime operations only. More-serious contingencies such as humanitarian intervention and peace enforcement may require more than one carrier on-scene. Examples from 1996 alone are *Nimitz* and *Independence* off Taiwan, and *Enterprise* and *Carl Vinson* in the Persian Gulf. Libyan operations in March 1986 used three Atlantic Fleet carriers in the Mediterranean at one time. A major theater war (MTW) is estimated to require four or five carriers—six were ultimately involved in Operation Desert Storm—and the National Military Strategy envisions response to two MTWs simultaneously. Thus, in meeting such contingencies, something must give: presence in other areas, maintenance schedules, or sailor time at home port.

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[22]The majority of the Essex-class ships were decommissioned in the late 1960s and early 1970s.

[23]Friedman, 1983, p. 318. Previously separate anti-submarine and attack functions were combined in carrier air wings by the mid-1970s. All carriers were redesignated "CV."

[24]Chief of Naval Operations personnel policy established in 1986 that deployments shall not exceed six months in length, and that personnel shall remain home for 12 months after completing a 6-month deployment.

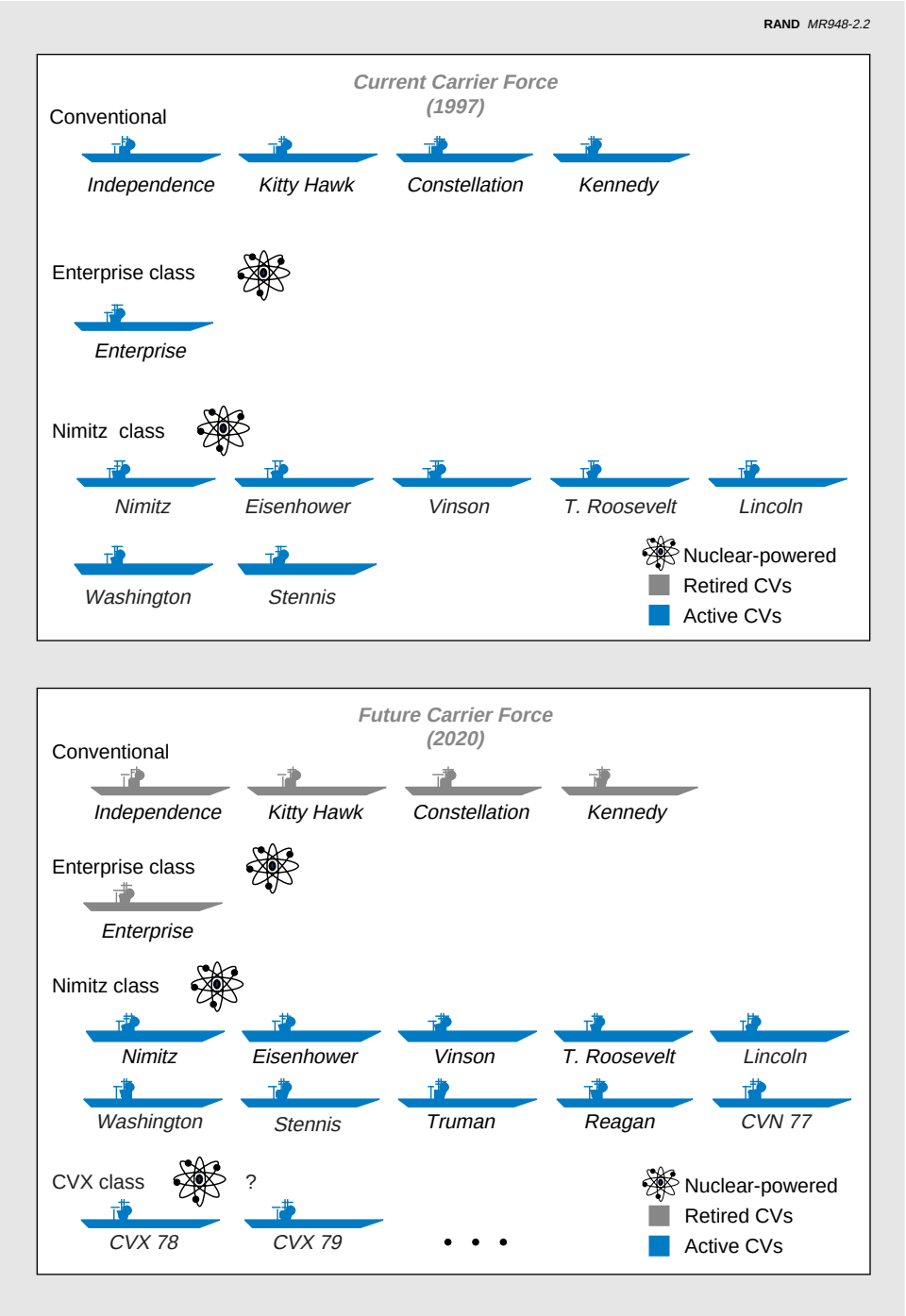

Figure 2.2—Current and Future Carrier Force Structures

Table 2.1

Continuous Carrier Forward-Presence Coverage in Three Key Regions

	Region		
Fleet Size	Mediterranean	Western Pacific	North Arabian Sea
	Indian Ocean/Persian Gulf Focus		
15	100%	100%	100%
12	81% (2.3-month gap)	80% (2.4-month gap)	100%
10	67% (4.0-month gap)	65% (4.2-month gap)	100%
	Mediterranean Focus		
15	100%	100%	100%
12	100%	87% (1.6-month gap)	79% (2.5-month gap)
10	100%	70% (3.6-month gap)	73% (3.2-month gap)

SOURCE: Director, Assessment Division (OPNAV Staff N81), April 29, 1993.

NOTES: *Gap* means there is no carrier in the unified commander in chief's (CINC's) area of responsibility (AOR). Gaps are months per year. The plans shown meet personnel-tempo and operational-tempo objectives; they account for both routine and longer-term (nuclear refueling) overhauls and other maintenance requirements.

The need for crisis response thus represents a continuing demand on the 12 aircraft carriers remaining in the U.S. fleet. Figure 2.3 suggests that, if there was no excess of carriers before the end of the Cold War, there may not be an excess now.

Of the various factors underlying the 5-to-1 fleet-size-to-on-station ratio, ship maintenance is particularly important and plays a big role in our analysis. Figure 2.4 illustrates the nominal breakdown of a Nimitz-class carrier's life-cycle activities as outlined in the CVN 68 *Incremental Maintenance Program* (IMP).[25] Here "Maintenance" refers only to scheduled shipyard activities (it includes nuclear refueling), "Deployment" time is defined as long missions overseas, and "Training" is all other underway, homeport, and upkeep periods. This allocation of life-cycle activities is designed to achieve the objectives for personnel tempo (PERSTEMPO) and operational tempo (OPTEMPO);[26] improve the capability to meet large, sudden deployment demands; and reduce the probability of having more than one ship in maintenance at a time. In other words, it is designed to keep as many carriers operational as possible while

[25]Planning, Engineering, Repairs, Alterations—Aircraft Carriers (PERA-CV), *Incremental Maintenance Program for CVN-68 Class Aircraft Carriers*, Bremerton, Wash., January 1, 1997, p. 1-2.

[26]PERSTEMPO is an expression of the ratio between the amount of time during a ship's operating period that personnel must spend in their home ports and the amount of time under way or in foreign ports. The emphasis has been to ensure that PERSTEMPO meets established objectives (see footnote 24). OPTEMPO refers to the frequency and duration of at-sea operations and training of all naval (Navy and Marine) forces.

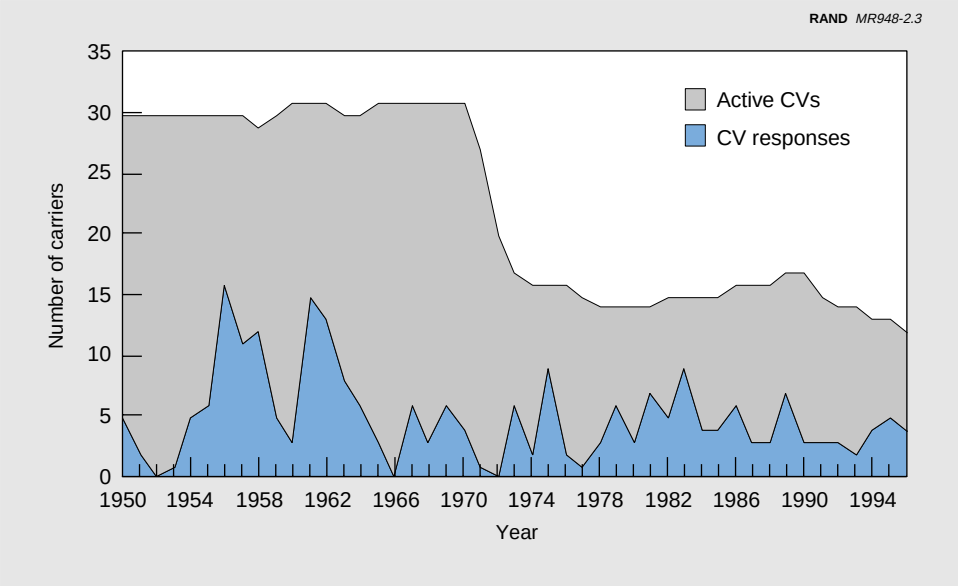

Figure 2.3—Carrier Response in Relation to Number of Carriers in Fleet

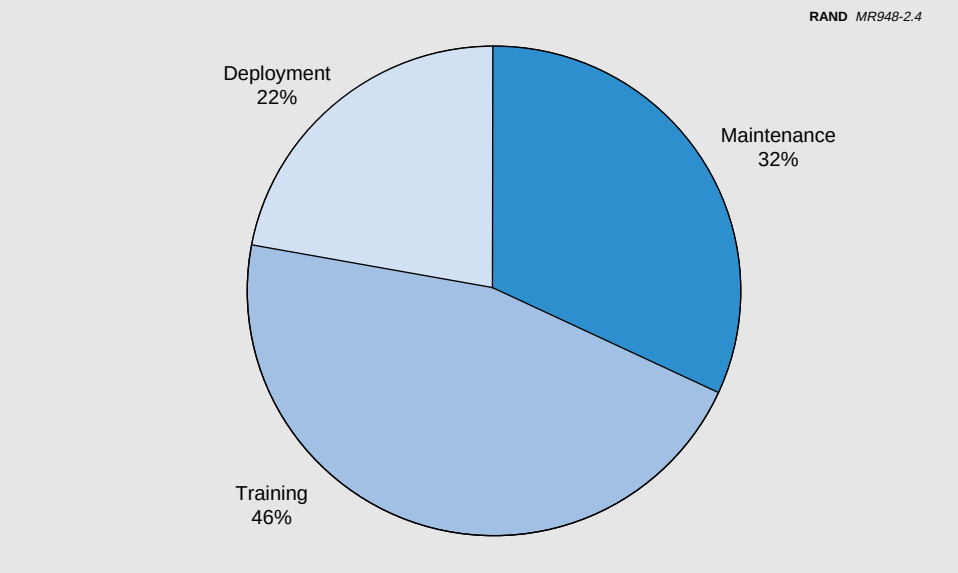

Figure 2.4—Breakdown of a Nimitz-Class Carrier's Life Cycle

maintaining the ships' material condition and maximizing their useful life. Just the same, under the plan, less than one-fourth of a carrier's 48-year life is actually spent deployed forward, on-station.

CHALLENGES TO AIRCRAFT CARRIERS

A number of critics have challenged the future value of aircraft carriers. These critics have made the following claims:

- There are other ways to project power. The United States could place greater emphasis on surface-ship- or submarine-launched cruise missiles or B-2 bombers instead of on aircraft carriers.
- Carriers are an expensive way to project power. An aircraft carrier requires several escort ships to provide defense against air, missile, and submarine attack. It requires auxiliary ships to deliver supplies and aviation fuel. Aircraft carriers today deploy approximately 50+ strike aircraft (F/A-18s and F-14s).
- Carriers represent too big a target. Loss of an aircraft carrier would be a major political blow to the United States and a tragic event in its own right. A carrier and the air wing deployed on the ship have a crew of approximately 5,000 persons.

The debate over such issues will continue, but the Navy and other military commanders have found the carrier to be a very flexible and valuable platform in responding to a crisis and to be key during a conflict.[27] Carriers deploy not just aircraft that can shoot down other aircraft or drop bombs and missiles on targets; they deploy surveillance aircraft that can provide control of a broad swath of sea, and they provide aircraft that can deploy mines or conduct anti-submarine operations. More recently, they have become *an integral part of peacekeeping operations.*

In the 1970s, the Navy extensively investigated smaller aircraft carriers—approximately one-half the size of the Nimitz-class vessels—under the assumption that smaller carriers would be cheaper than big ones. But the size of the ship limits the number of aircraft that can be deployed and their capabilities. A

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[27]The Commander of Operations Desert Shield and Desert Storm, Army General H. Norman Schwarzkopf, pointed out that, in August 1990, the carriers *Eisenhower* and *Independence* were within range of Iraqi targets less than 48 hours after President George Bush issued a deployment order. In Schwarzkopf's words, "the Navy was the first military force to respond to the invasion, establishing immediate sea superiority. And the Navy was also the first air power on the scene. Both of these firsts deterred, indeed—I believe—stopped, Iraq from marching into Saudi Arabia." Speech to the 1991 graduating class of the United States Naval Academy, reprinted in *Proceedings*, U.S. Naval Institute, August 1991, p. 44.

smaller ship can deploy fewer, less-capable aircraft, and it could prove less survivable than a larger ship.

The issue of whether bombers and cruise missiles can be substituted for aircraft carriers is still being debated. Cruise missiles remain expensive—$1–$2 million each—and are fine for destroying high-value targets. But they can be shot down or deceived, and, once launched, cannot be recalled. Bombers can attack any point on the globe, but they need refueling support. Bombers can only project power; they cannot remain on-station to control airspace or effect sea control. Additionally, bombers reacting from the United States are not present to deter aggression or prevent crises from occurring. Both bombers and cruise missiles could play a role at the margin of the debate on future aircraft-carrier needs. But, barring a major technology or cost breakthrough, we do not envision either B-2s or cruise missiles fundamentally altering the outlook for carrier demand.

In some ways, carriers have become more important in the post–Cold War era. The United States sustains far fewer forces abroad today, and local basing issues limit the United States' ability to make on-the-ground deployments. The United States has focused its interests on many areas of the world that have less-sophisticated infrastructures than Europe and that may not support a large deployment of ground-based aircraft.

THE AIRCRAFT CARRIER INDUSTRIAL BASE

To help in understanding aircraft-carrier construction issues, we briefly characterize the current carrier industrial base.

America's commercial shipping and shipbuilding industry has declined dramatically since World War II. Whereas numerous public[28] and private shipyards once constructed naval vessels, including aircraft carriers, today only six commercial yards remain that can build major naval vessels. Of these, only one, Newport News Shipbuilding, constructs nuclear-powered and conventionally powered aircraft carriers. Electric Boat Corporation is also nuclear-capable but builds submarines exclusively.

Newport News Shipbuilding was founded in 1886 and is headquartered at Newport News, Virginia. This yard, a land-level facility located along the banks of the James River, occupies approximately 550 acres, and comprises seven

[28] *Public shipyards* are those yards operated by the Navy. At present, they are Norfolk, Portsmouth, Puget Sound, and Pearl Harbor Naval Shipyards. None constructs ships; they are used for repair and overhaul activities (all are nuclear-certified). Facilities at Mare Island and Long Beach, Calif.; Charleston, S.C.; and Philadelphia, Penn., have been, or are being, closed.

graving docks (dry docks), including the largest dry dock in the Western Hemisphere; a floating dry dock; two outfitting berths; and five outfitting piers. It has 17.5 acres of all-weather on-site steel-fabrication shops and maintains its own technical school to train apprentices for skilled-labor positions.

Newport News has generally built large surface warships, including carriers, battleships, cruisers, and destroyers, as well as submarines and commercial ships. Since 1960, its focus has been on nuclear-powered ships, principally aircraft carriers and submarines. It was the lead designer of the Los Angeles–class nuclear attack submarine program.

The yard's dominance in aircraft carrier construction is what concerns us here. Of the 64 fleet carriers built and launched for the U.S. Navy, 29, or 45 percent, have been constructed by Newport News. Most of those not built by Newport News were wartime Essex-class ships. More significant, 13 of 17 modern, large-deck carriers, including all nuclear-powered carriers, have been constructed by this one yard. Not only is Newport News the only yard currently geared for carrier construction, it is the only yard to build carriers for the past 36 years (see Figure 2.5). This seeming monopoly is due partially to the requirement for unique facilities that the construction of large carriers—and particularly complex, nuclear-powered ships—poses.

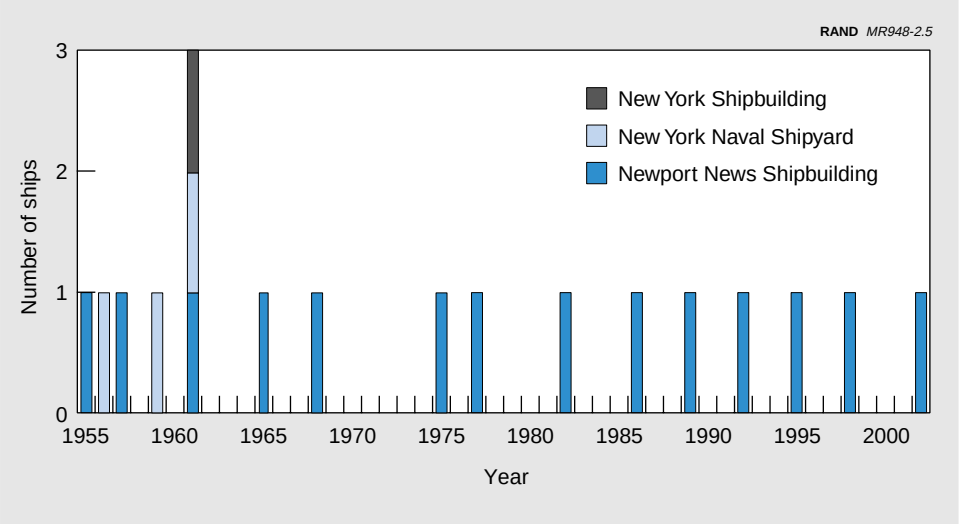

Figure 2.5—Carriers Completed Each Year, by Shipyard

Newport News has made and continues to make substantial capital investments to improve carrier shipbuilding processes and facilities, such as the automated steel factory and dry-dock extensions. Additional improvements are expected from lessons learned in NNS's ongoing commercial-ship-construction and overhaul projects. Two other commercial yards, Ingalls Shipbuilding, Inc., and Avondale, could be made capable of constructing *conventionally* powered aircraft carriers.[29]

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[29]For more on commercial Navy shipbuilders, see Ronald O'Rourke, *Navy Major Shipbuilding Programs and Shipbuilders: Issues and Options for Congress*, Washington, D.C.: Congressional Research Service, September 24, 1996.