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Aircraft Carriers

The Limits Of Nuclear Power

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Abbreviations

AAW	Anti-Air Warfare
AE	Ammunition Ship
AEW	Airborne Electronic Warfare
AO	Fleet Oiler
AOE	Fast Combat Support Ship
AOR	Replenishment Oiler
AP	Associated Press
ARG	Amphibious Ready Group
ASUW	Anti-Surface Warfare
ASW	Anti-Submarine Warfare
CAP	Combat Air Patrol
CASREP	Casualty Summary Report
CG	Conventionally Powered Guided Missile Cruiser
CGN	Nuclear-Powered Guided Missile Cruiser
CINCUSNAVEUR	U.S. Commander In Chief, Naval Forces Europe
CLF	Carrier Logistic Force
CNA	Center for Naval Analysis
CNO	U.S. Chief of Naval Operations
COMUSNAVCENT	Commander, U.S. Naval Central Command
CV	Conventionally Powered Aircraft Carrier
CVBG	Aircraft Carrier Battle Group
CVN	Nuclear-Powered Aircraft Carrier
CV-41	USS Midway, conventionally powered aircraft carrier
CV-60	USS Saratoga, conventionally powered aircraft carrier
CV-61	USS Ranger, conventionally powered aircraft carrier
CV-66	USS America, conventionally powered aircraft carrier
CV-67	USS John F. Kennedy, conventionally powered aircraft carrier
CVN-71	USS Theodore Roosevelt, nuclear-powered aircraft carrier
CVS	Anti-submarine Aircraft Carrier
DCNO	U.S. Deputy Chief of Naval Operations
DDG	Guided Missile Destroyer
DOD	Department of Defense
DOE	Department of Energy
EIS	Environmental Impact Statement
FY	U.S. federal Fiscal Year (1 October to 30 September)
GAO	General Accounting Office
HAC	U.S. Congress, House Appropriations Committee
HASC	U.S. Congress, House Armed Services Committee
INREP	Inport Replenishment
JCAE	Joint Committee on Atomic Energy
LPH	Amphibious Assault Ship

MARG	Mediterranean Amphibious Ready Group
MLF	Mobile Logistic Force
N.D.	No Date
OASD	Office of the U.S. Assistant Secretary of Defense
PACOM	Pacific Command
PGBF	Persian Gulf Battle Force
RSBF	Red Sea Battle Force
RRF	Ready Reserve Fleet
SAC	U.S. Congress, Senate Appropriations Committee
SASC	U.S. Congress, Senate Armed Services Committee
UNREP	Underway Replenishment
(U)	Unclassified
USS	United States Ship
V/STOL	Vertical/Short Take-Off and Landing

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Introduction

The U.S. Navy is asking Congress to fund its tenth nuclear-powered aircraft carrier, designated CVN-76, the ninth of the USS Nimitz (CVN-68) class. With a price tag of $4.5 billion, the CVN-76 is the most expensive single weapons system in the FY 1995 defense budget.[1] The new carrier is scheduled to join the fleet in the year 2003, with funding for another (projected at over $6.1 billion)[2] to follow at the turn of the century.

Can the United States afford to build more nuclear-powered aircraft carriers? And more importantly, is nuclear propulsion needed for aircraft carrier operations at all?

The Navy claims nuclear aircraft carriers are necessary and that additional construction and support costs are justified because of significant military advantages gained from nuclear propulsion. Neither is true. Not only are nuclear carriers more expensive in every facet of their life cycles, but the promises and expectations of significant military advantages from nuclear propulsion are not evident from past and current naval operations. In fact, the Navy itself does not make use of the advantages it highlights as justifying nuclear propulsion.

The United States is cutting defense budgets, a process that requires smart planning and innovative ideas. Highly maneuverable "blue-water" naval forces are being transformed from a global scenario of facing the Soviet Union to tailoring for "stand-off" interventions in littoral waters against rogue regimes. Even if nuclear propulsion did yield the significant military advantages argued by nuclear proponents, such capabilities exceed the military needs facing U.S. naval forces in the post-Cold War era.

As the Cold War came to a close, the overall pace of shipbuilding also declined. But the cocksure commitment to nuclear carriers was never re-examined. In fact, there has been an admission that military justifications are no longer paramount; the desire to retain a nuclear reactor and shipbuilding infrastructure is now the primary reason for building more nuclear carriers. "Neither the carrier [CVN-76] nor the SSN [nuclear-powered attack submarine] work is being justified on the basis of force levels," Nuclear Propulsion Director Admiral Bruce DeMars bluntly admitted before Congress in April 1992. Rather, he explained, "The issue is how to sustain essential capabilities which, if lost, cannot practically be reconstituted."[3] Building nuclear ships to keep an industry alive which has no utility in the civilian economy is incompatible with U.S. national security policy and interests.

The United States would gain more from pursuing a global ban on the use of nuclear power for naval warships than struggling to sustain a too expensive and shrinking nuclear industry for scenarios and conflicts that are unlikely ever to happen. Whether it be a Russian Navy returning to blue water ambitions, or a hypothetical scenario of a hostile country suddenly surging dozens of yet to be built nuclear warships into the world's oceans, no credible threat can justify continuing to build nuclear warships. A ban on nuclear propulsion is smart because it would save money at home, boost U.S. non-proliferation objectives abroad, and consolidate scarce resources in a healthier and more vital non-nuclear shipbuilding industry.

Already, there is some congressional interest in steering away from the Navy's all-nuclear plan. Eight congressmen wrote to Secretary of Defense Les Aspin in February 1993 that they believed it was in the U.S. national interest to retain "a significant number of conventional carriers" in the fleet.[4] Though committed in the FY 1995 shipbuilding budget, the enormous cost of CVN-76 has been challenged by Senator Alfonse D'Amato (R-NY), Representative Ron

Dellums (D-CA), chairman of the House Armed Services Committee, Representative Robert Andrews (D-NJ), and Senator Russ Feingold (D-WI).[5]

The Bottom-Up Review conducted in the first year of the Clinton Administration decided to defer funding of the next Nimitz ship (CVN-77) until after FY 1999, pending completion of a study to evaluate alternative aircraft carrier concepts for the 21st century.[6] The Congressional Budget Office (CBO) has outright suggested cutting the carrier fleet below the 12 boats outlined by the Bottom-Up Review to ten or even seven carriers.[7] Finally, although largely motivated by a desire to save conventional naval bases that were earmarked for closure as part of the defense drawdown, Congress ordered a study of the costs associated with nuclear versus conventional carriers.[8] The study is expected to evaluate ship-on-ship cost comparisons as well as life cycle differences.

Evaluating the claims of military advantage, however, is not anticipated and is more difficult and subjective. The purpose of this study is to attempt an examination of the performance of nuclear versus conventional carriers during actual crises and warfare.

The conclusions are surprising. In normal military operations, no meaningful advantage has ever been attained by the nuclear carrier force. In fact, the Navy's own evaluations of military operations do not even distinguish between nuclear and conventional ships. Each platform has certain advantages and disadvantages in performance, but in real world operations, nuclear ships are not practically thought to be more capable or operated differently than conventional ships. Nuclear and conventional ships have the same missions.

Rather than conveying this reality to the Clinton Administration and to Congress, however, the Navy continues its quest for an all-nuclear-powered aircraft carrier force.

This study does not make alternative recommendations regarding ship designs or military strategies. Nevertheless, there are some basic observations:

* The cost of nuclear power is not justified, in peacetime or in wartime, in terms of useful military capability. Nuclear ships are more expensive, less available, and only comparable in generating and sustaining air operations. They operate as part of integrated and increasingly joint military missions close to land, and nuclear-powered carriers are not used any differently than their conventional counterparts.

* The costs associated with uranium mining and enrichment, fuel fabrication, spent fuel and reactor disposal, and the environmental legacy associated with reactor development and use, are barely factored into, but are a significant consideration in, overall program cost.

* Smaller platforms such as large-deck amphibious ships have begun to serve many of the same functions as mega-carriers. Today's large-deck amphibious ships with vertical/short take-off and landing (V/STOL) aircraft are larger than the new nuclear-powered aircraft carrier currently being constructed in France. These ships are described by the U.S. Navy as "enough to compensate for the reduced number of [large] carriers" in certain scenarios.[9]

* Nuclear power has associated with it additional political liabilities that always constrain its operations -- foreign port calls and basing, and passage of controlled straits and canals -- thereby reducing the flexibility of nuclear-powered ships.

* Proportionally, the burden of nuclear power will increase as the overall size of the Navy continues to decline, thus further aggravating the shortage in the Navy's shipbuilding budget and limiting flexibility in

downsizing efforts.[10]

* If the Navy eliminated nuclear-powered aircraft carriers, savings could be put towards urgent domestic programs and foreign assistance projects, or reducing the sizeable national debt.

Summary and Main Findings

Proponents of nuclear propulsion for aircraft carriers argue that nuclear power provides unique *military* capabilities over conventional ships that justify the additional resources. Over the years of arguing for a nuclear fleet, proponents have listed a variety of advantages gained from nuclear propulsion. Some lists have been more extensive than others.[11] The Navy's most recent (March 1994) white paper promoting a new nuclear carrier lists three main military advantages derived from nuclear propulsion:

1. virtually unlimited range at maximum speed;
2. the ability to remain on-station indefinitely without refueling; and
3. greater storage capacity for combat consumables, such as bombs and jet fuel.[12]

The findings in our report, however, conclude that during the two last major wars (the Vietnam and Gulf Wars), the period between the two conflicts, as well as in crisis responses and deployments in general, operations have not matched the promises or expectations of nuclear propulsion. Nuclear-powered aircraft carriers do not transit faster to a region, remain longer on-station, or drop significantly more ordnance or launch more aircraft sorties than do conventionally powered carriers. In fact, the Navy itself does not appear to distinguish between nuclear and conventional carriers in its operational planning or crisis preparations.

In the Vietnam War, nuclear refueling delayed the deployment of the only nuclear carrier in the fleet at the time -- the USS Enterprise (CVN-65) -- by nearly a year and forced the carrier into the least impressive "turnaround"[13] period of any carrier in the war. Despite the Navy's general claims, the USS Enterprise neither deployed faster nor carried more aircraft squadrons than other carriers, and its war efficiency was restrained with less time on-station, fewer cruises, and briefer deployments than conventional counterparts (see Tables 7 and 8).

In the Gulf War, nuclear propulsion was inconsequential. Despite half of the Navy's carrier fleet being nuclear-powered, only one such boat -- the USS Theodore Roosevelt (CVN-71) -- took part in the war. Nuclear propulsion did not speed up its deployment, did not allow it to stand down or replenish less than conventional carriers, did not enable it to carry more aircraft, and did not enable it to launch more strike sorties or drop significantly more bombs on targets in Iraq and Kuwait. In fact, the nuclear carrier achieved the lowest combat mission performance of any carrier deployed in the Gulf War, and in some important offensive categories, such as "kill-box" strike missions, mustered fewer missions than the other carriers deployed inside the Persian Gulf (see Table 20).

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In three categories of flight operations, however, the USS Roosevelt demonstrated higher performance by launching more *overall* sorties, more strike *missions*, more aerial *refueling* sorties, and dropping more bombs than any conventional aircraft carrier taking part in the war (see Tables 10, 18, 22, and 23). To conclude that this accomplishment was due to nuclear propulsion, however, would be an error. The higher performance was achieved only because the USS Roosevelt is a bigger ship -- not because it is nuclear-powered.

Even in those categories of flight operations where the nuclear carrier did better than its conventional competitors, performance fell far short of the extra capacity cited by the Navy to justify nuclear propulsion. The Chief of Naval Operations Aircraft Carrier Handbook specifically justifies a 50 percent higher construction cost of the USS Roosevelt over a conventional carrier because of its capacity to carry 70 percent more aviation fuel, 50 percent more ordnance, and a 20 percent greater ordnance strike-up.[14] But in the war, the nuclear carrier only flew 13 percent more aerial tanker sorties, three percent more strike missions, and dropped only 14 percent more ordnance. Clearly, in a procurement cost-benefit analysis, the accomplishment of the USS Roosevelt's air wing is offset by the ship's 50 percent higher construction cost, 16 percent greater size, and 16 percent extra crew (see Tables 10, 18, 22, and 23).[15]

The Navy's case for a nuclear advantage has historically hinged on having nuclear cruisers escorting nuclear carriers, facilitating the advantages of speed and independence. Nevertheless, no nuclear escorts were assigned to the USS Roosevelt battle group for the transit from the United States.

> **"I do not think operationally that when we schedule the operation, we schedule whether it is a nuclear carrier or a conventional carrier."**
>
> Admiral Frank Kelso, Chief of Naval Operations, April 1993.

In some circumstances, the Navy will admit that these theoretical advantages of nuclear power are inconsequential when it comes to real life operations. As Chief of Naval Operations Admiral Frank Kelso, told Congress in response to questions in April 1993: "From an operational standpoint -- about where it can go and what it can do -- the nuclear carrier obviously has greater endurance. So when I look at them from an operational standpoint, I mix them. But one is one or one is the other, as far as what the capability of the carrier can do.... I do not think operationally that when we schedule the operation, we schedule whether it is a nuclear carrier or a conventional carrier." He added, "Whatever carrier is available in its maintenance cycle and training cycle is the one we send."[16]

In conclusion, there is no evidence that the Navy itself assigned nuclear ships or made use of the alleged "unique" capabilities it credits to its nuclear warships in the war.[17]

Nuclear power provides certain theoretical advantages in now abandoned Cold War scenarios. But even here, the main advantage of nuclear power, its independence from outside support, has never been a practical advantage. Aircraft carriers, nuclear-powered or not, rarely go to sea without the company of escort ships, nearly all of which are conventionally powered. All carrier battle groups, in addition, are escorted by slower supply ships that carry everything the task force needs to sustain operations. Sea operations, while in theory sustainable at a high tempo because of nuclear power, are in fact significantly restricted by human and physical realities. A nuclear ship might be able to steam without limit, but pilots cannot fly without rest and breaks, aircraft require maintenance, repair demands periods of slowed tempo, and resupply requires stand downs.

In fact, while the Navy argues the extra cost of nuclear carriers is "directly offset by the elimination of the cost of buying and delivering propulsion fuel oil, and the reduced cost of the logistic support forces *due to less frequent replenishment* of combat consumables,"[18] the number of replenishments carried out by the USS Roosevelt during the Gulf War equaled those performed by the newest conventionally

powered carrier, the USS Kennedy (see Table 21).

Throughout an expected operating life of 50 years, a nuclear carrier will spend almost one-third of its life -- over 16 years -- in shipyards. In contrast, a conventional carrier will spend less than one-fourth of its time in a similar state.[19] As nuclear carriers replace conventional ones, this nuclear overhaul and maintenance burden will result in a smaller carrier fleet less available for crisis response and peacetime operations; nuclear ships are 15 percent less available than conventional ones.[20] Nuclear-powered ships, in addition, have also historically proven to be less available when called upon in crises. The historical record indicates that nuclear carrier deployments lag behind conventional deployments.

Between 1976 and 1988, for example, the average conventional carrier was 15 percent more active and available for crisis response, spending more days at sea than nuclear carriers in two out of every three years (see Table 3); all this at reduced construction and maintenance costs. Even after the Navy started building *only* nuclear carriers in the 1970s and 1980s, conventional carriers continued to be called upon to respond to crises more often. In 45 such contingencies between 1980 and 1992, oil-powered aircraft carriers consistently were used in two out of three deployments (see Table 4).

During the Gulf War and its aftermath, the three-year period between August 1990 and June 1993, deployments to the Persian Gulf region notably favor non-nuclear ships. This is at a time when the number of nuclear and conventional carriers in the fleet is about even, and the phaseout of older conventional carriers "that still have service life remaining"[21] has been accelerated. Conventional carriers made twice as many deployments and averaged longer deployments than their nuclear competitors during this period. The longest single deployment achieved by any aircraft carrier in that period was mustered by the 38-year-old USS Saratoga (CV-60) which was away from home for seven-and-a-half months.[22]

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Overall, our conclusion is that the claims that nuclear propulsion is advantageous for naval operations are not substantiated. In whole, nuclear power is a burden for naval operations, not an advantage. In making its case for more nuclear aircraft carriers, however, the Navy leadership has never shared the true record with Congress or the public. Instead the performance of nuclear warships has been unevenly presented to ensure continued funding.

In the post-Cold War period, U.S. naval strategy is shifting to greater emphasis on so-called littoral warfare scenarios. These anticipate carriers operating closer to land. In such scenarios, the old justifications for nuclear propulsion -- global "blue water" conflict with the Soviet Union where high speed and endurance at sea are advantageous for survival against a similarly nuclear-powered and nuclear-armed opponent -- are less and less conceivable and completely outdated.[23] In an age of "joint warfare," with a regional rather than global warfare orientation in military planning, such scenarios are no longer conceivable.

Part I:

The Nuclear Carrier Mystique

The History of Nuclear Carriers

Nuclear-powered aircraft carriers are a new phenomenon in naval operations. As early as 1958, only four years after nuclear power had gone to sea onboard the USS Nautilus (SSN-571), the Navy envisioned a fleet where six of twelve aircraft carriers would be nuclear-powered.[24] It would take more than 35 years to realize that dream.

The first nuclear carrier, the USS Enterprise (CVN-65), a one-of-a-kind ship, was under design and construction for more than 10 years.[25] Commissioned on 25 November 1961, one month after the cruiser USS Long Beach (CGN-9) became the first U.S. nuclear surface ship, the USS Enterprise was equipped with eight nuclear reactors to provide sufficient power. Not only was the carrier the biggest warship ever built, its construction price soared from an original estimate of $314 million to over $472 million,[26] and has remained controversial due to its maintenance costs ever since.[27]

The Congress wanted a second nuclear carrier to follow soon, and long-lead funding was appropriated in the FY 1960 budget for a nuclear propulsion plant. The money was not released by the Department of Defense, however, and Congress eventually decided to build a conventional carrier until more experience was collected with the nuclear ships.[28] The result was the USS America (CV-66), funded in the FY 1961 budget with an oil-burning power plant. It was commissioned in 1965.

While the USS America was under construction, a fierce battle erupted over what propulsion type to install in the next aircraft carrier. The Navy wanted a four-reactor nuclear propulsion plant, but the Department of Defense said it was too expensive.[29] As a result the USS John F. Kennedy (CV-67), finished in 1968, had an oil-burning plant. The USS Kennedy "should never have been built using conventional power," the House Armed Services Committee grieved after the launch.[30]

Yet the combined effect of two decades of lobbying by nuclear advocates under the stewardship of Admiral Hyman Rickover, and hundreds of millions of dollars worth of research, created strong nuclear support in Congress. "Certainly," L. Mendel Rivers, chairman of the House Armed Services Committee, told President Johnson in late 1967, "there will be no additional carriers authorized by our committee unless they are nuclear-powered."[31] Even Secretary McNamara, a non-believer in the eyes of the nuclear lobby, gave in and his posture statement on the fiscal years 1967-1971 budget included plans to build three nuclear-powered aircraft carriers of the Nimitz class.[32]

The program got backing from Congress, and the first series production of nuclear carriers commenced. Still, the nuclear carriers continued to be controversial. The first Nimitz class carrier (CVN-68) was funded on schedule, although some delay was encountered during construction. But congressional disputes over the second carrier, the USS Dwight D. Eisenhower (CVN-69), caused its long-lead funding to be stretched over two years, 1968 and 1969. Full funding was only released in 1970 because attention shifted to the third carrier, USS Carl Vinson (CVN-70). Intense congressional studying delayed its funding to 1974.[33]

Curiously, as late as 1972, at a time when one nuclear aircraft carrier was operating and two more were under construction, the National Security Council had given no recommendation relating to the role or numbers of nuclear aircraft carriers in the fleet.[34] Yet the efforts to secure more nuclear ships continued unabated, and at one point language was even included in the 1975 Defense Authorization Act (Title VIII) that first-line warships built from that date could *only* be nuclear-powered. If the Administration wanted to build conventional first-line warships, the law said, the President had to certify that a nuclear-powered warship would not be in the national interest.[35]

However, no nuclear carriers were funded between 1974 and 1980 due to continuing controversy about cost.[36] Long-lead funding for the USS Theodore Roosevelt (CVN-71) was included in the FY 1977 budget, but neither the Ford nor the Carter Administrations would release the money.[37] President Carter vetoed the defense bill, asking that the two billion dollars appropriated for building the carrier be applied to other defense needs.[38]

The nuclear-only provision of Title VIII had a short life. Although the House was eager to maintain it, the Senate Armed Services Committee proposed in 1977 that the language be canceled. At first the House succeeded in defending it, but in 1978 the language was softened. And while the new Title VIII called upon the United States to built capable, modern warships, obligatory construction of nuclear-powered major combatant ships was dropped.[39]

The intensifying of the Cold War in the 1980s allowed the Reagan Administration to stage a come back for nuclear aircraft carriers. More nuclear carriers were funded between 1983 and 1988 than in any previous period. While Congress had to force funding of the USS Roosevelt upon the Carter Administration in 1980,[40] the new Administration could not get enough nuclear carriers. Convinced that the extra cost "is more than offset over the service life" and because of "overwhelming military advantages,"[41] the Reagan Administration pressed for more nuclear carriers than any previous administration, proposing dual-funding in an attempt to reduce the cost of individual ships. CVN-72 and CVN-73 were funded in 1983, and CVN-74 and CVN-75 in 1988.[42]

Carrying on in the tradition of the Reagan Administration, the President Clinton wants two more nuclear carriers to be approved before the year 2000.[43] Long-lead funding has already been released for the first (CVN-76). Under current plans, the Navy will convert its aircraft carrier fleet to a solely nuclear-powered force.

More nuclear carriers were funded between 1983 and 1988 than in any previous period. Carrying on in the tradition of the Reagan Administration, President Clinton wants two more nuclear carriers to be approved before the year 2000.

Yet the nuclear carrier program has received little attention.[44] No post-Cold War assessment has taken a hard look at the need for nuclear-powered vessels.[45] One major study from 1991 ("Carrier 21") on future design and technology by the National Research Council, boldly assumes that all future large aircraft carriers should be nuclear-powered. "Nothing in recent experience suggest that non-nuclear power for a new generation of large ships of the aircraft carrier (CV) class should be preferred," the study asserts. "Indeed, future sustainability considerations would suggest using nuclear power for more ships if the initial costs are deemed supportable."[46] Despite the great expense involved, the putative military advantages of nuclear over conventional carriers and the long-term environmental consequences of continuing the nuclear commitment have not

been evaluated.[47]

As the carrier force shrinks from 13 ships in 1994 to 11 (plus one conventionally powered training carrier held in reserve) by 1999 (see Table 1),[48] the shift to nuclear power threatens to create additional procurement and shipbuilding costs that are currently unprogrammed. One argument offered by the Bottom-Up Review for converting to a nuclear-only aircraft carrier fleet and prematurely retiring three conventional carriers that still have service life remaining is the "training and maintenance efficiency to be gained by transitioning to an all-nuclear-powered carrier force."[49] Why this necessarily means transitioning towards a *nuclear* rather than conventional carrier fleet is unclear. Building new conventional carriers would equally support training and maintenance efficiency, especially considering that the rest of the surface fleet is *not* nuclear.

In order to offset the loss of older ships leaving the force between now and the year 2014, four new Nimitz class carriers will be required to implement the all-nuclear plan.

To maintain the anticipated carrier force, procurement of nuclear carriers will not end with the ninth Nimitz class. To the contrary, as the Navy implements its plan for a permanent super carrier force of 11 nuclear ships, it will have to continue building Nimitz class ships to account for retirement and attrition. When the last fully operational conventional carrier retires in 2008,[50] 11 nuclear carriers will remain. But one of those ships, the USS Enterprise (CVN-65), will be nearly 50 years old, at the end of its life. In order to maintain 12 carriers in the face of retirement of all conventional ships, at least two additional new nuclear carriers would be required before 2014.[51] This means that in order to offset the loss of older ships leaving the force between now and the year 2014, four new Nimitz class carriers will be required to implement the all-nuclear plan.[52]

Admiral Rickover and the Nuclear Lobby

Because of their exorbitant construction cost, nuclear-powered surface ships were controversial from the start. Weighing cost against military gain became an ongoing battle between the Department of Defense and naval nuclear advocates. Securing congressional support was vital to the fulfillment of Admiral Rickover's dream of an all-nuclear force, and in this regard he was remarkably successful.

While naval nuclear propulsion remained cloaked in military secrecy for four decades out of reach from public scrutiny, the Naval Nuclear Propulsion Program under Admiral Hyman Rickover covertly secured powerful ties to Congress to guarantee funding. In many ways the naval nuclear lobby outlived the civilian government. "Chiefs of naval operations, secretaries of the navy, secretaries of defense, and presidents served their terms and departed, but Rickover remained," one historian wrote. "Only in Congress were there individuals who continued in office for comparable lengths of time. Strong ties developed between Rickover and key legislators on defense and atomic energy, enabling him to exert unusual and unparalleled influence in the introduction of nuclear propulsion into the fleet." At a naval aviation luncheon in Washington, Rickover was once asked publicly, "How do you get things done?" He answered: "You just outlive them."[53]

The alliance with Congress was essential to getting the money to build nuclear warships, but Rickover felt the Navy did not do the job. "I must confess," he once said, "that by Navy rules I don't know what it takes to get along with Congress." The Navy was not comfortable with the self-minded Admiral, who openly

challenged its leadership. "My primary duty is in the Atomic Energy Commission" was his frequent lament before congressional subcommittees. "I have additional duties in the Navy to help me do my job. This is where I get fouled up," Rickover said. "If it weren't for the fact that my organization was in the Atomic Energy Commission," he once told a House committee, "I doubt we would have a nuclear navy today." Congressmen could sympathize with the Admiral, the underdog fighting naval bureaucracy. So it was in Congress that the nuclear navy was built; "I am a creature of Congress," Rickover would say.[54]

While congressmen are always invited onboard warships for VIP visits, Admiral Rickover did better. Entire hearings of the Joint Committee on Atomic Energy would be held onboard nuclear-powered warships, including the USS Nautilus (SSN-571), USS Skipjack (SSN-585), and USS George Washington (SSBN-598), shortly after these types went into operation.[55] Showing off the product, talking to the crew, and getting acquainted with the people was the best way to ensure continued support.

Rickover's congressional attention was manifest. Once at a launching of a nuclear submarine, Rickover was being introduced to the wives of the ship's senior petty officers when a congressman arrived. One officer's wife recalled the event. "Without an 'excuse me' or 'thank you' to the wives and men who would go to sea and make his submarine operate, he promptly turned away and hurried over to the arriving congressman, who was already being met." It was always Congress first -- and at times Congress only.[56]

Bureaucracy irritated Rickover. Once in 1977, looking back at three decades of serving as head of the nuclear propulsion program, he named 14 Secretaries of Defense, 16 Deputy Secretaries of Defense, 13 Directors of Defense Research and Engineering, eight assistants to the Secretary of Defense for atomic energy, 15 Secretaries of the Navy, 18 Under Secretaries of the Navy, 11 Chiefs of Naval Operations, 14 Vice Chiefs of Naval Operations, five Chiefs of Naval Material, and 11 commanders of the Naval Sea Systems Command (and its predecessor organizations):[57]

> On the average, each of these hundred and twenty key officials in the Department of Defense approval chain held his position in little over two years. In any given year, about four of these ten top positions had a new incumbent. Since my own tour of duty…spans this entire period, I undoubtedly have a different view of the events that have occurred than do the officials I have mentioned and their numerous subordinates whose approval had to be obtained before I could proceed with my work.[58]

Various administrations would sometimes support and sometimes vigorously oppose nuclear warships, but congressional support -- although not guaranteed -- was much more continuous. Over the years, the powerful House and Senate Armed Services Committees and the Joint Committee of Atomic Energy would prove to be the nuclear Navy's best allies. Lobbying of congressional committees was extensive, especially when orchestrating timely reactions or hearings in response to opposition to nuclear shipbuilding.

When the Department of Defense decided to cancel funding of two nuclear surface ships from the budget in 1961, for example, the nuclear lobby quickly began preparations for a hearing in Congress. Admiral Rickover met with legislators and the Navy chiefs and in late April, Carl Vinson opened the House Armed Services Committee hearings on nuclear shipbuilding. Vinson and Rickover had outlined the points to be made; the hearing schedule was changed so the Committee could hear Rickover speak. Agreement was reached with the Senate and one nuclear ship, the USS Truxtun (CGN-

35), was reinstalled in the budget.[59]

The new willful Secretary of Defense, Robert McNamara, had several clashes with Navy and Senate leaders in the early 1960s that would later alienate him within the nuclear lobby and backfire during congressional hearings. In the buildup of the naval quarantine in the Cuban Missile Crisis in late 1962, for example, McNamara clashed with Chief of Naval Operations Admiral George W. Anderson over a warship trailing a Soviet submarine. The two men got into a fight over who should control what the ship did. The objective of the quarantine was not to shoot anybody, McNamara said, but to communicate a political message to Khrushchev. "Now, Mr. Secretary, if you and your deputy will go back to your offices, the Navy will run the blockade," Anderson responded. "That's the end of Anderson," McNamara told his deputy after the event. "He won't be reappointed, and we've got to find a replacement for him. As far as I am concerned, he's lost my confidence." Admiral Anderson was appointed ambassador to Portugal in 1963.[60]

Prior to his transfer in August 1963, Anderson sided with McNamara on what type of propulsion the USS John F. Kennedy aircraft carrier should have. The Naval Nuclear Propulsion Program and the Congress had pressed for nuclear power, but McNamara -- with the backing of Admiral Anderson -- rejected this. Only six months before his appointment as ambassador to Portugal, Anderson told his staff that the USS Kennedy would stay conventional. But then Anderson suddenly changed his mind. And as Congress and the Navy made a last pitch for a nuclear-powered USS John F. Kennedy, the Joint Committee on Atomic Energy contacted Anderson in Portugal to guarantee that his late support for a nuclear carrier was included in the congressional records.[61]

In many ways, the battle over the USS Kennedy's propulsion is a case in point of how the nuclear lobby worked. Shortly after the House and Senate Armed Services Committees finished hearings on the FY 1963 shipbuilding program, the Joint Committee on Atomic Energy was flown to Guantanamo Bay, Cuba, for a tour of the USS Enterprise, followed by a hearing onboard. The sales tour worked and in its report the Committee concluded: "The United States must prosecute vigorously the conversion of the Navy to nuclear propulsion in the surface fleet as well as in the submarine fleet."[62]

McNamara was not convinced, however, so Rickover first turned to Senator John O. Pastore, the new chairman of the Joint Committee on Atomic Energy, who immediately wrote to McNamara. Secretary of the Navy Fred Korth was next on Rickover's list, and he also contacted McNamara. A hearing was held and virtually all the witnesses were supporters of nuclear propulsion. McNamara, however, did not change his mind.

Pastore was infuriated and wrote directly to President Johnson in December 1963 complaining that the decision on the carrier would adversely affect national security and that the Committee hoped Congress would take action in the coming session. As the House of Representatives met in 1964, as many as a dozen resolutions called for nuclear propulsion for the ship.[63] Nonetheless, McNamara won and the USS Kennedy was completed with conventional propulsion.

Letters of Performance

Nothing was more persuasive, however, than a detailed account from the captain of a nuclear ship itself praising nuclear propulsion. Admiral Rickover would frequently use such accounts as proof of the military advantages afforded by nuclear power. Especially when new programs had to be ensured.

In late 1962 and early 1963, for example, as the debate heated over the USS Kennedy, the nuclear proponents began publishing "evidence" of the advantages of nuclear propulsion. In October, Admiral Rickover promoted an unclassified version of hearings held by the Joint Committee on Atomic Energy onboard the USS Enterprise. In the foreword, Committee Vice Chairman Chet Holifield praised the tremendous strides nuclear propulsion had made under Rickover and declared that it was time to convert the surface fleet to the new technology.[64]

On 2 January 1963, shortly after the Cuban Missile Crisis, Rear Admiral J. T. Hayward, Commander, Carrier Division Two, reported to Secretary of the Navy Fred Korth in a letter clearly intended for publication how the USS Enterprise "outperforms every carrier in the fleet."[65] His assessment was soon supported by the commander of anti-submarine forces in the Atlantic, who cited five cases where refueling had forced warships to break off surveillance of Soviet forces. "In Washington these often cited advantages of nuclear propulsion seem to get lost in a shuffle of paper," Hayward said. "Off Cuba they were real."[66]

On 25 January 1963, Rear Admiral Hayward received a message from Vice Admiral Charles D. Griffin, deputy chief of naval operations (fleet operations and readiness) alerting him that the carrier debate had started. Hayward was onboard the USS Enterprise in the Atlantic and on 17 February he sent Admiral Rickover a photograph of his ship and the USS Bainbridge as they met on 7 February; it was the first ever rendezvous of two nuclear-powered surface ships. Although the picture was supposedly only a memento of an historic occasion, Hayward noted that the weather had been so bad that he had not been able to refuel his oil-fired destroyers for 48 hours and had been forced to slow down to conserve fuel. "Our transatlantic trip was extremely rough," reported Captain Raymond E. Peet onboard the USS Bainbridge. "RADM Hayward had more than his share of problems trying to fuel the other DD's. Anyone who witnessed that operation would think nuclear power is not only a bargain, but an operational necessity for the Navy…."[67]

Early in 1966, Admiral Rickover had begun collecting information on the performance of nuclear ships off Vietnam, asking their commanding officers to let him know of instances in which nuclear propulsion proved particularly advantageous. In April that year, he wrote: "It has taken us many years to win the fight for nuclear power in aircraft carriers. I truly believe we can get over the top on the acceptance of nuclear power in major fleet escorts."[68]

Resource constraints, however, ultimately led to abandonment of a scheme for all-nuclear task forces, thereby undermining the performance advantages of the nuclear carriers. But congressional enthusiasm and support for the nuclear mega-ships never waned.

"Fish Don't Vote"

In the vigorous and at times almost personal battles with the Department of Defense over nuclear propulsion, key congressional leaders took upon themselves at times an almost messianic role in the promotion of nuclear power at sea. "I am sick and tired of having the Committee on Armed Services and the Congress of the United States treated like little children," chairman of the House Armed Services Committee L. Mendel Rivers bluntly exclaimed from the House floor in December 1967 when the Department of Defense held up funding of more nuclear cruisers. "We represent the people of the United States. Not a single member of the Department of Defense has been elected by the people," Rivers pointed out. "The people I represent, the people the Committee on Armed Services represents, and the people the House represents want two more nuclear-powered frigates in our fleet. They

want them started now. I will not tolerate any further delay by the arrogance of one man who seeks to thwart the will of Congress and I herewith and hereby serve notice."[69]

Rivers was a loud and enthusiastic supporter and promoter of the naval nuclear program, facilitating countless Committee hearings on the advantages of nuclear propulsion, aggressively challenging various administrations to build more nuclear ships, and steering the Committee's support for a nuclear-powered surface fleet in the early 1960s.[70] He also lobbied hard for the Navy to place military facilities in his state. "If Rivers puts anything else in Charleston," House Appropriations Committee member Robert Sikes joked in early 1960 when facilities began flooding into Charleston, "the whole place will completely sink from sight from the sheer weight of the military installations."[71]

Other nuclear proponents included Representatives Carl Vinson and William H. Bates. Carl Vinson had been chairman of the Naval Affairs Committee before World War II and continued on the House Armed Services Committee after the war.[72] He strongly supported building nuclear warships and was largely responsible for maneuvering funding for the USS Truxtun (CGN-35) through Congress and the Department of Defense.

William H. Bates was a Representative from Massachusetts, who served on the Joint Committee on Atomic Energy since 1959. He was a strong supporter of nuclear propulsion and of Rickover himself. When the carrier USS Kennedy was launched in 1967 with conventional instead of nuclear propulsion, Bates declared from the floor: "It is a sad commentary for those who have worked for the development of nuclear propulsion in our Navy to see a ship which will be with us in the year 2000 will be propelled by conventional means, and not nuclear propulsion."[73]

Chet Holifield, who was vice-chairman of the Joint Committee on Atomic Energy, was another unbridled promotor of nuclear propulsion, arguing that all aircraft carriers and major warships should be nuclear-powered. When the USS Kennedy was launched with conventional propulsion, he opined: "Godspeed to all who sail in *Kennedy*. Our freedom depends on the brave men who will man such ships, but I wonder if we are doing, as a nation, what we should do to provide these brave men with the best to do the job. *Kennedy*…was obsolete when it was launched. It is a second-best aircraft carrier."[74]

In acknowledgment of their efforts, nuclear advocates, such as Senator John C. Stennis, Representative William H. Bates, Representative Glenard P. Lipscomb, Representative L. Mendel Rivers, Representative Richard B. Russell, and Representative Carl Vinson, and eventually Admiral Hyman G. Rickover himself, had nuclear-powered ships named after them. When asked why the tradition of naming attack submarines after fish had been changed, one admiral reportedly responded: "Fish don't vote."[75]

The End of an Era

The Arab oil boycott and the energy crisis in 1973-1974 were everything the nuclear Navy had hoped for. Seemingly, the vulnerability of the fuel supply was apparent to all, and only nuclear propulsion could ensure free and unconstrained maneuverability. Ironically, the ultimate effect was quite different than anticipated.

In part as a result of the energy situation, the Atomic Energy Commission was abolished, and the Joint Committee on Atomic Energy was dismantled. In January 1977, the House Armed Services Committee was given authority over national security programs of the AEC's successor, the Energy Research and

Development Administration (ERDA, the predecessor to the Department of Energy). The Naval Nuclear Propulsion Program now gave testimony to the House Subcommittee on Intelligence and Military Applications of Nuclear Energy.[76]

Without the powerful Joint Committee leadership, the new Congress was reluctant to provide funding for more nuclear-powered escort ships. Despite the 1975 Department of Defense appropriation legislating a nuclear-only major warship construction program, no nuclear-powered cruiser has been funded since the FY 1975 budget.[77]

Studying the Justifications

Over the years, the Naval Nuclear Propulsion Program and various congressional committees produced numerous hearings and reports demonstrating that conventional warships are inferior to nuclear warships. The studies were provoked by endless disputes over the extra cost versus the military advantages of nuclear warships. The various administrations focused on costs and the ability to build "a balanced Navy." The Naval Nuclear Propulsion Program, which was obsessed with building more nuclear warships, believed the only way to move quickly towards a nuclear navy was to ensure a steady construction program that would create and maintain the skills in vendors and shipyards.[78]

"I don't believe in cost-effectiveness," Admiral Rickover said to Secretary of the Navy Paul Nitze in 1967 during a discussion about propulsion types. "I believe that the Navy should have the best ships that can be bought, and I believe that nuclear-propelled ships are better than gas-[turbine]-propelled ships, and I believe that the Congress will give the Navy whatever money it requires to build the best ships, and as far as the Navy is concerned, the issue of cost-effectiveness does not arise. The only issue is which ship is the best ship."[79]

Consequently, the justifications became laundry lists about what nuclear-powered warships could do better than conventional ships:

> Representative Morris: Admiral, do any of those studies show that a nuclear propulsion plant does not have a military advantage?
>
> Admiral Connolly: No, sir. I was never confronted with any discussion to the effect that nuclear power was not *ipso facto* superior to conventional power, never in any of my discussions was anything said that it was not superior.[80]

The justifications did not attempt to evaluate *whether* nuclear-powered warships were necessary in naval operations. The nuclear proponents already *had* decided that nuclear propulsion was needed. Rather, the objective of the studies was more to back up the argument for building more nuclear warships.

Although supervising a flow of studies himself, Admiral Rickover ridiculed them when the Department of Defense reached different conclusions about the need for nuclear ships. During hearings in the House Armed Services Committee in April 1967, Admiral Rickover cited Bret Harte's poem, "Cardwell of Springfield," about an episode in the Revolutionary War when the Americans ran out of cannon wadding and Reverend James Cardwell brought from the church an armload of Isaac Watt hymnals: "Now put Watts into the boys! Give 'em Watts." Rickover belittled that in the next war U.S. officers would be exhorting their men, "Now put studies into 'em boys. Give 'em studies."[81]

But while nuclear advocates could focus on promoting their "super-ships," the Department of Defense had to find a balance between cost and real-world naval operations and needs. The sea-control mission, former Chief of Naval

Operations Admiral Elmo Zumwalt wrote in 1976:

> requires a large number of platforms from which weapons can be fired and planes be launched, a large number of ships. In most cases seven or five or even three ships of moderate capability would contribute far more to the success of this mission than one super-ship, as a series of analyses ordered by Robert McNamara, when he was secretary of Defense, decisively demonstrated. For twenty years Rickover has been working successfully toward a super-ship Navy, and so it is partly his doing that for twenty years the Navy has been getting smaller except of course in the item of nuclear-propelled submarines.[82]

Nuclear power was the next logical step in ship propulsion -- from sail, to coal, and to oil. It was a technical fascination about nuclear power that drove the original commitment, rather than an effort to match technology to the kind of naval operations that would realistically be carried out. As will be shown below, the record of nuclear carrier operations in the real world has never matched the promising expectations or claims.

The Rise and Fall of the All-Nuclear Force

Although construction continues, the function and operation of nuclear carriers today are unlike those portrayed at their conception in the 1960s and in the studies carried out by the nuclear proponents during that time. Projecting air power ashore has remained the core today as then for both conventional as well as nuclear carriers. But the nuclear carriers were sold based on their independence and extra punch allegedly derived from nuclear propulsion. Harvesting those capabilities depended upon the carriers being accompanied by nuclear-powered escort ships.

"A task force…with nuclear and conventional power," the Pacific Fleet commander said in 1972, "cannot take full advantage of the versatility of nuclear propulsion when married with non-nuclear-powered surface ships."[83] This assessment was in consonance with an earlier conclusion made by Secretary of the Navy Paul Nitze, that if a nuclear aircraft carrier task group is not escorted *only* by nuclear ships, its increased endurance "cannot be realized."[84] The House Armed Services Committee reached the same conclusion after holding extensive hearings on nuclear propulsion for surface ships in 1966. "It is clear to the Committee of Armed Services," the report stated, "that advantages of nuclear power for the aircraft carrier are not fully achieved if the entire task force is not nuclear-powered."[85]

"The conventionally-powered destroyers," on the other hand, "can be used for the [oil-powered] *John F. Kennedy* and the *America*," the House Armed Services Committee concluded.[86] In fact, the Committee -- together with the House Appropriation Committee and the Joint Committee on Atomic Energy -- concluded in the late 1960s that it would be "wasteful" to continue building non-nuclear escorts for nuclear carriers.[87] In other words, all-nuclear or not at all.

Yet, Secretary of Defense McNamara concluded at the time, "No senior or civilian official in the Department of Defense recommends that we build ships to operate all-nuclear task groups." He himself was not convinced that the alleged advantages of nuclear escort ships justified the cost. Faced with the prohibitive costs involved in building the nuclear escort ships the Navy wanted, McNamara recommended -- as did later the Chief of Naval Operations -- that nuclear carriers be escorted by only a few nuclear ships.[88]

The Congress and the Navy Nuclear Propulsion Program wanted all major warships

(those above 8,000 tons) to be nuclear-powered, and McNamara's position infuriated the Chairman of the House Armed Services Committee, L. Mendel Rivers: "I want the American people to know that the greatest nation on the earth possesses now only four nuclear [surface escort] ships. This seems to be of no concern to the Secretary of Defense."[89]

Given resource constraints, however, Navy plans eventually sought to create four all-nuclear task groups -- two in the Atlantic and two in the Pacific.[90] At first, the plan was to pursue 24 ships, but in 1972, the Navy admitted that its objective "though desirable, is unattainable within a reasonable period of time when viewed in the light of current and anticipated budgetary constraints."[91] The escort plan was pared down to 20 nuclear-powered escorts: four for each of four planned nuclear-powered carriers, and four additional for independent missions, two in the Atlantic and two in the Pacific.[92]

Though used on special occasions for public relations purposes, such as the 1964 "Sea Orbit" cruise around the globe, the 1975 "Northern Cruise" in Europe, and the 1980 Indian Ocean deployment, all-nuclear task groups never became a reality. "We have been trying to operate with the all-nuclear carrier task forces around the carriers that we have now," Deputy Chief of Naval Operations Vice Admiral Doyle told the Senate Appropriations Committee in 1979, but "we only have eight nuclear-powered cruisers; so that really is not enough to go around. We are trying to operate them together, but we have to substitute conventional ships to fill out the task force."[93]

Nonetheless, as recent as 1987, the "Ship's Mission" description of the cruiser USS Virginia (CGN-38) pretended as if nothing had happened since the 1960s. The nuclear power plant "provides VIRGINIA with the high speed and endurance which is so vital to our Navy's nuclear powered task force concept." This and the ship's armament "makes VIRGINIA the ideal escort ship for the latest generation of nuclear aircraft carriers."[94] Likewise, the mission of the sister ship USS Mississippi (CGN-40) is "to operate offensively with nuclear attack carrier strike forces."[95]

Nuclear escorts were just too expensive, and the Navy managed in the end to build only nine nuclear cruisers -- barely enough for two all-nuclear carrier battle groups. Despite congressional hearings and numerous naval nuclear propulsion studies demonstrating the "need" for nuclear-powered escorts, the Navy decided with little fanfare in February 1993 -- for budgetary reasons -- to accelerate the retirement of all its nuclear-powered cruisers. The USS Texas (CGN-39) had already been stricken after only 15 years in the fleet, and the USS Long Beach (CGN-9), USS Bainbridge (CGN-25), USS Truxtun (CGN-35), and USS Virginia (CGN-38) were earmarked to follow. Only two nuclear cruisers -- the USS California (CGN-36) and USS South Carolina (CGN-37) -- will remain active after FY 1997,[96] and then only because they completed expensive refueling overhauls before the Navy decided to eliminate the nuclear escorts.

Unable to utilize the "advantages" of nuclear power without the nuclear cruisers, the demise of the nuclear escort never stopped the Navy from requesting (or Congress from funding) nuclear carriers: Six nuclear-powered aircraft carriers have been authorized since the Navy dropped its all-nuclear escort goal in 1972.

The significance of scrapping the nuclear escorts, however, should not be lost in the routine decommissioning of dozens of warships in the post-Cold War budget reductions. Military advantages for nuclear-powered cruisers were as significant -- if not more so -- to naval operations as those argued to justify building aircraft carriers with nuclear propulsion.[97]

Now the nuclear escorts are quietly retired,

and the military advantages the Naval Nuclear Propulsion Program, the U.S. Navy, the Joint Committee of Atomic Energy, and the House and Senate Armed Services Committees spent so much time, so many studies, and so many hearings highlighting as critical to U.S. naval operations have become utterly irrelevant. This development has strong bearing on the nuclear carriers, because harvesting the "overwhelming military advantages"[98] built into the nuclear-powered aircraft carrier is dependant on the ship being escorted by other nuclear-powered combatants. Foremost among these advantages is independence from logistic supply.

Supply: The Deception of Independence

From the earliest days of nuclear power, the Navy argued that its principle interest in aircraft carriers was "based on the demonstrated capability of a nuclear carrier to operate for long periods of time, and at high sustained speeds as required, with greatly reduced dependence on logistic support."[99] A nuclear-powered carrier, the Navy argues, does not need to carry large amounts of propulsion fuel, allowing less frequent replenishment and freeing onboard space for more aviation fuel and aircraft ordnance.[100]

From the first operations of nuclear-powered ships, independence was hailed as one of the most important advantages. In a letter to Secretary of the Navy Fred Korth in 1963, Rear Admiral Hayward, who commanded the task force in the 1962 Cuban Missile Crisis, hailed the advantages of the USS Enterprise. Hayward said: "In Washington these often cited advantages of nuclear propulsion seem to get lost in a shuffle of paper -- off Cuba they were real." Admiral Rickover later used the letter during a congressional hearing in 1970 for nuclear-powered warships, and added that Admiral Hayward's evaluation of the importance of eliminating dependence on propulsion fuel logistic support was fully supported by the commander of the Atlantic anti-submarine forces, who in turn referred to five cases where refueling had forced Navy ships to break off track of Soviet diesel submarines during the crisis.[101]

The sailing endurance of nuclear propulsion and the extra fuel and ordnance spaces have never freed nuclear aircraft carriers from replenishment.

Yet the examples are dubious. Fuel supply in general was not a problem for the U.S. Navy in the mainly littoral contingency which was close to fuel stores and opposed by few hostile naval forces. As far as the application of nuclear propulsion to surface ships was concerned, the Cuban Missile Crisis provided no answer. Although the bigger USS Enterprise was able to launch more aircraft than the accompanying USS Independence (CV-62), operations did not call for sustained cruising speed. The "problem" for the U.S. Navy in 1962 was not the type of propulsion that powered its warships, but the lack of escort and patrol craft.[102] Nonetheless, the Cuban Missile Crisis has frequently been used as an example of the alleged advantages of nuclear propulsion.

Another example involves the nuclear carrier USS Nimitz (CVN-68). At its commissioning ceremony, the carrier was praised for its high speed capabilities and virtually unlimited endurance. Yet when it departed for its first two overseas deployments to the Mediterranean in 1976 and 1977, its escorts included traditional oil-fueled destroyers and frigates as well as much slower ammunition ships and oilers. Despite the ship being nuclear-powered, its aircraft and escort ships needed fuel. So in March 1979, the "Nimitz shifted from a conventional five-day work week to a ten-hour day, four-day work week as a response to the *energy crisis*" brought about as a

result of the Arab oil embargo.[103]

The sailing endurance of nuclear propulsion and the extra fuel and ordnance spaces have never freed nuclear carriers from replenishment. Nuclear as well as conventional aircraft carriers must periodically replenish or transfer provisions, aircraft and diesel fuel and other petroleum products, repair and spare parts, ammunition, food, personnel, mail, and garbage. According to an April 1988 Congressional Budget Office study, a typical carrier battle group, exclusive of its logistics ships, has enough supplies for only about five days of combat before it needs resupply. With its logistics ships, a carrier can only operate for about 15 days before requiring outside replenishment.[104] A modern Nimitz class nuclear carrier can only carry sufficient aviation fuel for about two weeks of flight operations (9,000 tons aviation fuel),[105] while a conventional carrier can store about 65 percent of this,[106] corresponding to about 10 days of flight operations.

In typical battle group operations, about one-third of the fuel carried by the group is used by the conventional carrier, about one-third is used by the escorts, and one-third by aircraft. Thus, nuclear power in the carrier eliminates only one-third of the fuel support requirement.[107] In theory, while a Nimitz class carrier can load 70-90 percent more jet fuel than a conventional carrier because of the additional space,[108] in reality, protection of the nuclear propulsion plant from attack has resulted in inclusion of unique side protective shields, an addition that reduces internal volume with less accommodations for extra fuel.[109] Moreover, aircraft carriers also typically refuel their own escort ships, and since during combat operations, combatants normally are kept fueled to about 65 percent capacity to remain ready for high speed maneuvering required for sustained operations, support of the non-nuclear escort force demands regular interruptions of air operations and movement.[110]

The dependency of nuclear battle groups upon replenishment was recognized by the Department of Defense even in the early 1970s. When asked by the Joint Committee on Atomic Energy in 1972 whether he agreed to building all-nuclear task groups, Deputy Secretary of Defense David Packard responded:

> No, I believe that it might be useful to have them, but that very large cost of all-nuclear carrier task forces preclude using them exclusively, particularly in areas where we operate and bases are available. We recognize that the necessity to provide oilers for conventionally powered carrier task forces can cause problems, but those problems are surmountable in our operations. In any case, during a shooting war, we would have to provide oilers and ammunition ships for the aircraft and escorts, whether the force is nuclear or conventionally powered.…What is important is not the composition of naval forces or the fact that they may be nuclear-powered, but whether or not those forces, including all their elements, can deter war and, if necessary, cope with it.[111]

"During a shooting war, we would have to provide oilers and ammunition ships for the aircraft and escorts, whether the force is nuclear or conventionally powered."

Defense Secretary Packard, 1972

Nonetheless, since Packard gave his statement in 1972, seven nuclear-powered aircraft carriers and two nuclear-powered cruisers have been funded by Congress.[112]

Without supply ships a nuclear-powered aircraft carrier's unlimited endurance would

soon become irrelevant due to lack of basic supplies. "Replenishment at sea is one of our biggest tasks, both in taking on cargo and fuel," a sailor on the nuclear carrier USS Theodore Roosevelt (CVN-71) said shortly after the Gulf War. "Without this we wouldn't have food or repair parts and TR [Theodore Roosevelt] could not complete her mission."[113] Like conventional carriers, the nuclear carrier is dependent on support ships for sustained operations. When an aircraft carrier deploys from the United States with its screen of escort ships and submarines, a fast combat support ship is deployed with it to operate "continuously"[114] as an "integral unit"[115] of the carrier battle group. It is because of such supply ships, not nuclear power, that carrier battle groups are able to operate independently.

The purpose of the battle group's fast combat support ship is to "receive petroleum products, ammunition, provisions and stores from shuttle ships and redistribute these items to the ships in the battle group."[116] These shuttle ships, known as underway replenishment (UNREP) groups, include oilers, ammunition and/or stores ships, which replenish from various facilities on land and resupply the battle group's fast combat support ship during deployment.[117] Some 16-18 shuttle UNREP ships are normally forward deployed in the Mediterranean, western Pacific, and Indian Ocean areas in support of fleet operations. In addition, two fleet support ships (AS/ARS) are generally forward deployed in the Mediterranean, and two in the Pacific and Indian Oceans.[118] These ships provide fuel and ammunition "for about 30 days, depending on the tempo of operations."[119] Without mentioning nuclear power, the Navy described its extended fleet sustainment:

> The combination of Combat Logistic Force ships…plus over 22 strategically-located [sic], worldwide fuel-storage sites, gives the U.S. Navy the ability to remain on-station as long as required. Combat Logistic Force ships are capable of providing the full range of logistics required by the fleet such as fuel (20 to 30 days), ordnance (scenario dependent), food (75 days), spare parts (90 days), and a wide range of services (salvage, towing, repair, maintenance, diving and fire fighting). These Combat Logistic Force ships are usually strategically located or deployed to react to the needs of the fleet. Fleet oilers, for instance, shuttle fuel from fuel storage sites back to the battle group, and can resupply individual units of the battle group, as well as any accompanying combat store ship. The ability to sustain itself indefinitely, anywhere in the world, enables the projection of U.S. influence worldwide.[120]

While at sea, nuclear carriers, like their conventional counterparts, constantly receive extensive replenishment. Navy documents released under the Freedom of Information Act give several examples of the replenishment burden of nuclear carriers during operations in the 1980s:

> * During 1984, the USS Carl Vinson (CVN-70) received over 19.2 million gallons of JP-5 jet fuel from tankers, pumping over 16.2 million gallons to its embarked aircraft and 278,000 gallons to other ships. At least 34 different underway and vertical replenishments were carried out during the year with other ships, an average of one every 11 days. Fifteen of these (44 percent) took place between USS Carl Vinson's departure from the U.S. West Coast on 13 October and the end of the year (79 days) during an extended Pacific deployment, corresponding to an replenishment every 5.2 days. Four of the fifteen (26 percent) involved the supply of fuel to other combatants.[121]
>
> * In 1985, the USS Carl Vinson carried out "an exceptionally difficult one-hundred [sic] seven day at sea [sic] period during which the most extended prosecution ever of a Soviet CHARLIE I submarine in the Indian

Ocean occurred." Until its return to the U.S. West Coast, the nuclear carrier conducted 47 replenishments with other ships during 127 days of steaming, corresponding to once every 2.7 days. The ship's air department received over 13,799,066 gallons of jet fuel from tankers and pumped over 13,817,099 gallons to aircraft during the year.[122]

* During a Pacific deployment in August-September 1986, the USS Carl Vinson conducted over 30 underway replenishments, or an average of one every fifth day while at sea. The nuclear ship's fuel division received over 23,500,000 gallons of jet fuel from tankers. In an attempt to reduce the number of underway replenishments, the USS Carl Vinson sailed into Pusan, South Korea, to conduct its first ever Inport Replenishment (INREP) with a Mobile Logistic Force (MLSF) ship. This new "policy" of INREP was continued in subsequent ports, but when the ship subsequently deployed to the northern Indian Ocean with its escort ships "support of the battle group again became a challenge as it remained dispersed throughout the Indian Ocean and CARL VINSON continued to be responsible for logistic coordination."[123]

* Finally, after returning to sea following drydock work in August 1987, the USS Carl Vinson conducted at least 11 major underway replenishments, corresponding to about one per every 11th day, every 6.3 days if only counting days at sea. The fuel department received over 6,289,525 million gallons of JP-5 aircraft fuel from tanker and pumped over 5,680,242 million gallons into aircraft.[124]

Building nuclear carriers has not reduced the need for supply ships. During the period the Navy stopped building conventional carriers to switch to the supposed more independent nuclear variants, it also increased its fleet of fast combat support ships.[125] In FY 1993, Congress funded the fourth unit of a whole new class of supply vessels -- the new USS Supply (AOE-6) class.[126] According to the Navy, the Supply class "will maximize flexibility of the Navy's aircraft carrier battle groups (CVBGs) by assigning one fast-moving, multi-product support ship operating continuously with each CVBG." The mission will be to provide delivery of on-station munitions, bulk petroleum/oil/lubricants, and dry and frozen provisions to carrier groups underway. Three ships are under construction and a fourth has been placed under contract; a fifth is being considered.[127] The Navy is also building a new class of 18 T-AO-187 class fast fleet oilers to form the "backbone of the oiler fleet for the next 40 years," and increasing the cargo oil and ammunition capacity of existing AO-177 class fleet oilers.[128]

Finally, while Nimitz class carriers have some 50 percent more aviation ordnance capacity than modern conventional carriers, and 20 percent greater rate of ordnance "strike-up" with three as opposed to two weapons elevators,[129] the ships do not take advantage of the increased capacity in operations. The Navy describes the extra ammunition space of the Nimitz as a "design bonus, not a design drive,"[130] indicating that extra ordnance capacity was not an objective of building nuclear carriers.

But although the Chief of Naval Operations told the Joint Committee on Atomic Energy in 1972 that "the size of the carrier will be about the same whether nuclear or oil-fired steam propulsion is used,"[131] the sheer weight of the nuclear power plant with its heavy shielding drove up ship tonnage. The size of USS Enterprise "was determined, not by air requirements, but by the character of her powerplant," the Navy's Aircraft Carrier Handbook states. "The reactor was approximately equal in weight to the usual combination of boilers and fuel, but the ship

still required liquid-filled side protection against torpedoes. That weight was reflected in increased length."[132]

Whether extra ordnance space was a key feature for nuclear carriers or not, abandonment of all-nuclear task groups and retirement of nuclear cruisers nullified the arguments of staying power, because if a nuclear carrier does not have all-nuclear escorts, it cannot stay on-station and expend its ordnance supply before it will have to retire and replenish fuel for its aircraft and escort ships. If accompanied by four conventional escorts, according to the Navy, "the carrier will have to retire for replenishment with less than half its aviation ammunition expended."[133]

Always Available -- Always Better?

Nuclear-powered aircraft carriers are often portrayed as being faster than non-nuclear carriers. When the USS George Washington (CVN-73) was commissioned in July 1992, for example, its ceremonial pamphlet boasted that nuclear propulsion will "give her virtually unlimited range and endurance and a top speed in excess of 30 knots."[134]

The historical record does not support the claims of high speed endurance for nuclear carriers.

But the claim of higher speed must be understood correctly. Rather than referring to a higher top speed as such, the argument relates to a nuclear ship's alleged ability to *sustain* a certain high speed for a longer period.[135] By not having to slow down for fuel replenishment, so the argument goes, the nuclear ship is able to get to a distant region faster and take up operations immediately without having to replenish. Yet in real world naval operations, this hardly ever happens.[136] As noted, replenishments are frequent.

And, indeed, the historical record does not support the claims of high speed endurance for nuclear carriers. Most recently, in the 1991 Gulf War, nuclear aircraft carriers did not deploy any faster than older non-nuclear carriers. The oil-powered USS John F. Kennedy (CV-67) transited the Atlantic Ocean in only eight days,[137] while the nuclear-powered USS Theodore Roosevelt (CVN-71) spent 12 days making the same distance. Moreover, the USS Roosevelt made its transit *in company* with an oil-powered carrier, the USS America (CV-66). Once in the Red Sea, the USS Roosevelt was quickly dispatched from the Red Sea to join two conventional carriers, the USS Midway (CV-41) and USS Ranger (CV-61), already on-station in the Persian Gulf. The transit from the Red Sea, however, was done at 30 knots and in company with the conventionally powered USS Leyte Gulf (CG-55).[138]

In fact, when the 35-year-old USS Saratoga (CV-60) departed Mayport, Florida, in August 1990 together with its escort ships en route to the Gulf War, it crossed the Atlantic Ocean faster than any nuclear carrier had ever done, "making the normally ten-day voyage in seven days -- hailed by the Chief of Naval Operations as the fastest Atlantic crossing since World War II."[139]

Throughout the operation of nuclear-powered aircraft carriers, rapid deployments have been cited as evidence of the need for nuclear power. One frequent example cited by the U.S. Navy is the use of a nuclear task force in response to the Iran hostage crisis in 1980 (see Part II). But the deployment was a public relations gesture, not an operational necessity. Conventional carriers were already on-station in the region, and quicker to reinforce. Over a period of time, conventional ships carried more of the load than nuclear ships.

Nuclear-powered aircraft carriers are generally hampered, in fact, by less operational

availability than their conventional counterparts. This is evident in the number of deployments made by nuclear carriers in the last two major wars the U.S. Navy has been involved in, and in the general peacetime deployment of the ships.

In the Vietnam War, the nuclear-powered USS Enterprise made fewer cruises and was on-station less time during deployments than several of the conventional carriers. Again in Operation Desert Storm, nuclear aircraft carriers were largely unavailable. The single nuclear carrier that did deploy, the USS Roosevelt, accomplished no outstanding achievements attributable to nuclear power compared to the performance of its conventional counterparts.

The performance of nuclear carriers in Vietnam and the Gulf War is no different than the general deployment pattern of aircraft carriers in the two decades between the wars. In the 13-year period between 1976-1988, conventionally powered aircraft carriers deployed an average of 1,133 days per year in total compared with 326 for nuclear carriers, accumulating much more sea days than their nuclear counterparts (see Table 2). Of those carriers in the fleet that actually deployed when not in overhaul or maintenance, conventional carriers exceed nuclear carriers in terms of at-sea days in two out of three years. Between 1976-1988, the *average* conventional carrier spent some 150 days during a deployment, while its nuclear counterpart deployed for only 128 days, or nearly 15 percent less.

A comparison of operations over time indicate that the conventional carriers accumulate more at-sea days that their nuclear counterparts.

A comparison of operations over time indicate that the conventional carriers accumulate more at-sea days that their nuclear counterparts (see Table 3).[140] This finding is in agreement with a recent General Accounting Office report that described the operational pattern of nuclear and conventional carriers. According to the study, "conventional carriers have a slightly higher operational availability

A nuclear carrier will spend less time forward deployed than it does at home.

than nuclear carriers (because of the shorter lifetime maintenance time)" and can be sustained at comparable at-sea level with less support.[141]

The operational availability of an aircraft carrier is determined by its overall employment cycle, the planning baseline used for operational forces, repeated several times during a ship's life. Though there are variations depending on the class of ship involved, the average employment cycle is nine years for a nuclear carrier, and six years for a conventional carrier.[142] For a nuclear-powered aircraft carrier, the employment cycle consists of an 84-month operating period followed by a complex 24-month overhaul phase.[143] Each 84-month operating period is made up of four 20-month deployment cycles including an extra four month inter-deployment phase. A deployment cycle, however, does not mean the carrier will be deployed overseas during the entire period. In fact, out of the 20-month deployment cycle, only six months -- or 30 percent -- will be spent in crisis response, forward deployment, or transition between homeport and an area of operation. The remaining 14 months are spent on post-deployment stand down (leave, routine upkeep, personnel turnover), maintenance and modernization, and ship and air wing training. Fleet exercises during this period correspond to only five percent of the deployment cycle. During the entire nine-year employment cycle

period (108 months), a nuclear carrier's deployment phase is only 24 months, corresponding to about 22 percent of its lifetime.[144]

Two of the nine years in the nuclear carrier's employment cycle, corresponding to more than 22 percent, will be spent in a major overhaul during which the carrier cannot deploy at all. Adding all the time spent in stand down, training, maintenance and overhaul, a nuclear carrier will spend less time forward deployed than it does at home.[145]

Because it does not have the burden of nuclear propulsion, a conventional aircraft carrier has a shorter employment cycle. It lasts only six years consisting of an operating period of five years and an overhaul phase of only one year. The operating period has only three deployment cycles.[146] As a result of this, a conventional aircraft carrier spends only 16.7 percent of its employment cycle in overhaul, 24 percent less than a nuclear-powered aircraft carrier.

Throughout its expected operating life of 50 years, a nuclear aircraft carrier will spend almost one-third of its life -- over 16 years -- in a shipyard for major maintenance and overhaul. In contrast, a conventional carrier, also with a 50-year operating life, will spend less than one-fourth of its time in a shipyard.[147] In the long term, the burden of nuclear power on carrier availability and operations is considerable.

Part II:

Crises Response

Nuclear Carriers Preferred?

The importance of nuclear propulsion to aircraft carriers ordered to respond to regional crises has been highlighted numerous times by Navy officials, especially in isolated regions where fuel supplies are scarce. A case in point has been carrier operations in the Indian Ocean.

"Several years ago there was a crisis, and it was necessary to send a carrier task force to the Indian Ocean," Admiral Rickover pointed out in March 1979 during a congressional hearing on the Naval Nuclear Propulsion Program. "The carrier that was sent was a nuclear ship, the *Enterprise*….When the crisis developed there were no prepositioned tankers. Fortunately there was a nuclear-powered ship available at that time." Indeed, Rickover added, "That has happened time and again, that is, in time of an emergency, the nuclear ship has been able to respond quickly."[148]

The Admiral's example, however, was far from the truth. Although the USS Enterprise (CVN-65) was indeed used for several Indian Ocean contingencies in the early 1970s, so were several conventionally powered aircraft carriers as well as Amphibious Ready Groups containing "mini-carriers."[149] Yet, the naval leadership in Washington was eager to justify funding of more nuclear warships, so when naval forces were ordered to deploy off Pakistan in December 1971 to be ready to evacuate American citizens, the USS Enterprise was assigned by central authority, while all other warships -- all of which were conventionally powered -- were assigned by local commanders.[150]

Even after the Navy started building *only* nuclear carriers in the 1970s and 1980s, conventional carriers continued to be called upon more often to respond to crises around the world. Indeed, the Navy itself has not favored nuclear over conventional propulsion when ordering carriers to respond to crisis situations or participating in major naval exercises. In 45 such contingencies between 1980 and 1992, oil-powered aircraft carriers consistently were used in two out of three deployments (see Table 4). One example was given by Admiral James Lyons, Commander of the Pacific Fleet, during congressional hearings in March 1987:

> [L]ast year I took the carrier *Ranger* and I surge-deployed it for 58 days -- an unheard of operation -- surge-deployed a carrier for 58 days to the western Pacific. It worked out great. It was the one thing -- that and the *New Jersey* battleship in Inchon during the Asia Games -- which provided the confidence and the backup for the stability on the Korean Peninsula during that tense period….And today, as we are standing here, I have surge-deployed the *Ranger* again, and it is enroute [sic] to Korea, this time to participate in Exercise Team Spirit. These are not normal, predictable patterns of operations….[151]

Nuclear Carriers Held Hostage

Nuclear advocates have always been quick to point out situations where conventional carriers were a disadvantage in crisis response. In 1972, for example, the Chief of Naval Operations told Congress that although the conventionally powered carrier USS Kennedy was rushed to the Mediterranean Sea the previous year because of the Middle East crisis, "because she did not have nuclear propulsion, she had to steam at a slower speed to conserve fuel. Furthermore, she had to be refueled when

she arrived in the Mediterranean. Nuclear power would have permitted her to arrive 2 days sooner -- and she would have been ready, without needed refueling, immediately upon arrival."[152] The CNO did not tell Congress, however, why the USS Kennedy was slowed down. During its cruise, which took place from late September 1970-February 1971, the carrier was suffering from propulsion problems due to design faults that had nothing to do with conventional propulsion. The problem was known to the Navy, and had hampered ship operations prior to the crisis.[153]

Ironically, what the Navy also did not tell Congress, and what no one in Congress asked, was why it did not send its nuclear-powered aircraft carrier instead. The embarrassing answer was that it could not -- the USS Enterprise could not deploy because it was in a complex overhaul at Newport News Shipyard at the time to have its eight nuclear reactors refueled and did not complete sea trials until 19 January 1971.[154] But this early story of nuclear versus conventional carrier pales in comparison with the experience of the "hostage crisis" of 1979-1980 and the Navy's attempts to promote nuclear power through its deployments.

In late 1979, at the time of the Iranian hostage crisis and Soviet Union's invasion of Afghanistan, the Navy announced it would redeploy a nuclear-powered task force centered around the aircraft carrier USS Nimitz (CVN-68) from the Mediterranean to the Indian Ocean.[155] The Navy later stated that the "superior capability of nuclear propulsion permitted a sustained average speed of 25.0 knots to arrive on-station in the Indian Ocean."[156] Once in the Indian Ocean, the Nimitz spent 108 days on-station until it was relieved by another nuclear carrier, the USS Eisenhower (CVN-69). Between its departure from Naples, Italy on 4 January 1980 until its arrival back at Norfolk on 26 May, after 144 days at sea, the USS Nimitz did not visit a single port. President Carter visited the task force in Norfolk, Virginia, and thanked the crew for their sacrifice during the extended nine-month deployment. It seemed like the perfect confirmation of the need for naval nuclear power.[157]

Overlooked in the nuclear promotional, however, was the fact that the first ships to arrive on-station in the Indian Ocean were conventional carriers. The USS Kitty Hawk (CV-63), which was at the end of its six-and-a-half month deployment in the Pacific, was ordered to proceed from Subic Bay to the Arabian Sea on 21 November 1979, to join the USS Midway (CV-41), which had relieved the USS Constellation, which had been on-station. These two conventional carriers stayed on-station until the Nimitz arrived.[158]

Thus, both the USS Constellation and the USS Midway were originally able to get to the Arabian Sea faster than the USS Nimitz. The USS Constellation battle group, for example, was ordered to the area on 7 March 1979, and arrived on-station on 16 March, after only nine days underway. The USS Midway's transit also lasted nine days.[159]

Even after the Navy started building *only* nuclear carriers in the 1970s and 1980s, conventional carriers continued to be called upon more often to respond to crises around the world.

Despite its independence from port calls, the USS Nimitz conducted 38 underway replenishments in the three-and-one-half months on-station in the Indian Ocean, or an average of one every 2.7 days. Such a level of external support is average, and largely matches the experience of nuclear and conventional carriers in the Gulf War ten years later (see Part III). Like a conventional carrier, it was the USS

Nimitz's aircraft operations that drove the need for fuel. The carrier's air wing logged a total of 16,544 hours of flight time while on-station,[160] requiring constant replenishment from oilers.

The USS Nimitz was subsequently relieved by another nuclear task force centered around the USS Eisenhower.[161] The USS Eisenhower group entered the Indian Ocean on 29 April 1980,[162] returning to the United States after 251 days, a deployment described by the Navy as "the longest deployment for a Navy ship since World War II."[163] But the Navy's record-keeping is faulty: conventional carriers have been deployed for much longer periods. During the Vietnam War, for example, the USS Coral Sea (CV-43) set a record of 331 days away from home from 7 December 1964 until 1 November 1965.[164]

During 1979, the Navy extended the deployments of its warships well beyond their peacetime schedule to maintain the presence in the Indian Ocean. The USS Midway (CV-41) was at its homeport for 84 days during the year, being underway for more than 280 days. Nine month deployments became normal, as the Chief of Naval Operations boasted that the USS Midway and USS Kitty Hawk (CV-63) "have been at sea for periods of time that are more extensive than at any time since World War II, including our fighting in Korea and Vietnam."[165]

Overall, conventional carriers carried most of the load in the Indian Ocean. During 1980, eight aircraft carriers conducted 10 cruises to the Indian Ocean/Arabian Sea. Only three were nuclear-powered. The carriers accumulated a total of 723 days on-station during the year, including one tour by the USS Eisenhower totaling 199 days; the USS Midway (CV-41) with two tours totaling 118 days; the USS Constellation (CV-64) with one tour of 110 days; and the USS Nimitz with one tour of 108 days. Other carriers involved were the USS Coral Sea, USS Independence, and USS Kitty Hawk (CV-63).[166]

The high tempo operations tested the endurance of all ships, not just the conventional carriers and their escorts. "The Indian Ocean force, right now," Chief of Naval Operations Admiral Thomas Hayward told Congress on 19 February 1980, "is operating at close to 100 percent operating tempo; they are at sea almost continuously, without going into port."[167] In congressional hearings at the time, Senator John Stennis, chairman of the Senate Appropriations Committee and a vigorous promoter of naval nuclear propulsion, found himself face-to-face with the realities of naval operations in the Indian Ocean -- realities that demonstrated that nuclear propulsion was not superior:

> Admiral Turner: The *Constellation* is one of our most modern carrier air wings. It has most of the aircraft we have talked about. It has two squadrons of F-14's. It has a squadron and a half of the A-7E's… It has one squadron of A-6E's… It has a squadron of jamming aircraft. It has a squadron of antisubmarine aircraft. It has logistic aircraft onboard. It has helicopters for antisubmarine warfare. It has an aircraft that we have not talked about, and older tactical reconnaissance photographic aircraft, the RF-8G. It has three of those onboard. It is prepared to do any mission it is called upon to do in the Indian Ocean or Gulf of Aden, from reconnaissance, antisubmarine warfare, power projection, control of sea lanes, relaying of information. It is a totally flexible equipment package.
>
> Senator Stennis: Is that a nuclear carrier?
>
> Admiral Turner: No, sir; it is a conventionally powered aircraft carrier.
>
> Senator Stennis: It is conventional?
>
> Admiral Turner: Yes, sir.

Senator Stennis: In other words, should you be challenged there, you would have all these things that you have enumerated with which to respond. Or if you wanted to move around a thousand or so miles either way, you could do that.

Admiral Turner: Yes, sir. It is part of the battle group. There are two surface combatants with the carrier, one submarine, and a logistics support ship that is carrying fuel and weapons for the utilization of the battle group. So, it is a completely integrated, self-sufficient package to carry out the national objectives.

Senator Stennis: Is there anything else anywhere in the world that will compare with that formidable military power that you just enumerated?

Admiral Turner: Yes, sir. There are 11 such combinations that compare with it and they are all called U.S. Navy battle groups."[168]

Even as the crisis abated and U.S. military interest in the Middle East increased, nuclear propulsion became an obstacle rather than a benefit to deployments to the Indian Ocean. When Egypt opened the Suez Canal to larger ships in 1981, conventional carriers began using it on a regular basis. But as aircraft carrier crises responses continued in the eastern Mediterranean and Middle East, nuclear ships were constantly disadvantaged due to Egypt's general ban on nuclear ship transits of the Canal. USS America (CV-66) became the first aircraft carrier to use the Suez Canal after reopening, making a southern transit on 6 May 1981. This was soon followed by the USS Independence (CV-62) which transited north to the Mediterranean on 15 May. Likewise, in response to the assassination of President Sadat, the USS America and the USS Preble (DDG-46) entered the Mediterranean from the Indian Ocean via the Suez Canal on 21 October.[169]

The Joint Chiefs of Staff (JCS) quickly realized the value of sending conventional carriers through the Canal. In response to events in Israel in late-1982, the JCS directed the USS Forrestal (CV-59) to be positioned in the Mediterranean within five days. The USS Forrestal moved to the Mediterranean from the Arabian Sea together with its non-nuclear escorts on 13 October.[170] Again, when an aircraft carrier was ordered into the Northern Arabian Sea in January 1983, the USS Nimitz had to turn over with the USS America (CV-66) off Lebanon so the conventional carrier could use the Suez Canal.[171] Yet when the nuclear carrier USS Carl Vinson (CVN-70) was ordered from the Mediterranean to the Indian Ocean later that year, its nuclear power plant prevented it from using the Suez Canal, and it was forced to sail all the way around Africa.[172]

As aircraft carrier crises responses continued in the eastern Mediterranean and Middle East, nuclear ships were constantly disadvantaged due to Egypt's general ban on nuclear ship transits of the Canal.

Since the first carrier transits, nuclear propulsion has continued to hamper the Navy's maneuverability between the Mediterranean and Indian Ocean. Although Egypt in late-1984 permitted the nuclear cruiser USS Arkansas (CGN-41) to transit the Suez Canal -- the first nuclear ship ever to do so -- the transit was so controversial that the ship had to sail at night and in secret. "They've done something nice and we don't want to spill it," one U.S. official said.[173] The Navy hoped these were signs Egypt would ease its stand on nuclear power.

But the explosion at the Chernobyl reactor in the Ukraine in April 1986 prompted Egypt to

review its transit policy. In the summer of 1986, the Egyptian government formally turned down a U.S. request for the nuclear-powered aircraft carrier USS Enterprise (CVN-65) to sail through the Suez Canal. Heading home from the Indian Ocean, U.S. officials described how the USS Enterprise instead had to sail the much longer route around the southern tip of Africa. At a Washington press conference, Defense Secretary Caspar Weinberger refused to discuss Egypt's motivations for barring the nuclear carrier. Pentagon and State Department appeals that certain nuclear ships had been allowed to make the transit had little effect on the Egyptian government.[174]

"We have been dealing with this potential problem for 30 years," director of Naval Nuclear Propulsion Admiral McKee acknowledged during congressional hearings in February 1987 when discussing the problem of nuclear transits and port visits:

> The *Enterprise* and *Arkansas* have gone through [the Suez Canal] but we have had a running argument with the Egyptians for eight years, starting before I came to Naval Reactors, and it really gets down to the question of accepting our assurances that we will take the same precautions overseas that we do in our own country. Dealing with foreign nuclear sensitivities is getting harder and harder. Chernobyl restarted the clock on the argument with the Egyptians.

Elaborating on why Egypt bans nuclear transits, Admiral McKee said: "Part of it is money, pure and simple. They say, we will let you come through if you will pay a premium for nuclear ships and give us money to build hospitals, so in case you have an accident, we can take care of the casualties. The bill gets very, very large."[175]

Although the Egyptian ban on nuclear transits of the Suez Canal has remained in effect, nuclear-powered ships were allowed to transit during the Gulf War in 1990-1991. This, however, was only after Secretary of Defense Dick Cheney personally sought permission to send the USS Dwight D. Eisenhower (CVN-69) through the Canal.[176] The nuclear cruisers USS Mississippi (CGN-40) and USS Virginia (CGN-38) were also allowed to transit,[177] as was the nuclear carrier USS Theodore Roosevelt (CVN-71), though nuclear submarines were barred. Despite these experiences, however, nuclear ship transits will always be hostage to the political circumstances of the day. So when the USS Theodore Roosevelt once more was allowed to use the Canal in July 1993, permission was only granted when the U.S. Navy agreed to pay $1.2 million in transit fees and Egyptian authorities provided tight security on both sides of the Canal as the nuclear ship passed.[178]

Part III:

Wartime Use

A: The Nuclear Carrier Enterprise in the Vietnam War

Initial Deployment

From the beginning of the Vietnam War, naval nuclear power was unavailable for combat. In the spring of 1964, four conventional carriers -- the USS Ticonderoga (CV-14), USS Bon Homme Richard (CV-31), USS Constellation (CV-64), and USS Kitty Hawk (CV-63) -- deployed to the Western Pacific. The USS Kitty Hawk was assigned the first "Yankee Team" navy missions. And when North Vietnamese gunboats attacked the USS Maddox (DD-731) on 2 August, it was aircraft from the USS Ticonderoga that responded.[179]

Even four months after the first carriers were dispatched, when Congress passed the so-called Gulf of Tonkin Resolution on 10 August authorizing the President to "take all necessary measures to repel any armed attack against the forces of the United States and to prevent further aggression," the Navy responded by dispatching the conventional carriers USS Kearsarge (CV-33) and USS Ranger (CV-61).[180]

As for the Navy's nuclear ships, they were busy conducting public relations. On 31 July 1964, the nuclear carrier USS Enterprise and the cruisers USS Long Beach (CGN-9) and USS Bainbridge (CGN-25) were ordered from the Mediterranean Sea on a cruise around the world to demonstrate the operational independence of nuclear-powered ships on the world oceans. The new supercarrier "nuked" around Africa and sped across the Indian and Pacific Oceans,[181] while its conventional sister ships were busy in the Gulf of Tonkin.

When the air war later commenced against targets in North Vietnam, again the conventional aircraft carriers USS Ticonderoga and USS Constellation were the first to launch strikes.[182] Likewise, the Navy's participation in Operation Rolling Thunder, the first large-scale bombing campaign against North Vietnam, began on 26 March 1965 with air strikes launched from the USS Hancock (CV-19) and USS Coral Sea (CV-43).[183]

The tempo of operations caused the Navy to shift carriers from the Atlantic Fleet to the Pacific in Southeast Asia (Task Force 77). The first Atlantic carrier to do so was the USS Independence, which departed Norfolk on 10 May 1965 and arrived at Subic Bay on 17 June after steaming around Africa, bringing the number of aircraft carriers assigned to Task Force 77 to five for the first time.[184]

From the beginning of the Vietnam War, naval nuclear power was unavailable for combat.

The Navy's nuclear carrier, the USS Enterprise, also homeported at Norfolk at the time, had returned from the "Sea Orbit" demonstration cruise seven months earlier. But the USS Enterprise was unable to join the USS Independence because it had to go into drydock between November 1964-July 1965 to have new nuclear fuel installed in its eight nuclear reactors. (The new cores lasted until 1970, when the carrier was again refueled).[185] The USS Enterprise was not ready for its first Vietnam deployment until late October 1965, more than a year after the first carrier operations took place.[186]

The USS Enterprise left Norfolk on 26 October 1965, spent a total of 131 days on-station between December 1965-June 1966, and then proceeded to Alameda, California, its new West Coast homeport. From there, the USS Enterprise made five additional Vietnam War cruises and spent a total of 669 days on-station until Congress ordered the cessation of all combat operations in Southeast Asia on 15 August 1973.[187]

The Navy's promotional statistics in relation to additional aircraft space, increased speed, time on-station, and war performance were neither always correct nor complete, and failed to substantiate these exaggerated claims.

The deployment of the USS Enterprise in the Vietnam War, the first time nuclear propulsion was used in wartime, was a high profile affair, and the subject of much interest. During a Senate debate on 16 August 1966, for example, an elated Senator George Aiken told his colleagues, "I happened to be in Saigon on the 2d [sic] of December, which was the day that the *Enterprise* went into action in that area. Everybody was talking about the *Enterprise* running circles around the conventional powered Navy ships that we had there."[188]

Such rhetoric helped convince Congress to support building more nuclear carriers. There were no independent assessments of nuclear versus conventional performance, however. The nuclear carriers' record was a product of publicity and hearsay, driven by budgetary and technological ambitions. Our study shows the Navy's promotional statistics in relation to additional aircraft space, increased speed, time on-station, and war performance were neither always correct nor complete, and failed to substantiate these exaggerated claims.

Additional Aircraft Space

Rear Admiral Henry L. Miller, who commanded the USS Enterprise when it first went into combat, told Congress in 1966 that his ship carried one more squadron than any of the big conventional carriers due to the additional deck space afforded by the elimination of smokestacks, air intakes, and other items to support conventional boilers.[189]

The claim is fallacious. On its six war deployments, the USS Enterprise carried nine squadrons on four occasions and ten on two.[190] But most conventional carriers also carried nine squadrons, and six conventional carriers even made deployments with 10 squadrons. In fact, the USS Ranger made three 10-squadron deployments -- more than any other carrier (including the USS Enterprise) in the war. Moreover, the USS Kitty Hawk, which made six war deployments -- five with nine squadrons and one with 10, even carried 11 squadrons during a November 1973-July 1974 deployment -- more than any other carrier. For comparison, during an additional deployment from September 1974-May 1975, the USS Enterprise carried only nine squadrons.[191] The Enterprise also did not take on more squadrons or detachments than conventional carriers during the war (see Table 5).[192]

Increased Speed

In addition to aircraft capacity, the Navy provided other examples of the unique characteristics of nuclear-powered warships, including their increased speed of deployment. For example, Admiral Miller described in a paper to the Joint Committee on Atomic Energy in 1966 how the USS Enterprise deployed from Norfolk "without any prepositioned oilers or replenishment vessels, whereas conventional warships would have required refueling several times en route," thus taking longer.[193]

The claim is again false. The USS Enterprise did not make its deployments faster than conventionally powered aircraft carriers deploying from the East Coast. Between leaving Norfolk on 26 October 1965 and arriving on-station off Vietnam on 2 December, the USS Enterprise was underway for 38 days. Turnover to 7th Fleet control ("in-chop") was made after 27 days. For comparison, the USS Independence (CV-62) in-chopped after only 26 days on its first war deployment, while the USS America (CV-66) in-chopped after 27 days of steaming on its third war deployment.[194] When the USS Saratoga deployed from the East Coast on 11 April 1972, it made its deployment in only 37 days, or one day less than the USS Enterprise, in-chopping after 28 days and taking only nine days to get on-station for operations.[195] The USS Saratoga's deployment was the fastest East Coast deployment done during the Vietnam war.

Nuclear propulsion did not free up the USS Enterprise from replenishment. Although capable of storing more jet fuel than conventional carriers, "UNREPS were a daily occurrence," the commander later described in his annual cruise report. "The numerous underway replenishments caused a wear and component failure rate of winches far in excess of previous experienced." As many as 152 replenishments were conducted.[196]

At the time of the USS Enterprise's first deployment, the Navy decided to transfer all of its nuclear-powered surface ships to the Pacific Fleet. The USS Enterprise and the cruiser USS Bainbridge (CGN-25) both changed homeports in 1965, while the USS Long Beach (CGN-9) and USS Truxtun (CGN-35) followed in 1966.[197] The decision to transfer the nuclear surface fleet to the Pacific was based on a study that had been underway for sometime on the operating experience gained with the nuclear-powered surface ships. "It was deemed," said the Navy, "that the [nuclear] task force, with its long endurance, self-sufficiency, and versatility could be best utilized in the vast reaches of the Pacific."[198] Secretary of the Navy Paul Nitze told a Navy League conference on 27 October 1967 that the Navy could "deploy a nuclear-powered ship from the West Coast to the South China Sea in 9 days while a normal transit for conventionally powered ships is close to 15 days."[199] However, in the real world, deployments did not happen that way. Instead, the average deployment time from homeport to in-chop with Task Force 77 off Vietnam for the USS Enterprise was 25 days.[200]

Even once moved to the Pacific, the USS Enterprise did not deploy significantly faster than many conventional carriers. The fastest cruise from Alameda to on-line off Vietnam took 21 days, from 12 September-3 October 1972. For comparison, the USS Midway (CV-41) made the same distance in only 20 days, between 10-30 April 1972. The fastest cruise between out-chop and Alameda was accomplished by the USS Ticonderoga (CV-14) in December 1964, making the distance in only six days.[201]

Time on-station

Throughout the entire Vietnam War, a total of 21 aircraft carriers made 86 war cruises and spent a total of 9,178 days on-station off Vietnam. In 1966, nine attack carriers, the hybrid USS Intrepid (CVS-11), and four anti-submarine warfare (ASW) carriers spent a total of 1,253 days on-station, a 17 percent increase over 1965. In 1967, 10 attack carriers and four ASW carriers spent 1,197 days on-station. During 1970, aircraft carriers spent only 755 days on-station, and in 1971 the level of activity was even lower with only 587 days on-station.[202]

In arguing for construction of more nuclear ships in the mid-1960s, the Chief of Naval Operations told the Secretary of the Navy that "one of the primary measures of task group effectiveness" during combat operations "is the percent of time the group is able to remain on-

station to conduct strike operations."[203]

Using the measure of time on-station, the USS Kitty Hawk was the most effective task group achieving an average of 69.5 percent on-line for each deployment. The USS Kitty Hawk's best performance was 79.3 percent achieved during its last deployment between 17 February-28 November 1972. The USS Enterprise came in third after the USS Coral Sea with an average of 66.3 percent on-station. The longest on-station period accomplished in the Vietnam War was achieved by the oil-powered USS Ranger in January-March 1965 (59 consecutive days). For comparison, the USS Enterprise's longest on-station period was between 2 December 1965-15 January 1966 (45 days) (see Table 6).[204]

The longest on-station period accomplished in the Vietnam War was achieved by the oil-powered USS Ranger.

Aircraft carriers operating with Task Force 77 on Yankee Station were normally maintained for up to five weeks at a time. As mentioned above, the Pacific Fleet had too few carriers, and in order to offset the shortage and keep as many carriers as possible off Vietnam, several measures were taken. One of these involved extending on-station periods beyond the normal three weeks.[205]

Another measure to overcome carrier shortages involved extending the length of deployments beyond the normal six months. This record was set by the USS Coral Sea spending 331 days away from home from 7 December 1964-1 November 1965; again, the longest deployment done by the USS Enterprise was only 274 days, from 12 September 1972-12 June 1973.[206]

Finally, turnaround time between deployments was reduced to increase the availability of carriers. The USS Hancock, for example, left its homeport on 10 November 1965, only 164 days after returning from its first war deployment. The Hancock's turnaround record was further shortened several times, with USS Kitty Hawk setting the Vietnam War record of only 145 days in homeport in 1966. For comparison, the USS Enterprise's shortest turnaround was 150 days between returning from its first war deployment on 21 June 1966 and deploying again on 19 November. The USS Enterprise's longest turnaround was 343 days, forced upon the carrier between 2 July 1969 and 11 June 1971 by a nuclear refueling overhaul.[207] No conventional carrier experienced a similar turnaround balloon.

War Performance

Overall in the Vietnam period, the USS Enterprise's days on-station ranked only seventh after much older carriers like the USS Hancock and USS Oriskany, which spent 842 and 782 days on-station, respectively. The record number of days on-station was set by the World War II carrier USS Coral Sea, which achieved 876 days on-station -- or more than 30 percent longer than the 14-year younger USS Enterprise. Likewise, the USS Enterprise performed six war cruises, only sixth best after older carriers like the USS Hancock and USS Oriskany, which accomplished eight and seven cruises, respectively.[208] (see Table 7).

Table 8 compares the USS Enterprise's performance in Vietnam with six conventional carriers in terms of days deployed, days on-station, days off the line, and the number of off-line periods. The average for each of these categories compared with the number of war cruises conducted by the individual carrier is also calculated. According to this data, the USS Enterprise neither deployed the most, nor stayed longest on-station, nor achieved more on-station

periods than the conventional carriers.

On average, the USS Coral Sea conducted the longest war cruises typically lasting 256 days compared with the USS Enterprise's 227 days. In fact, all the conventional carriers examined had longer average deployments than the nuclear carrier. The USS Kitty Hawk had the longest average on-station periods lasting 134 days of each deployment, compared with the USS Enterprise's 111 days on-station. Moreover, the nuclear carrier on average achieved fewer on-station periods than any of the conventional carriers during each deployment.

During the USS Coral Sea's record 331-day deployment between 7 December 1964 and 1 November 1965, the ship steamed 105,000 nautical miles, and the air wing (CVW-15) flew over 10,800 combat sorties, participating in 160 major strikes, dropping over 6,000 tons of ordnance, and recording over 16,500 launches. During one shorter deployment of 132 days between July 1967 and April 1968 (199 days shorter), the USS Coral Sea launched 11,328 combat and combat support sorties, nearly 10 percent more than during the record length cruise in 1964-1965.[209]

When the USS Enterprise went on-station on 2 December 1965 as the first nuclear-powered ship ever to engage in combat, a total of 137 sorties were flown on its first day. On the following day the USS Enterprise set a record of 165 sorties.[210] But as experience was gained in the war, such records were broken numerous times. On 10 March 1971, the USS Ranger and USS Kitty Hawk set a record 233 strike sorties for one day on Yankee Station and went on during the ensuing six-day period to break all strike effectiveness records of the previous three years.[211]

Nuclear power was not the decisive factor in air wing performance; ship size was. "As the largest all jet [sic] Air Wing in the Navy, operating from the largest carrier afloat," the USS Enterprise's cruise report later observed, "the ENTERPRISE/CVW-9 team quite naturally flew a large number of sorties."[212] Overall, the USS Enterprise did not perform better than conventional carriers in the Vietnam War, yet the selected record of "achievements" was directly used as proof to justify procurement of new nuclear carriers.

B: Nuclear Carriers in the Gulf War

The lesser achievements of nuclear-powered carriers in the Vietnam War can be partially attributed to the fact that only one ship of the type was in existence. In the Gulf War of 1990-1991, however, with six nuclear carriers in the fleet, the invisibility of nuclear propulsion is indeed a mystery. Of the six aircraft carriers involved in combat, only one -- the USS Theodore Roosevelt (CVN-71) -- was nuclear-powered.

Nuclear-powered aircraft carriers were largely unavailable for deployment in the Gulf War. Instead it was conventionally powered carriers that were sent to do battle with Iraq.

Nuclear-powered aircraft carriers were largely unavailable for deployment in the Gulf War. Just like at the beginning of the Vietnam War, the USS Enterprise (CVN-65) was up for a nuclear refueling and could not sail. The USS Nimitz (CVN-68) had returned from a deployment in June 1990 and was not ready to deploy, and the USS Carl Vinson (CVN-70) was preparing to enter Puget Sound Naval shipyard in October 1990 for a year-long overhaul. The newest carrier at the time, USS Abraham Lincoln (CVN-72), had been commissioned in November 1989 but was shifting homeport from Norfolk, Virginia, to Alameda, California, and would not be ready

for deployment until mid-1991.[213]

Instead it was conventionally powered carriers that were sent to do battle with Iraq. Although the nuclear-powered carrier USS Dwight D. Eisenhower (CVN-69) was initially dispatched from its routine deployment with the Sixth Fleet in the Mediterranean Sea to respond to the Iraqi invasion of Kuwait, it was at the end of its cruise and was routinely "rotated" back to the United States before Operation Desert Storm began. Indeed, there is no indication that the Navy made use of the "unique capabilities" of nuclear power for the sake of reducing replenishment, making high-speed transits, achieving higher operational rates, or longer on-station periods. Conventionally powered warships fully matched -- and often exceeded -- the performance of their nuclear counterparts.

Composition of various carrier battle groups deployed in the Gulf War also give no indication that nuclear propulsion was used to "speed up" deployment, either in assigning individual carriers fewer oil-burning escort ships, in lessening the need for slower supply ships in the battle group, or by letting nuclear carriers sail the longest distances. In terms of propulsion, the composition of battle groups was completely random, and the assignment of only three nuclear cruisers in the war shows that the Navy did not consider nuclear escorts an important feature of even the USS Roosevelt battle group.

Conventional carriers were the workhorses of the Gulf War and its aftermath. Between August 1990 and June 1993, non-nuclear carriers were on-station almost 70 percent of the time the U.S. Navy had aircraft carriers in the Persian Gulf region, achieving a total of 38 months. Conventional carriers made double the number of deployments of nuclear carriers.[214] As in the Vietnam War, and in the period 1976-1988, nuclear carriers did not stay on-station longer when deployed in the Gulf: the average length of deployment was 3.2 months for conventional carriers and only 2.8 months for USS Roosevelt (see Table 9).

Response to the Iraqi Invasion

When Iraq invaded Kuwait on 2 August 1990, the U.S. Navy coincidentally had two aircraft carriers nearby: the conventionally powered USS Independence (CV-62) in the Indian Ocean and the USS Eisenhower in the Mediterranean Sea. Almost immediately, the USS Independence was dispatched to the northern Arabian Sea and the USS Eisenhower was ordered into the Red Sea.[215] Since Egypt did not allow nuclear warships to transit the Suez Canal, the movement of the USS Eisenhower from the Mediterranean through the Canal required a personal request by Secretary of Defense Dick Cheney to Egyptian President Hosni Mubarak.[216]

The first aircraft carrier to deploy from the United States was the conventionally powered USS Saratoga (CV-60), which departed Mayport, Florida on 7 August. Ironically, the USS Saratoga would replace the nuclear-powered USS Eisenhower, which transited the Strait of Gibraltar on 3 September back to its homeport in Norfolk, Virginia.[217] The USS Saratoga, 34 years old in 1990, would then have sufficient sustainability and endurance to remain in the region throughout the war, and ended up spending the most time of any carrier on-station, seven-and-a-half months in total (see Table 9).[218]

The deployment of the USS Saratoga and its escorts overseas had been scheduled prior to Iraq's invasion, but the first carrier to be mobilized in crisis response was another conventional ship, the USS John F. Kennedy (CV-67), which departed Norfolk on 15 August with only four days warning. In these four days, the group accomplished the normally 30-day process of locating and replenishing the supplies necessary for a six-month deployment.[219]

The conventionally powered USS Ranger (CV-61) was the second carrier to deploy. Even after months of preparation, and the now looming offensive, it was announced on 7 December that the conventional ship would depart the following day for the Gulf region as part of President Bush's announcement of a doubling of U.S. forces on 8 November.[220]

The first -- and only -- nuclear-powered aircraft carrier to deploy from the United States was the USS Theodore Roosevelt. Its deployment was announced on 27 November, and one month later, on 28 December, it departed Norfolk together with the conventional USS America (CV-66) carrier battle group.[221]

The USS Roosevelt did not transit the Atlantic faster than the conventional carriers. The USS Kennedy completed one week of training off the U.S. coast after leaving port on 15 August and began its Atlantic transit on 22 August, arriving in the Mediterranean after only nine days on 30 August. Following various turnovers, briefings, port visits, and exercises, the carrier arrived on-station in the northern Red Sea on 15 September.[222] By comparison, the USS Roosevelt departed Norfolk on 28 December[223] and began an immediate transit.[224] It entered the Mediterranean at noon on 8 January after 12 days transit,[225] and a week later, on 14 January, transited the Suez Canal and arrived on-station in the Red Sea. The USS America accompanied the nuclear-powered carrier the entire time.[226]

The Navy had another nuclear-powered aircraft carrier available at the time of the Gulf War, but chose not to deploy it. The USS Nimitz (CVN-68) was assigned to the Third Fleet in the eastern Pacific from 1 January-16 March 1991, and while the Navy said it could have sent the ship, the USS Nimitz was not fully worked up. "And sending our carriers that haven't been fully worked up only means sending inexperienced aircrews and ships." the Navy explained to *Navy Times*.[227]

Carrier Placement

Carrier operations during the Gulf War were split between the Red Sea, Gulf of Oman/Northern Arabian Sea, and the Persian Gulf. As the war got underway, the USS Midway (CV-41), USS Ranger (CV-61), and USS Roosevelt initially formed the Persian Gulf Battle Force (PGBF) with overall command embarked on the USS Midway. In the Red Sea, the USS Saratoga, USS America, and USS Kennedy formed the Red Sea Battle Force (RSBF) with overall command on the USS Kennedy.[228]

When coalition air strikes commenced on the night of 16 January, two aircraft carriers, the USS Ranger and USS Midway, were operating in the Persian Gulf.[229] Prior to Operation Desert Shield, aircraft carriers had never operated regularly inside the Gulf. The USS Independence and USS Midway had made brief entries into the Gulf during the mobilization phase to test carrier operations in the confined waters. The decision was made to send the USS Roosevelt into the Gulf as well, and during the war, the USS America joined the other three carriers to increase the number to four.

The USS Roosevelt, which completed its transit of the Suez Canal and entered the northern Red Sea on 14 January, was ordered to continue to the Persian Gulf immediately -- not because of speed afforded by nuclear power or independence from propulsion fuel -- but because moving the USS Saratoga or the USS Kennedy out of the Red Sea would have wasted four months of integrated strike training done by the two carriers.[230] The result of decisions made on the basis of real world military need rather than nuclear public relations was that the USS Roosevelt arrived in the Gulf two days after bombing began, on the evening of 19 January,[231] and conducted its first strike on the day of 20 January.[232] Thus the USS Roosevelt

neither accrued advantage over the USS America in its transit from the United States because of nuclear power, nor was its nuclear propulsion plant of any advantage in terms of mobilizing the carrier quicker for deployment earlier.[233]

The standard operational procedure for the three carriers in the Red Sea was a six-day rotation: Two carriers would launch strike aircraft while the third would rest in an area known as "gasoline alley" to replenish munitions, stores, and fuel. Each carrier was on-station for four days conducting either a night or daytime cycle, then "off duty" for two days. The off-duty carrier was still tasked with standing various defensive air alerts.[234]

As the war proceeded, aircraft carriers operating in the Persian Gulf began moving north closer to their targets. This began on 4 February, when the distance to the Kuwaiti shore was decreased from 280 nautical miles to 250. After 15 February, the carriers moved even further north to a distance of only 180 nautical miles from Kuwait City.[235]

On 7 February, the USS America was dispatched from the RSBF to augment the three other carriers in the Gulf.[236] Though conventionally powered, the Pentagon later described the USS America's move as taking advantage of the generic mobility of an aircraft carrier:

> Mobility is one of the carrier battle group's greater advantages. The *America* CVBG [carrier battle group], initially used during the Strategic Air Campaign against targets in the western Iraq, moved from the Red Sea to the Persian Gulf in early February. This re-deployment reinforced the Persian Gulf battle force's participation in tactical operations against Iraqi forces in Kuwait.[237]

There is some indication that the nuclear-powered surface ships were positioned in less forward positions to their conventional counterparts. The operation of the nuclear-powered USS Roosevelt in the Persian Gulf appears to have been partially constrained as a measure to protect the nuclear propulsion plant from mines and Iraqi attack. The USS Roosevelt's operational box was further south than the other carriers, and nuclear cruisers could easily have hit sea mines, because other large warships were severely crippled by them.[238]

Air Operations

Aircraft onboard the six carriers flew 18,117 fixed-wing sorties during the Gulf War, of which 95 percent were "combat" related. Of the fixed-wing sorties flown, 16,899 were combat or direct combat-support missions, and the remaining 1,218 sorties were logistics flights, functional check flights for newly arrived or repaired aircraft, and other indirect support activities.[239] Far less than half (7,646 sorties), however, were actual *strike* sorties (see Table 10).

The size of carrier air wings varied considerably, depending upon the mission of the carrier and the size of the aircraft carrier. Compositions ranged from a low 58 fixed-wing aircraft on the USS Midway to a high of 76 on the USS Kennedy.[240] The USS Roosevelt came in third with 72 aircraft -- the same as the USS Saratoga (see Table 17).

Composition of air wings was also varied. The most strike-prone air wing was the USS Midway with 48 strike aircraft, compared with only 18 on the USS Ranger. The USS Roosevelt came in fourth with 36 strike aircraft, the same as the USS Saratoga. All carriers had 20 F-14A Tomcats for defensive support, except the USS Midway which tasked a portion of its multi-mission F/A-18 Hornets for the defensive role (as did other aircraft carriers earlier in the war). Taking the allocation of F/A-18s for defensive missions onboard the USS Midway

into consideration, the wing on the USS Kennedy was the most offensively oriented with 40 strike aircraft.[241]

Sorties actually flown by carriers were much fewer -- about 50 percent less -- than were originally estimated in war plans. Prewar assumptions were that six carriers would produce 252 accumulated flying days in 42 days of combat. In reality, the carriers only operated six days at total capacity, and only 201 flying days were achieved.[242] Overall, carrier based aircraft achieved an average of 1.1 sorties per aircraft per day, including all carriers and all off-line periods.[243] During the first day of the war, the Navy launched 228 combat sorties from four aircraft carriers.[244] On the last full day of the war, some 600 combat sorties were flown from six carriers.[245]

Red Sea sorties during the Gulf War averaged 3.7 hours in length, and Persian Gulf sorties 2.5 hours. Many flights lasted as long as five hours, and virtually every flight required airborne refueling at both the beginning and the end of the mission.[246]

Though Red Sea aircraft had longer distances to their targets, flight cycles were more or less the same compared with carriers operations in the Persian Gulf. Each carrier would launch aircraft for 14-15 hours, and then go off-cycle to conduct maintenance and receive supplies. Duty cycles were either morning (AM) or evening (PM) and were specified as 00:00-15:00 or 12:00-03:00 to accommodate returning strike recovery times. Each carrier flew two large strikes with times-on-target generally nine hours apart to allow for deck repair and weapons loading. Air defense (CAP) cycle times were AM or PM for 12-hour periods.[247]

Flight operations from Red Sea carriers reportedly were "tuned" by the availability of land-based tankers sorties, and, according to the Center for Naval Analysis, the RSBF "could surely have mustered more strikes and strike sorties in the first half of the war had there been more land-based tanking available." Even after the USS America departed the Red Sea on 7 February, the USS Kennedy and USS Saratoga produced approximately as many sorties per day as with three carriers. None of the RSBF carriers reportedly experienced flight deck problems that would have limited their sortie-generating capability.[248]

After the USS Roosevelt got on-station in the Persian Gulf, the three carriers rotated, with each conducting air operations for approximately 15 hours during a 24-hour interval. During the remaining nine hours, a carrier would suspend its air operations. On-duty for the USS Ranger and USS Roosevelt occurred during opposite portions of the 24-hour interval -- with three hours of simultaneous operations during turnovers. USS Midway's on-duty period was roughly centered on one of the USS Ranger's and USS Roosevelt's turnovers.[249] Even after the USS America moved into the Persian Gulf, increasing the number of available carriers to four, the Navy largely continued operating three carriers on-station at the same time, with only two days of four-carrier operations occurring between 4-23 February.[250]

Throughout the war, the Red Sea carriers would typically have about five stand-down periods, compared to four for carriers operating in the Persian Gulf. Red Sea carriers normally would stand down every five days or so, until the USS America departed on 7 February, when the two remaining carriers changed the intervals to a stand-down every seven or eight days. While the USS Saratoga had one stand-down during the last week of the war, the USS Kennedy had no complete stand-down period from 17 February until the ceasefire ten days later.

Persian Gulf carriers normally stood down every 10 or 11 days, with the USS Ranger having the longest consecutive period of air

operations, lasting from 13 February through the end of the war. While the USS America stood down every five days while operating with the RSBF, the carrier did not stand down at all from when it entered the Gulf on 14 February until the end of the war.

In three categories of flight operations, the USS Roosevelt clearly demonstrated a higher performance by launching more *overall* sorties, more strike *missions*, more aerial *refueling* sorties, and dropping more bombs than conventional aircraft carriers in the war. The USS Roosevelt's air wing flew 4,149 sorties, corresponding to approximately 106 sorties each day the carrier was operating. Aircraft flew 160 strike missions, 670 aerial refueling sorties, and a total of 2,450 tons of ordnance were dropped on targets in Kuwait and Iraq (see Tables 10, 18, 22, and 23).

To conclude that this accomplishment was due to nuclear propulsion, however, would be in error. The upper hand was not consistent, and was achieved only because the USS Roosevelt is a bigger ship -- not because it is nuclear-powered. Curiously, even in those categories of flight operations where the nuclear carrier did better than its conventional competitors, performance fell far short of the extra capacity cited by the Navy to justify building an aircraft carrier with expensive nuclear propulsion. The Chief of Naval Operations Aircraft Carrier Handbook specifically justifies the 50 percent higher construction cost of the USS Roosevelt over a conventional carrier because of its capacity to carry 70 percent more aviation fuel, 50 percent more ordnance, and a 20 percent greater ordnance strike-up.[251] But in the war, the nuclear carrier only flew 13 percent more aerial tanker sorties, dropped 14 percent more ordnance, and accomplished three percent more strike missions. In a cost-benefit analysis, the USS Roosevelt's achievement was more than offset by its 50 percent higher construction cost, 16 percent greater tonnage, and 16 percent extra crew (see Tables 10, 18, 22, and 23).[252]

On-station and off-line periods for each carrier are shown in Tables 11-16. During the Gulf War, there is no noted difference in the stand-down cycles of the USS Roosevelt with the conventional carriers. Operating cycles were geared to warfare tempo dictated by issues such as stamina, maintenance and replenishment needs, distance to target, and availability of external support such as aerial refueling, all standard influences over wartime operations that equally impact nuclear or conventional ships.

Strike Operations

Composition of air wings significantly influenced how many strike sorties each carrier was able to muster. In the initial phases of the war, over 80 percent of all F/A-18 sorties were assigned to defensive anti-air warfare. As the Iraqi threat was perceived to diminish, more and more F/A-18s were diverted to interdiction. By the end of the war, 30 percent of F/A-18 sorties were directed at defense and strike support while 70 percent delivered ordnance on targets.[253]

When nuclear carriers were being discussed in Congress in 1972, Chief of Naval Operations Admiral Elmo Zumwalt stated that Nimitz class carriers (such as the USS Roosevelt) could operate more aircraft, launch and recover twice as many aircraft, carry 2.9 times as much aviation fuel, and 2.7 times as much aviation ordnance as that of the USS Midway class.[254] Twenty years later, when the Navy put the two carrier types together in the Persian Gulf, the World War II carrier matched the strike-performance of the new supercarrier.

Although the USS Midway had only two steam catapults compared with four on the USS Roosevelt,[255] the two carriers achieved approximately the same number of strike sorties and strike missions, while the USS America and USS Ranger were somewhat lower. USS

Midway launched a total of 1,660 strike sorties (48.8 per day on-station) in 155 strike missions, compared with 1,624 for the USS Roosevelt (41.6 sorties per day) in 160 strike missions. For comparison, the RSBF carriers only achieved little over half the level of strike sorties of the PGBF because of their longer flight distance from targets (see Tables 10 and 17).

The high level of strike sorties by the USS Midway is reflected in its air wing composition. Unlike the USS Roosevelt, the USS Midway air wing was used almost exclusively for strikes, and its strike packages were generally larger than those of the nuclear carrier. For the first two days of the war, the air wings onboard the USS Midway and USS Ranger in the Persian Gulf shouldered the burden of offensive operations. During those days, the USS Midway and USS Ranger flew more than 40 strike sorties per day in addition to the many other types of sorties flown. Though this pace of sorties could only be maintained for a few consecutive days, strike packages launched from the USS Midway were consistently larger than those flown from the USS Roosevelt.[256]

On day 37 of the war (22 February), the USS Roosevelt finally leveled with the USS Midway in the number of strike sorties. But the USS Roosevelt only accomplished this because the USS Midway had to stand down and dispatch to Bahrain on 16-21 February for repairs to its flight deck. Once back on the line, the USS Midway continued its strike missions achieving a total of 1,660 sorties compared with the USS Roosevelt's 1,624 (see Tables 10 and 19).

As Persian Gulf carriers moved closer to targets, they achieved higher rates of strikes. However, "kill-box" strike mission rates against battlefield targets, were lower for the USS Roosevelt than for conventional carriers. The USS America had a far higher level of activity achieving 62 missions in 17 days, or 3.3 per day. The USS Roosevelt had 57 missions in 22 days achieving a rate of 2.6 missions per day -- or the lowest overall of the Persian Gulf carriers (see Table 22).[257]

Looking only at strike sorties (those attack sorties in which bombing was anticipated), prewar estimates were also higher. Prewar planning anticipated an average of 37 strike sorties per carrier per day. The *Center for Naval Analysis* concludes an average of 30 per day were achieved in actual operations,[258] while our estimate is that an average of 36 strike sorties were actually achieved. Of these daily strikes, USS Midway achieved the highest with 48.8 strike sorties per combat day, compared with 41.6 for the USS Roosevelt. Overall, a total of 7,646 strike sorties were achieved, corresponding to less than 43 percent of the sorties launched from all aircraft carriers in the war (see Table 10).

Defensive sorties (Defensive Counter Air and F-14 Offensive Counter Air) accounted for 4,865 sorties (26.9 percent) of all carrier sorties. Initially, the USS Roosevelt provided air and fleet defense for the other carriers in the Persian Gulf,[259] and defensive missions were given a far larger share of the ship's overall effort than was called for in higher level tasking. As a result, interdiction (bombing) missions were not met. Defensive sorties accounted for over 25 percent (1,240 sorties), or 31.8 per day.[260] As the war progressed, however, and the Navy determined a lessened threat to their forces by Iraq, the USS Roosevelt dedicated an increasing proportion of its sorties to strike warfare. Overall, however, the USS Roosevelt expended about 54 percent of its sorties on fleet defenses.[261] USS Ranger accomplished the second highest number of defensive sorties, 1,004 in total, corresponding to almost 26 sorties per day (see Table 10).

The mix of sorties -- offensive and defensive, and those directed against the Iraqi "Navy" (called surface strike) -- changed

significantly with time. In January, for example, surface strike sorties were often 20 percent of all sorties flown from the aircraft carriers in the Persian Gulf. As the Iraqi Navy was destroyed, however, this percentage decreased to less than five percent by the ceasefire. Likewise, defensive sorties declined substantially with time.[262]

Though combat mission performance rates for aircraft carriers operating in the Gulf War were reported as exceeding 90 percent, and much higher than peacetime rates,[263] the combat mission performance rate for aircraft on the USS Roosevelt was lower than that of any of the five conventional aircraft carriers in the war -- between 81 and 83 percent. For comparison, aircraft on the 45-year-old USS Midway had a rate of 91 percent.[264]

Ship Operations

The Navy has stated that "the high investment costs for nuclear ships are in a large part caused by efforts to insure that they are reliable and dependable." Nuclear ships have a "high nuclear reliability (over 99 percent)."[265] However, any alleged advantage of nuclear power did not appear in the Gulf War in terms of ship operations. There were no differences in the readiness status of nuclear and conventional carriers during their deployment for the Gulf War.[266]

Altogether, over 20 major supply ships and tenders supported U.S. naval forces in the Gulf War,[267] representing almost 60 percent of the Navy's combat logistic force (CLF). Over 40 percent were there during the peak period from January to March 1991.[268] At the beginning of the air war, there were 22 CLF ships in the region, and 82 other consumer-related ships. Nine CLF ships were in the Red Sea, five were in the Gulf of Oman and Northern Arabian Sea, and eight were in the Persian Gulf.[269] Jeddah, Saudi Arabia, was the Combat Logistic Stores Facility for replenishment ships assigned to the Red Sea, thus giving them the ability to restock, repair, and rearm without depending on the Suez Canal as their logistics link.[270] As the USS Roosevelt moved south from the Red Sea on 15-16 January towards the Persian Gulf, and as the USS America followed suit on 14 February, logistic forces moved with them. Consequently, on 24 February, there were only five CLF and

Any alleged advantage of nuclear power did not appear in the Gulf War in terms of ship operations.

17 consumer ships left in the Red Sea, and one of each in the Gulf of Oman and Northern Red Sea, while there were 18 CLF and 71 consumer ships in the Persian Gulf.[271]

Navy operating forces carry at least 90 days endurance in most classes of supply ships,[272] and given the duration of the Gulf War, support capabilities were never seriously tested or strained. Moreover, the logistic support ships replenished carrier battle groups at sea much more frequently than they did during peacetime forward deployments.[273] There is no indication that nuclear propulsion made any difference in reducing the reliance of the USS Roosevelt group on its replenishment ships. For example, both of the carrier battle groups that deployed from the United States on 28 December, the nuclear-powered USS Roosevelt and the conventional USS America battle groups, each had an ammunition ship and an oiler as part of their escort,[274] and none of the accompanying supply ships could exceed 20 knots in sustained speed.[275]

A comparison between the USS Roosevelt and the USS Kennedy (the newest conventional carrier) replenishment during the Gulf War shows the USS Roosevelt conducted 63 replenishments in 183 days and the USS Kennedy conducted 78 replenishments in 226 days. On average, both carriers replenished

once every 2.9 days during their deployments.

Carrier groups had no difference in terms of assigned support ships, indicating no logistical advantage with a nuclear-powered carrier. Oilers were assigned to both nuclear and non-nuclear aircraft carriers.

During the war itself, however, the USS Kennedy replenished 32 times while the USS Roosevelt replenished 21. But this difference is probably a result of the USS Kennedy's aircraft having to fly much longer missions from their position in the Red Sea to targets in Iraq and Kuwait, thus requiring more fuel (see Table 23).

Nuclear propulsion also did not make a difference in terms of taking advantage of the extra aviation fuel supply available to increase sortie ranges or decrease refueling requirements. Despite a Nimitz class carrier's cited ability to carry double the amount of JP-5 fuel of conventional carriers, the USS Roosevelt was not employed in the Red Sea, where the extra fuel might have been used to facilitate the longer missions and additional fuel consumption of aircraft. Overall, the USS Kennedy and USS Saratoga air wings had sortie lengths that were 42 percent higher than Persian Gulf carriers.[276] Moreover, Red Sea Battle Force carriers transited back and forth between the Red and Mediterranean Seas during Operation Desert Shield, operations that could have made use of nuclear power to reduce propulsion fuel demands. Extra jet fuel storage capacity seemingly did not assist in striking targets in Iraq. One of the motivations behind sending carriers into the Persian Gulf was the inability or reluctance of the Air Force to schedule sufficient land-based aerial refueling in the strike plans for strikes to be conducted from carriers in the Gulf of Oman.[277]

In-flight refueling was provided by tanker aircraft from the carriers themselves as well as air force tankers. Though a nuclear-powered aircraft carrier is credited with being able to store 70-90 percent more aviation fuel than conventional carriers, the USS Roosevelt did not carry more tankers than other carriers to take advantage of the fuel supply.[278] USS Roosevelt's tankers, for example, flew only 12 percent more sorties than those of the smallest wing, the USS Ranger (see Table 22).

The Navy was allocated approximately 42 Air Force tanker support sorties daily, or 16 percent of the aerial refueling sorties. The rest had to be provided by carrier-based tankers. After 13 February, each strike sortie from the USS Roosevelt called for the inclusion of one S-3 configured tanker. As the Gulf carriers moved closer to Kuwait, the requirement for aviation fuel diminished.[279]

Ships themselves were refueled as often as necessary (about once every three days) to keep them well above 60 percent capacity. Pre-planning had aircraft carriers and principle battle group combatants refueling every five days, but in practice refueling occurred more frequently (about every two to three days), especially to take onboard JP-5 fuel for aircraft. While aircraft carriers can complement fast combat support ships within the battle group by refueling its own escorts, the availability of oilers in the Gulf War precluded carriers having to provide fuel to other battle force ships.[280] Thus an additional "advantage" of nuclear power was nullified in the real world, where the Navy found adequate supplies.

Carrier groups, in addition, had no difference in terms of assigned support ships, indicating no logistical advantage with a nuclear-powered carrier. Oilers were assigned to both nuclear and non-nuclear aircraft carriers. Supply of oil to conventional carriers, in addition, was not a problem, given the Navy's investment in CLF ships. "Overall fuel support to Navy ships was outstanding," the Center for

Naval Analysis concluded. "MSC [Military Sealift Command] and Navy tankers provided timely responsive support to meet all routine and emergent requirements."[281]

Altogether, the six aircraft carriers dropped 12,000 tons of bombs on Iraq and Kuwait during the war. Ordnance planning anticipated much higher levels of consumption, given inflation of the Iraqi threat and a more intense ground war -- consumption per carrier per day for the war was planned at 62 percent higher than what was actually experienced.[282] Thus, given that the planned ordnance requirements were based on a worst case scenario for a six-carrier battle force operating for 60 days, none of the carriers experienced any serious supply problems.[283] The USS Roosevelt air wing dropped about 20 percent of the total ordnance dropped by the Navy, some 2,450 tons.[284] This is more than was dropped by any other carrier, but only some 250 tons more than was accomplished by the USS Ranger (see Table 23).

Ammunition was provided to the carrier mainly from an ammunition-ship (AE) assigned to each battle group. The carriers rearmed nearly every one to two days, except when they were off duty. The USS Ranger in the Persian Gulf, for example, was rearmed 14 times by its assigned ammunition ship. The USS Roosevelt, also in the Persian Gulf, was first armed by the USS Nitro (AE-23) which was later relieved by the USS Kilauea (TAE-26). During the last 20 days of February (9-28), the USS Kilauea rearmed the USS Roosevelt seven times delivering over 1,600 short tons of ordnance to the carrier and relieving it of 140 tons of retrograde material.[285]

In the Red Sea, logistic support was similar to that in the Persian Gulf area, and principle CLF ships for replenishing carrier battle groups tended to be the multi-product (AOE, AOR) ships. There were some differences in the composition of forces, however, because it was easier to establish supplies in the Red Sea than in the Persian Gulf. As a consequence, the availability of pre-positioned ships with fuel and ordnance in the Red Sea was more extensive than in the Persian Gulf.[286] Still, carrier supply operations changed little with the onset of war. "The policies and practices employed in peace served equally well in combat -- the Supply Department fought the war logistically just as it had trained…," the USS Kennedy reported.[287]

In the Persian Gulf, the number of bombs carried by aircraft increased with the different phases of the war. The ordnance loadout for attacks on the battlefield typically was double to even triple the number of bombs carried by aircraft flying strategic bombing missions.[288] Though nuclear-powered aircraft carriers are credited with being able to store more ordnance and aircraft and launch more sorties, it was the USS Saratoga and not the USS Roosevelt that was first in these categories. On 30 January, during the "battle of Khafji," the USS Saratoga was able to launch its entire force of F/A-18 aircraft and deliver 100,000 pounds of MK-83 1000-lb. bombs, the largest amount of bomb tonnage carried in a single mission.[289]

Part IV:

The Penalties of Nuclear Propulsion

The question of nuclear propulsion is not merely a matter of military performance. An evaluation of the benefits of building aircraft carriers with nuclear propulsion also must take into consideration the penalties of nuclear power: radioactive waste, extra costs, and anti-nuclear sentiments.

The environmental burden -- and to some extent operational and decommissioning costs -- are unclear and unaccounted for. The always ardent dispute over who handles and stores nuclear waste is a continuous and expensive controversy. In addition, Navy and government officials are continuously called upon to respond to political quarrels abroad when nuclear-powered warships attempt to visit foreign countries and transit controlled waterways.

The Financial Burden

Few question that nuclear-powered aircraft carriers are more expensive to build, operate, maintain, and decommission that their conventional counterparts.[290] The construction lead time of a nuclear carrier exceeds that of a conventional carrier by over 40 percent. Yet construction cost is normally the only figure presented to the public or readily available in annual budgets. But a nuclear aircraft carrier necessitates additional costs for a more expensive power plant, production and fabrication of nuclear fuel, the additional crew to man and operate nuclear reactors, shore-based support facilities, overhaul and refueling, disposal of nuclear fuel, and decommissioning of the nuclear reactors.

While nuclear aircraft carriers only make up about two percent of the hulls to be constructed in the Navy's current shipbuilding plan,[291] nuclear carrier procurement and refueling consume almost 20 percent of the Navy's annual shipbuilding and conversion budget for the period FY 1995 through FY 1999 ($1.2 billion). After FY 2000, this commitment is expected to increase about 40 percent (to $2 billion annually).[292] Adding two additional ships beyond those envisioned (the 11th and the 12th Nimitz hulls) would mean a further increase, far beyond anticipated defense spending levels.

While nuclear aircraft carriers only make up about two percent of the hulls to be constructed in the Navy's current shipbuilding plan, nuclear carrier procurement and refueling consume almost 20 percent of the Navy's annual shipbuilding and conversion budget.

The nuclear power plant for a Nimitz class carrier costs over $800 million,[293] of which about one-third is for the reactor cores.[294] The industrial effort required to build a Nimitz class carrier nuclear propulsion plant is a highly specialized undertaking, requiring the setting up of "special production lines" larger and different from those producing smaller submarine reactors. The engineering effort is equivalent to that required to build the nuclear propulsion plants for about 10 Los Angeles class submarines or that required to build the nuclear propulsion plants for about four Virginia class cruisers. "The leadtime [sic] for procurement of these large nuclear propulsion plant components is more than 2 years longer than the next most limiting hardware," the Naval Nuclear Propulsion Program told Congress in 1972 as two Nimitz class carriers were under

construction. In fact, "It was known from the start that delivery of these components would control the construction scheduled for the *Nimitz* class carriers."[295] During the three fiscal years 1991-1993, the Navy plans to spend nearly a billion dollars on reactor plant support equipment,[296] and almost $600 million is budgeted for the Navy's nuclear reactors from FY 1994 through FY 1999.[297]

> **"DoD cannot afford to rely on an industrial base that is dependent on DoD for its existence."**
>
> Defense Secretary Les Aspin, 1994

Naval nuclear reactors are so highly specialized that they require specialized facilities for processing, testing, accounting, and safeguarding. The fuel used in naval nuclear reactor cores, for example, is completely different from that used in commercial reactors and the process required to manufacture the fuel is unlike that used in connection with civilian fuel manufacturing. "Except for NFS [Nuclear Fuel Services in Tennessee, the sole supplier of enriched uranium pellets]," the Navy stated in 1981, "no commercial or DOE facility can presently produce or has the facilities to produce naval nuclear fuel."[298] In the post-Cold War era, such a highly specialized naval nuclear industry is at odds with U.S. defense policy. The "DoD cannot afford to rely on an industrial base that is dependent on DoD for its existence," Secretary of Defense Les Aspin concluded in his January 1994 report to the President and the Congress.[299]

Radioactive materials also burden maintenance and overhaul, complicating training and certification, repair work, and complex overhaul. In fact, overhauls and nuclear fuel represent some of the most significant additional support costs of nuclear ships compared with non-nuclear vessels. They are *fixed costs* that are difficult to reduce once the ship has been put in operation. Because of the dangers of radiation exposure, it is more expensive to overhaul a nuclear-powered warship than a non-nuclear one.

Each refueling overhaul of a nuclear-powered aircraft carrier is a two-and-a-half year financial undertaking of more than $2 billion, far more than the cost of maintaining and supporting a conventional ship over the same time period.[300] The refueling overhaul of the first twin-reactor Nimitz class carrier, scheduled to start in 1998, is expected to cost $2.3 billion,[301] more than the anticipated cost of the refueling overhaul of the old eight-reactor USS Enterprise (CVN-65).[302] The combined cost of refueling overhauls for the 10 existing and planned Nimitz class carriers adds more than $25 billion to their original procurement, making them the most expensive weapons in the U.S. arsenal.

It costs about $80 million each year to modernize and perform major maintenance on a Nimitz class carrier. This is about $25 million, or about 48 percent, more than it costs to support a conventional aircraft carrier. This does not include indirect costs, such as the physical infrastructure or bases, waste treatment and storage operations, and personnel assigned to the nuclear support facilities.[303] "Work on nuclear propulsion plants," the Navy stated before Congress in 1982, "requires a much larger investment in facilities, security control, technical expertise, training, and quality control than that required for fossil-fueled ships."[304] The result of all this is that nuclear aircraft carriers spend more of their service life in overhaul and maintenance than conventional aircraft carriers, and are less available or ready for deployment.[305]

Nuclear propulsion demands safety, and nuclear safety comes at a higher cost. Compared to the engine room on a conventional aircraft carrier, the nuclear-powered plant on a

nuclear carrier requires larger engineering billets and a bigger department. Moreover, nuclear personnel generally have higher educations and pay grades. Likewise, regulatory demands have continued to drive up operating costs, causing substantial investment in safeguards and accountability. The safeguards program required for naval fuel fabrication facilities is now comparable to that required for nuclear weapons facilities.[306] Altogether, the result is an industry which is unattractive from a civilian standpoint.

In the past, construction of nuclear-powered carriers has taken an average of 7.2 years between funding and commissioning, compared with only 4.2 years for conventional carriers.

Furthermore, the very long production lead-time of nuclear reactor components themselves normally add two years to construction of nuclear-powered carriers compared with conventional ships. In the past, construction of nuclear-powered carriers has taken an average of 7.2 years between funding and commissioning, compared with only 4.2 years for conventional carriers.[307]

Finally, at the end of their active life, nuclear-powered aircraft carriers -- like all warships -- will have to be scrapped. But nuclear propulsion complicates decommissioning, driving costs up. Decommissioning the first nuclear carrier, USS Enterprise, around 2014 has been estimated at about $600 million, or ten times the price of decommissioning a non-nuclear carrier.[308] Added to this comes the yet unknown cost of storing the spent nuclear fuel for hundreds of years.

In addition to building and operating the nuclear-powered ships, research and development of new reactors and operation of land-based prototypes adds further to the cost of keeping nuclear carriers in the fleet. Since 1979, Naval Nuclear Propulsion Program requests have totaled over $9 billion,[309] equivalent to the procurement cost of more than two aircraft carriers. Combined, in FY 1995 the Department of Energy and the Navy plan to spend nearly $1.5 billion on naval propulsion work.[310]

In short, less expensive and logistically more simple conventionally powered ships are being replaced on a less than one-for-one basis[311] with more expensive and more complex nuclear-powered carriers.

The Burden of Radioactive Waste

Unlike conventional aircraft carriers, nuclear-powered carriers produce highly radioactive spent nuclear fuel requiring containment from the environment for centuries. The first nuclear-powered aircraft carrier, the USS Enterprise, has expended 32 reactor cores since it was commissioned in 1961. The carrier is currently having another eight cores installed at a refueling overhaul at Newport News Shipbuilding in Virginia, and the new fuel will last till the USS Enterprise is decommissioned around 2014. Newer twin-reactor carriers of the Nimitz class design each burn up at least four cores during their lifetime.

Radioactive waste requires special facilities and personnel certified to handle the hazardous materials, complicating maintenance and operation and driving costs up. Handling and storing radioactive materials is notoriously expensive, and since the 1950s at least $10-20 billion has been spent on the Idaho National Engineering Laboratory (INEL) facility at Idaho where spent naval nuclear fuel is examined and stored.[312] Temporarily storing spent nuclear fuel from the USS Enterprise in a special barge at Newport News awaiting transit to Idaho costs

$400,000 a month, and additional special security costs associated with storing spent nuclear fuel at naval shipyards add $1.5 million per year.[313] Costs incurred by the Navy for transport, receipt, storage, and processing of spent naval nuclear cores in the period 1981-1992 was over $330 million dollars.[314] A new cooling pond constructed at INEL to temporarily stack spent naval nuclear fuel cores cost $132 million in 1981 dollars.[315] Likewise, replacing conventional carriers homeported at Mayport, FL, with nuclear carriers requires nearly $100 million for construction of shore maintenance facilities to support radioactive materials.[316] This cost was reproduced at a half dozen nuclear homeports.

After having produced nuclear waste for four decades, the Navy still has no permanent depository.

After having produced nuclear waste for four decades, the Navy still has no permanent depository. Instead, the highly radioactive materials have been stacked temporarily in cooling ponds at INEL. Since 1957, the Navy has sent over 500 shipments with a total of about 1,000 metric tons of spent nuclear fuel to INEL from ships, submarines, and land-based test reactors. Over 600 tons of this waste was reprocessed at the site until the Department of Energy ceased reprocessing spent fuel in April 1992. An additional 300 shipments with 150 tons of spent reactor fuel were scheduled to have been shipped between mid-1993 and mid-1995[317] (about 70 containers), and approximately 24 more nuclear warships are scheduled to be refueled or defueled by the end of FY 1995, the next nuclear carrier in 1998.[318]

In addition to spent reactor fuel, nuclear-powered aircraft carriers also create a variety of medium- and low-level radioactive waste products, including both liquid and solid waste. Shielded by thick steel and lead walls in order to protect the ship's crew from hazardous radiation, the fission process in the reactors irradiates cooling water, machinery, and equipment which then has to be specially stored and protected from human exposure.

Solid low-level waste includes machinery, filters, plastic and clothes, and materials which have been irradiated onboard the ship or during maintenance and overhaul. Until 1970, some solid waste such as contaminated ion exchange resin beds was dumped at sea, but since then such materials have been collected and packaged in containers and buried on land at waste sites licensed by the U.S. Nuclear Regulatory Commission (NRC) or a state under agreement with the NRC. The Navy reports that solid radioactive waste from the naval nuclear propulsion program has amounted to approximately 1.8 million cubic feet since 1961, or an average of about 60,000 cubic feet per year.[319]

Medium- and low-level radioactive liquid and solid waste is also created during maintenance and overhaul when work is being performed in the reactor compartments or waste storage areas. Refueling and overhauling the USS Enterprise at Newport News, in addition to overhauling and building other nuclear ships at the yard, has generated "more radioactive waste than normal," a Department of Defense audit report found in 1993. "Additionally, many of the reactor parts and some ancillary parts must be replaced. These parts are radioactive and must be safeguarded and disposed of at radioactive waste sites." In FY-70, when the USS Enterprise was undergoing its second refueling at the yard, there were 28,000 cubic feet of radioactive waste at Newport News. In FY-92, as the USS Enterprise entered its fourth refueling, the level peaked at 19,226 cubic feet.[320]

In addition, accidents add to the waste stream when equipment, clean-up gear, and personnel is contaminated. On 17 October

1992, for example, a nuclear spill occurred onboard the USS Enterprise at Newport News Shipbuilding. Four compartments and nine personnel on the carrier were contaminated with radioactive water when a welder failed to follow standard procedures while welding a valve.[321] Clean-up costs in such accidents further add to the overall cost of nuclear propulsion.

While solid waste is buried on land, some radioactive coolant water is routinely discharged into the world's oceans. The Navy's nuclear ocean dumping is exempt from international treaties banning all such dumping from civilian nuclear power plants, but the Navy claims its dumping takes place "under strict controls," and that annual discharges to international waters have been *exactly* 0.4 curies for the past 20 years. Inside the 12-mile zone, the Navy claims "less than 0.002" curies have consistently been released to the environment.[322]

While solid waste is buried on land, some radioactive coolant water is routinely discharged into the world's oceans.

The largest amount of coolant water is discharged when the reactor is heated up to operating temperature, forcing the cooling water to expand. This normally happens a few times per month on each ship and the quantity discharged each time averages about 500 gallons.[323] But while some of these discharges are "controlled," others are not. In November 1992, for example, it was revealed that the nuclear-powered cruiser USS Long Beach (CGN-9) leaked some 109 gallons of primary coolant while moored at San Diego Naval Station over a period of two weeks. Navy documents released to the *San Diego Union* said the primary relief valve that helps regulate the discharge of radioactive cooling water overboard had malfunctioned, and that primary coolant also had been leaked at Pearl Harbor, Hawaii; Indian Island, Washington; and Rodman, Panama. The Navy denied it was an environmental risk and added that it was a "very small amount of valve leakage that is unavoidable and occurs on all [nuclear] ships [and] is well understood and accounted for."[324]

No Waste To Go

In June 1993, a Court ruling barred all spent nuclear fuel cores from being shipped to the INEL waste facility. The piling up of spent reactor cores at the site for 40 years with no permanent storage facility in place -- *de facto* becoming a permanent dump site -- provoked the State of Idaho to demand an Environmental Impact Statement (EIS) before accepting any more shipments. The Naval Nuclear Propulsion Program was unsuccessful in overturning the court decision, but it managed to reach agreement with the governor of Idaho for 19 interim shipments claiming the nuclear fleet would otherwise choke in its own waste risking disruption of vital naval operations.[325]

Faced with the prospect of temporarily storing spent fuel cores at naval shipyards, EISs are now underway for the naval shipyards where spent nuclear fuel is removed from nuclear warships.[326] Since all of the shipyards have a long history which predates nuclear propulsion, however, they also happen to be located near populated centers in traditional seaport areas. More than 1.7 million people live within 10 miles of the six shipyards currently defueling nuclear warships,[327] and storing nuclear waste down-town is likely to continue to cause political frictions.

Public trust in the Navy's nuclear operations is vital if this plan is to go ahead. The Navy is exceedingly conscious of the vulnerability of its nuclear program to public opinion. Navy instructions warn that, "because of public reaction, even a minor accident could have a serious impact on the Navy and on the operation

More than 1.7 million people live within 10 miles of the six shipyards currently defueling nuclear warships.

of its nuclear-powered warships throughout the world."[328] "Our whole business depends on public trust and confidence," Admiral Bruce DeMars, head of the Naval Nuclear Propulsion Program, told congressional lawmakers during a 1993 hearing on the transport of spent naval nuclear fuel. "We recognize that. We exercise it in forums such as this and we treat that as a very important public trust. We publish the details of our environmental and safety record annually and, of course, send that to Congress," Admiral DeMars said.[329]

Yet the integrity of the Navy's environmental and safety record -- like everything else in society -- is conditional on unbiased control. During a 1993 congressional hearing on EISs and the transport of spent naval nuclear fuel to Idaho, Admiral DeMars assured Congress: "The Navy is not seeking an exemption from the National Environmental Policy Act or from any other environmental statute."[330] At the same time, however, the Navy was actively seeking exemption from the Clean Water Act being considered by Congress to bring all Federal facilities under control. Subjecting the Naval Nuclear Propulsion Program to the Act, the Navy claimed, would have "impugned" its allegedly clean, but nonetheless self-monitored, environmental record.[331]

Operational Constraints

Nearly 40 years after the first nuclear-powered warships began operating, port visits by nuclear-powered warships remain highly controversial, and several countries continue to not accept them because of concern over radiological accidents.

While countries such as New Zealand have outright barred nuclear-powered warship visits to its ports, others such as Denmark accept nuclear-powered warships in principle but demand so much technical information about the reactors -- information needed to assess environmental effects of a potential accident, but information the United States refuses to provide -- that no nuclear warship has ever been able to visit.[332]

During most of the 1980s, the Navy operated a development program to open foreign ports to nuclear-powered warships. In January 1982, for example, the USS Nimitz (CVN-68) became the first nuclear carrier to be granted permission to visit the Spanish isle of Mallorca. "This first-time visit for NIMITZ to the capital city of Palma set [sic] the precedence for future U.S. nuclear carriers to visit Spanish ports,"[333] the Navy reported. The Nimitz returned to the island exactly one year later.[334]

The result of this decade-long naval diplomatic effort, however, has not been impressive. Although about 15 more ports were opened, the number of countries accepting nuclear ship visits remained virtually unchanged. Admiral DeMars told Congress in April 1992 that nuclear-powered warships were "able to enter over 150 ports in the U.S. and abroad"[335] in 1991. About one-third of these ports were in the United States, while over 100 ports visited by nuclear-powered warships during 1990 and 1991 were in 50 foreign countries.[336]

As the carrier fleet continues to shrink, homeporting one or more carriers overseas will likely become more attractive to the Navy in order to maintain continuous, or near continuous, carrier presence in distant oceans. Because of nuclear power, however, few countries are likely to permit U.S. nuclear carrier homebasing. One aircraft carrier is currently homeported in Japan, but although the country accepts visits by nuclear-powered aircraft carriers, none have ever been homeported there. At any rate, since the United States is unlikely to move the extensive nuclear maintenance apparatus needed to sustain a nuclear-powered aircraft carrier overseas, returning the ship periodically to the United States for repair and maintenance would render

gains from overseas homeporting mute.

Anti-nuclear sentiments also continue to hamper the Navy's maneuverability between the Mediterranean and Indian Ocean. Although Egypt on some occasions has permitted use of the Suez Canal, the country maintains a general ban on nuclear-powered warships transiting the waterway. When the first U.S. nuclear surface ship was permitted through in 1984, elated U.S. officials called it a "breakthrough" for U.S. diplomacy.[337]

"We have been dealing with this potential problem for 30 years," former director of Naval Nuclear Propulsion Admiral McKee acknowledged during congressional hearings in February 1987 when discussing the problem of nuclear transits and port visits. It "really gets down to the question of accepting our assurances that we will take the same precautions overseas that we do in our own country. Dealing with foreign nuclear sensitivities is getting harder and harder. Chernobyl restarted the clock on the argument with the Egyptians."[338]

Reactors in the Line of Fire

The risk of a nuclear-powered warship being sunk or critically damaged by a mine or enemy air and/or missile attacks has received surprisingly little attention. "Blue water" naval strategies are changing to operations in littoral waters, or "brown waters," bringing nuclear-powered ships and submarines closer to land.

To deal with such disasters, there is some indication that the nuclear-powered surface ships were positioned in less forward positions to their conventional counterparts in the Gulf War. The operation of nuclear-powered warships in the Persian Gulf appears to have been partially constrained as a measure to protect the nuclear propulsion plant from mines and Iraqi attack. The nuclear aircraft carrier USS Roosevelt's operational "box" was further south than the other carriers. And nuclear cruisers, which did not enter the Persian Gulf at all, could easily have hit sea mines with serious consequences.[339]

Nuclear carriers are sometimes portrayed as being virtually unsinkable. While undergoing annual Operational Readiness Inspection off Hawaii in January 1969, for example, the USS Enterprise (CVN-65) was involved in a serious accident. A Zuni rocket exploded on the aft section of the flight deck causing a fire to spread among several parked aircraft fueled and armed for takeoff. Nine major caliber bombs exploded in the fire, killing 28 crew and injuring 343 others. Fifteen aircraft were destroyed before the fire was brought under control.[340] The Navy later used the explosions, which had a force "equivalent of about six cruise missiles," as an example of the hardness of the ship, illustrating "the capability which our ship designers and shipbuilders have provided for our nuclear powered carriers." The USS Enterprise "could have resumed its scheduled air operations within hours, as soon as the debris was cleared from the aft end of the flight deck,"[341] the Chief of Naval Operations boasted before Congress in 1972.

The ship's commanding officer at the time of the accident, however, Vice Admiral Kent L. Lee, was less impressed. He described the dangers facing nuclear power at sea:

> [W]e had 15-20 aircraft on the aft part of the flight deck, loaded with fuel and fully armed with ammunition, Zuni rockets, and bombs. The safety of the ship was paramount. I knew we had to flood the hangar deck with the overhead sprinkler system and try to keep the fire contained to the aft part of the flight deck. With the minimal firefighting equipment we had on the flight deck, there wouldn't be much we could do. If the fire had spread to the hangar deck, we could very easily have lost the ship.[342]

Although high sustained speed is cited by the Navy to provide "relative immunity from torpedo attack," the Nimitz class carrier has been fitted with a new torpedo (or side) protective system.[343] The system is not foolproof protection of its nuclear reactors, however. A 1991 major study for future carrier design and technology (Carrier-21) by the National Research Council, concluded that in the future U.S. carriers will have to be at least as survivable as the current Nimitz-class design, if not more so, to maintain their effectiveness.[344] In fact, bottom protection in the eight Nimitz class carrier appropriated until 1994 is *inadequate* to protect against large under-keel torpedoes, but further increases have been inhibited by a combination of harbor depth restrictions and ship draft and inside volume availability.[345]

The report also concludes that "available studies show that hits on a carrier by one to three or four large air-delivered weapons, such as 500- to 1000-kg warheads of opposing cruise or ballistic missiles, can put it out of action for significant periods and make it more vulnerable to a killing attack." Moreover, a nuclear carrier "is also vulnerable to having its propulsion machinery seriously misaligned, its magazine exploded, and/or its back broken to torpedoes designed to explode under the keel. Despite the multilayered defenses determined to minimize the chances of a hit," the National Research Council concludes, "it must be accepted that a determined enemy will be able to land hostile fire on a carrier."[346]

Endnotes

1. The DOD budget request for FY 1995 contains $2.5 billion for procurement of CVN-76. Nearly $830 million was authorized in the FY 1993 budget for long-lead items for the nuclear power plant, and the FY 1994 budget earmarked another $1.2 billion for the carrier; Department of Defense, "Program Acquisition Costs by Weapon System," Department of Defense Budget For Fiscal Year 1995, February 1994, p. 45.

The price for the CVN-76 appears already to have increased by another $232.7 million, to approximately $4.6 billion; "Selected Acquisition Reports (SARs)," as of 31 December 1993, Department of Defense, 8 April 1994, p. 5; "Navy pegs F-14D upgrade at $1.6 billion in latest acquisition reports," *Inside the Navy*, 11 April 1994, pp. 5, 7.

2. Department of Defense, "Selected Acquisition Reports (SARs)," as of 31 December 1993, 8 April 1994, p. 5.

3. Admiral Bruce DeMars, Director, Naval Nuclear Propulsion Program, HASC, FY 1993 DOD, Naval Nuclear Shipbuilding Program hearing, 7 April 1992, p. 75.

4. Letter from Senator Arlen Spector, et.al., to Secretary of Defense Les Aspin, 10 February 1993, as reprinted in SAC, FY 1994 DOD, Part 1, p. 50.

5. See: "Sen. D'Amato: Navy Can Solve $3.5 Billion Gap by Canceling CVN-76," *Inside the Navy*, 7 February 1994, p. 4; AP (John Diamond, Washington), "Carrier Debate," 24 February 1994; "Key House chairman still sees little need for CVN-76; Dellums Questions Navy Plan to Use Sealift Funds for New Carrier," *Inside the Navy*, 28 February 1994, p. 14; "Bill Scrapping Procurement of CVN-76 expected to get Senate attention," *Inside the Navy*, 30 May 1994, p. 5.

6. Les Aspin, Secretary of Defense, "Report on the Bottom-Up Review," Department of Defense, October 1993, p. 53 (hereafter "Bottom-Up Review);" Robert Holzer, "Will it float? Navy ponders future carriers," *Navy Times*, 21 March 1994, p. 6.

One carrier study completed by the Center for Naval Analyses in 1992, reportedly caused strong negative Navy reactions, including a letter from an active-duty admiral demanding that the study be stopped because it was addressing non-nuclear propulsion for aircraft carriers; Thomas D. Taylor, Senior Fellow and Deputy Director, Aircraft Carrier Study, Center for Naval Analyses, "CNA carrier study besmirched," letter to the editor, *Armed Forces Journal International*, June 1993, p. 3.

Moreover, dwindling budgets and increasingly overlapping missions has provoked a debate between the Navy and the Air Force as to which service can best project U.S. military might overseas, aircraft carriers or long-range bombers; Don Ward, "Navy fires back at McPeak's salvo," *Navy Times*, 14 March 1994, p. 8.

7. "CBO Proposes Marine-Only Contingency Force; Seven to Ten Carriers," *Inside the Navy*, 14 March 1994, pp. 7-8; "CBO deficit cutting plan axes Seawolf, V-22, F/A-18E/F," *Inside the Navy*, 11 April 1994, p. 12.

Construction of big-deck amphibious ships, such as the LHD-7, may get priority over funding more nuclear carriers. LHDs serve as the centerpiece of Marine Corps Amphibious Ready Groups (ARGs), and the Corps has asked for 12 ARGs. If funded in the FY 1995 budget, LHD-7 may "steal" the money required to fund the CVN-76; "Senate appropriations may move to fund LHD-7 in FY-95," *Inside the Navy*, 11 April 1994, pp. 1, 13.

8. U.S. Congress, "Study of nuclear powered aircraft carriers and submarines," Conference Report (H. Rept. 103-339), FY 1994 DOD Appropriations, 9 November 1993, p. 94.

9. General Carl E. Mundy, Jr., U.S. Marine Corps Commandant, 29 April 1993; SAC, FY 1994 DOD, Part 1, p. 287.

When the USS Dwight D. Eisenhower (CVN-69) deploys to the Middle East and Indian Ocean regions in 1995, for example, part of it its deployment will be backed by the amphibious "mini-carrier" USS Nassau (LPH-4); Margo MacFarland, "Miller sees '95 deployment with more Army, USAF, Special Ops assets,"

Inside the Navy, 15 November 1993, p. 6.

10. One of the arguments listed by the "Bottom-Up Review" for prematurely retiring three older conventional carriers that still have service life remaining, is the "training and maintenance efficiency to be gained by transitioning to an all-nuclear-powered carrier force;" Bottom-Up Review, op.cit., p. 50.

Yet why this necessarily means transitioning towards a *nuclear* rather than conventional carrier fleet is unclear. Since about half of the carrier fleet is conventionally powered, building new conventional carriers would equally support the training and maintenance efficiency of the carrier force, especially considering that the rest of the surface fleet is *not* nuclear.

11. In January 1966, for example, Rear Admiral Henry L. Miller, who commanded the task group which included USS Enterprise and USS Bainbridge in the Vietnam War, said the nuclear-powered warship "can do just about everything better, easier, and faster than her conventional brethren." Specifically Rear Admiral Miller listed:

1. Increased tactical flexibility as a result of unlimited endurance at high speed.

2. Reduction of replenishment frequency with a greatly reduced dependence upon all forms of mobile logistic support (not only fuel) as a result of increased storage space formerly required for fuel oil.

3. Air intakes for boiler operations are eliminated thereby greatly improving the capability to seal the ship against atomic, biological, and chemical attack -- a quantum jump in ability to survive.

4. Elimination of the undesirable stack gasses and smoke which not only make it difficult for the pilots sitting in their planes prior to takeoff or during approaches for a landing but also adds considerably to the Navy's maintenance bill due to the corrosive effects of the stack gases on communication and radar antennas and on aircraft.

5. The concern for loss of fuel oil facilities is eliminated. This includes the loss of facilities at the source (in any foreign country) by political action. It also includes the loss of prepositioned fuel depots to the enemy or the loss of the replenishment oiler en route to refueling rendezvous as a result of enemy action.

6. There is the ability, under severe threat situations, to operate from distant bases completely free from mobile logistic dependency, with the capability of high-speed return to such bases for replenishment or aviation fuel and ammunition.

7. Increased maneuverability resulting from much more repair acceleration and deceleration.

8. High standards of technical training set in the nuclear-propulsion program.

9. A cleaner ship internally and externally saving hundreds of thousands of hours a year in cleaning ship and aircraft.

10. And finally, ships in the 1967 and 1968 programs will be with us until the turn of the century. We are buying time if we build nuclear-powered ships. We are buying reduced effectiveness if we purchase oil-burning warships.

Rear Admiral Henry L. Miller, commander, U.S. Navy, "Advantages of Nuclear Power and Its Utilization in a Combat Environment," 2 January 1966, contained in Joint Committee on Atomic Energy (JCAE) hearing of June 26, 1966, on "Naval Nuclear Propulsion Program," app. 1, pp. 37-42, partly reprinted in "Nuclear Propulsion for Naval Warships," JCAE Hearing and Subsequent Inquiry, 5 May-30 September 1972, p. 160 (hereafter "JCAE 1972").

12. "Navy kicks off campaign to sell CVN-76 carrier to Congress," *Inside the Navy*, 12 March 1994, pp. 7, 8.

13. The turnaround period is the time it takes to get a carrier returning from deployment ready to deploy again.

14. Department of the Navy, Director, CV and Air Station Programs Division (OP-55), DCNO (Air Warfare), Office of the Chief of Naval Operations, "Handbook of U.S. Aircraft Carrier Programs," n.d. (1 September 1986), p. 28 (hereafter "Carrier Handbook"); partially released under the Freedom of Information Act.

The extra fuel and ordnance capacity of the USS Roosevelt compared to the USS Kennedy cited by the U.S.

Navy is significantly higher than what is listed in the open military literature, which only credits nuclear carriers with about 35 percent extra jet fuel and ordnance storage capacity; *Combat Fleets of the World 1993* (Annapolis, MD: Naval Institute Press, 1993), pp. 791-793, 794 (hereafter "Combat Fleets of the World 1993"); *Jane's Fighting Ships 1993-94* (Alexandria, VA: Jane's Information Group Inc., 1993), pp. 766, 768 (hereafter "Jane's Fighting Ships 1993-94"); Norman Polmar, *Ships and Aircraft of the U.S. Fleet* (Annapolis, MD: Naval Institute Press, 1993), 15th edition, pp. 83-84, 86-88 (hereafter "Ships and Aircraft of the U.S. Fleet).

15. Open military literature credit USS Roosevelt and USS Kennedy with the following approximate capacities:

	USS Roosevelt	USS Kennedy	Difference	Increase
Displacement*	96300	80940	15360	16%
Jet Fuel*	9000	5920	3080	34%
Ordnance*	1954	1250	704	36%
Crew	6200	5200	1000	16%

* In metric tons. For sources see: *Combat Fleets of the World 1993*, op.cit., pp. 791-793, *794; Jane's Fighting Ships 1993-94*, op.cit., pp. 766, 768; *Ships and Aircraft of the U.S. Fleet*, op.cit., pp. 83-84, 86-88.

The ordnance increase roughly matches that reported by the Chief of Naval Operations in 1971, while jet fuel "endurance" is set to be 50 percent higher for the Nimitz class compared with a Forrestal class carrier. In an aircraft carrier fact sheet from 1972, the Naval Nuclear Propulsion Office lists the jet-fuel capacity to be 90 percent greater and the ordnance capacity 50 percent greater for the Nimitz class than for the Forrestal class carrier. The higher jet fuel capacity, however, assumes only nuclear-powered escort ships are accompanying the carrier; Admiral Elmo Zumwalt, Jr., Chief of Naval Operations, point paper on requirement for USS Carl Vinson (CVN-70), 11 January 1971, as cited in JCAE 1972, op.cit., p. 289; "The Aircraft Carrier," as reprinted in JCAE 1972, op.cit., p. 326.

In its new post-Cold War doctrine "…From the Sea," the Navy envisions an aircraft carrier operating in a regional conflict generating 100-150 strike sorties per day. None of the carriers in the Gulf War achieved this level, however, all averaging less that half of that per day, including the USS Roosevelt; Department of the Navy, "Carriers for 'Force 2001'," Spring 1993, p. 6 (hereafter "Carriers Force 2001").

16. Admiral Frank Kelso III, Chief of Naval Operations, SAC, FY 1994 DOD, Part 1, p. 301.

17. Only three of the Navy's nine nuclear-powered cruisers were used in the Gulf War; USS South Carolina (CGN-37), USS Virginia (CGN-38), and Mississippi (CGN-40).

18. Carrier Handbook, op.cit., p. 28; emphasis added.

19. General Accounting Office, "Navy Carrier Battle Groups: The Structure and Affordability of the Future Force," GAO/NSIAD-93-74, February 1993, p. 104, footnote 5 (hereafter "GAO 1993").

20. Although the Navy is currently experimenting with nuclear reactor cores that may last as long as 30 years, this will have no immediate effect on the frequency of refueling overhauls before the year 2050, since all nuclear carriers currently in the fleet are powered by existing core designs. Even then, nuclear carriers are generally expected to remain in service for 45-50 years, so even a 30-year reactor core will not eliminate the expensive mid-life refueling overhaul.

21. Bottom-Up Review, op.cit., p. 49.

22. Patrick Pexton, "Navy leaves Gulf without a carrier," *Navy Times*, 5 July 1993, p. 4.

23. Some, however, argue that nuclear propulsion is even more important for aircraft carriers in the post-Cold

War era. See, e.g., Commander J. D. Oliver, U.S. Navy, "Use the Carriers or Lose Them," *Proceedings*, September 1993, p. 67; Jacquelyn K. Davis, *Aircraft Carriers and the Role of Naval Power in the Twenty-First Century*, National Security Paper Number 13 (Cambridge, Massachusetts: Institute for Foreign Policy Analysis, 1993), p. 48.

24. The plan also included equipping twelve of eighteen guided-missile cruisers, and eighteen of fifty-four guided-missile frigates with nuclear power; Francis Duncan, *Rickover and the Nuclear Navy: The Discipline of Technology* (Annapolis, MD: Naval Institute Press, 1990), p. 101 (hereafter "Rickover and the Nuclear Navy").

25. After work on a nuclear propulsion plant officially got underway in late 1951, the entire program was canceled in 1953 pending the successful development of large civilian nuclear power stations. Reinstalled in 1954, design work continued on the program and finally in November 1961, the USS Enterprise was commissioned as the second surface ship in the U.S. Navy equipped with nuclear propulsion -- only one month after the USS Long Beach (CGN-9); JCAE 1972, op.cit., pp. 128, 129, 130.

26. *Rickover and the Nuclear Navy*, op.cit., p. 106.

27. *Ships and Aircraft of the U.S. Fleet*, op.cit., p. 90.

28. JCAE 1972, op.cit., p. 130.

29. In September 1964, the Center for Naval Analyses completed a major study on nuclear propulsion for surface ships with primary emphasis upon carriers. The report, nicknamed NAVWAF 33 for being the 33rd study by the naval warfare analysis group, found that a two-reactor carrier comparable in size to the USS Enterprise would cost about the same as a conventional Kennedy class carrier, plus a fast ammunition-oiler, plus a replenishment fleet oiler; *Rickover and the Nuclear Navy*, op.cit., p. 145.

30. JCAE 1972, op.cit., p. 217.

31. Representative L. Mendel Rivers, Chairman of the House Armed Services Committee, 13 November 1967, Letter to President Johnson; partially reprinted in JCAE 1972, op.cit., p. 203.

32. JCAE 1972, op.cit., p. 164.

33. *Rickover and the Nuclear Navy*, op.cit., pp. 163, 164, 165.

34. Admiral Thomas H. Moorer, Chairman, Joint Chiefs of Staff, JCAE 1972, op.cit., p. 12.

35. The Act developed at a time of international and national crisis.

The Arab nations had imposed an oil embargo upon the United States in October 1973. At a House Seapower Subcommittee meeting held at the Atlantic Fleet Compound at Norfolk, Virginia, in January 1974, the Commander-in-Chief of the Atlantic Fleet, Admiral Ralph W. Cousin, Jr., warned that the Mediterranean and Atlantic fleets would be faced with a severe fuel crisis by April unless the Navy received more funds.

The Nixon Administration was paralyzed by the Watergate affair. Unable to muster any opposition, President Nixon reluctantly signed the legislation on 5 August, only a few days before his resignation. He remarked that he had several reservations about some of the provisions, especially the nuclear-only language of Title VIII. He intended only to recommend nuclear propulsion when national interests justified the cost; *Rickover and the Nuclear Navy*, op.cit., pp. 166, 167.

36. Only one nuclear-powered cruiser, the USS Arkansas (CGN-41), was funded in the same period; *Ships and Aircraft of the U.S. Fleet*, op.cit., p. 107.

37. Norman Polmar, *The Ships and Aircraft of the U.S. Fleet* (Annapolis, MD: Naval Institute Press, 1978), 11th edition, p. 48.

38. *Rickover and the Nuclear Navy*, op.cit., p. 168.

39. Ibid., p. 168.

Even though the nuclear-only provision was dropped from Title VIII in 1978, Secretary of the Navy John Lehman nonetheless referred to it during the Reagan Administration's push in Congress in 1987 for funding of

two nuclear carriers in the FY 1988 budget. Lehman did not mention the provision had been dropped; John Lehman, Secretary of the Navy, SASC, FY 1988/1989 DOD, Part 6, 12 March 1987, p. 2884.

40. *Ships and Aircraft of the U.S. Fleet*, op.cit., p. 84.

41. John Lehman, Secretary of the Navy, SASC, FY 1988/1989 DOD, Part 6, 12 March 1987, p. 2884.

42. The cost of CVN-72 and CVN-73 were estimated at nearly $7 billion in total at the time of contract award (27 December 1982), not including outfitting and post-delivery costs. The Department of Defense acquisition report on series production of the Nimitz class in late 1991, however, list the costs in current-year dollars as $6.2 billion for the CVN-72 and CVN-73, and another $6.5 billion for CVN-74 and CVN-75; *Ships and Aircraft of the U.S. Fleet*, op.cit., pp. 83, 84.

43. Bottom-Up Review, op.cit., p. 53.

44. In July 1993, however, Captain Charles Girvin III, who was deputy director on the staff of Commander, Middle East Force/Carrier Task Force 151 during the Gulf War, criticized the Navy's over emphasis on nuclear-powered aircraft carriers for hanging on to an outdated Mahanian principle of the preeminence of the capital ship, and all other ships and systems existing primarily for its support. Girvin argued that aircraft carriers do not need to be nuclear-powered but can be gas-turbine powered, 40,000 to 50,000 tons ships; Captain Charles R. Girvin III, U.S. Navy, "Twilight of the Supercarrier," *Proceedings*, July 1993, p. 44.

45. There have been carrier studies undertaken in the 1990s, including: Center for Naval Analyses, "Aircraft Carriers and the Future," (CRM 92-172), September 1992; General Accounting Office, "Navy Carrier Battle Groups: The Structure and Affordability of the Future Force," GAO/NSIAD-93-74, February 1993; Congressional Research Service, Ronald O'Rourke, Foreign Affairs and National Defense Division, "Navy Nuclear-Powered Aircraft Carrier (CVN-76)," updated 1 March 1994. None deal seriously with the trade-off of nuclear and conventional power.

46. National Research Council, Naval Studies Board, "Carrier 21: Future Aircraft Carrier Technology," Volume I: Overview, Washington, DC: 1991, p. 34 (hereafter "Carrier 21").

The report finds that the "nuclear vs. conventional power issue was argued thoroughly at the time of the CVV/CVN discussions of the late 1970s," and suggests that propulsion type for smaller carriers could be nuclear or non-nuclear depending on views about the economics and other non-technical factors.

47. The House of Representatives has directed the General Accounting Office to study the cost-effectiveness to the Navy of the utilization of nuclear-powered aircraft carriers and nuclear-powered submarines. Among other items not relating directly to nuclear propulsion, the study will include:

* A comparison of the life-cycle cost, including the cost of processing or otherwise disposing of nuclear fuel and other nuclear waste removed from nuclear-powered ships, nuclear-powered aircraft carriers and nuclear-powered submarines with the life-cycle cost of conventionally powered aircraft carriers and conventionally powered submarines;

* An assessment of the refueling costs and the cost of disposing of the waste generated by such refuelings for the nuclear-powered aircraft carriers of the fleet through the year 2020;

* A detailed estimate of the costs associated with processing or otherwise disposing of nuclear fuel and other nuclear material from the existing nuclear-powered fleet of ships in the Navy; and

* A detailed description of all programs of the Department of Defense and the Department of Energy relating to nuclear propulsion systems for naval ships that utilize such systems required for the nuclear-powered aircraft carriers; U.S. Congress, House of Representatives, Conference Report (H.Rept. 103-339, accompanying H.R. 3116), making appropriations for the Department of Defense for the fiscal year ending September 30, 1994, 103d Congress, 1st Session, p. 94.

The study will be carried out by the General Accounting Office. As of April 1994, work on the study had not yet begun but was expected to commence "in a few months" to be completed in 1995; Phone conversation with staff at the National Security and International Affairs Division of the U.S. General Accounting Office,

15 April 1994.

48. The Navy had proposed a force of 12 active carriers and no training/reserve carrier; Congressional Research Service, Ronald O'Rourke, Foreign Affairs and National Defense Division, "Navy Nuclear-Powered Aircraft Carrier (CVN-76)," Updated 1 March 1994, p. 1 (hereafter "O'Rourke 1994").

49. Bottom-Up Review, op.cit., p. 50.

50. The current plan to phase out conventionally powered carriers currently in operation begins with USS Saratoga (CV-60) in 1994, followed by USS America (CV-66) in 1996, USS Independence (CV-62) in 1998, USS Kitty Hawk (CV-63) in 2002, and USS Constellation (CV-64) in 2008. At that point, all except the training carrier, USS John F. Kennedy (CV-67), will be nuclear-powered. The USS Kennedy is expected to be decommissioned in 2010.

The USS George Washington (CVN-73) was commissioned on 4 July 1992, replacing the USS Midway (CV-41). The USS John Stennis (CVN-74) was christened on 13 November 1993, and will replace USS Ranger (CV-61). The USS Kitty Hawk (CV-63), which is scheduled to be inactivated in 2002, will be replaced by the next nuclear carrier to be commissioned, the CVN-76; Les Aspin, Secretary of Defense, "Annual Report to the President and the Congress," January 1994, p. 168 (hereafter "Aspin 1994").

51. Bottom-Up Review, op.cit., p. 51.

The tenth Nimitz-class carrier, CVN-77, which will begin funding in FY 1999 and join the fleet in 2007, is expected to cost over $6.1 billion; Admiral Frank Kelso II, U.S. Navy, Acting Secretary of the Navy and Chief of Naval Operations, and General Carl Mundy, Jr., USMC, Commandant of the Marine Corps, "Department of the Navy 1993 Posture Statement," HASC, FY 1994 DOD, March 1993, p. 25; "Navy pegs F-14D upgrade at $1.6 billion in latest acquisition reports," *Inside the Navy*, 11 April 1994, p. 5.

52. These four new carriers would be: 1) CVN-76, replacing Kitty Hawk (CV-63) in 2003; 2) CVN-77, replacing USS Constellation (CV-64) in 2008; 3) CVN-78, replacing USS John F. Kennedy (CV-67) in 2010; and 4) CVN-79, replacing USS Enterprise (CVN-65) in 2014.

53. *Rickover and the Nuclear Navy*, op.cit., pp. 16, 245.

54. Norman Polmar and Thomas B. Allen, *Rickover: Controversy and Genius* (New York, NY: Simon and Schuster, 1982), pp. 206, 208, 232, 236, 237 (hereafter "Rickover, Controversy and Genius").

55. JCAE 1972, op.cit., p. 133.

56. *Rickover: Controversy and Genius*, op.cit., pp. 243-244.

57. Ibid., p. 245.

58. Ibid., p. 245.

59. *Rickover and the Nuclear Navy*, op.cit., pp. 117, 118, 119.

60. Deborah Shapley, *Promise and Power* (Boston, MA: Little, Brown and Company, 1993), pp. 176-178.

61. Admiral Anderson, U.S. Navy (Retired), letter to John T. Conway, Executive Director, Joint Committee on Atomic Energy, 29 January 1964, as reprinted in "Naval Nuclear Propulsion Program 1967-68," Joint Committee on Atomic Energy, 16 March 1967 and 8 February 1968, p. 265-266 (hereafter "JCAE 1967/1968"); *Rickover and the Nuclear Navy*, op.cit., p. 132.

62. JCAE 1972, op.cit., pp. 133-134.

63. *Rickover and the Nuclear Navy*, op.cit., p. 140.

64. Ibid., p. 130.

65. Ibid., p. 130; Rear Admiral J. T. Hayward, U.S. Navy, letter to Secretary of the Navy Fred Korth, 2 January 1963; reprinted in JCAE 1972, op.cit., p. 134.

"No other carrier has made over 10,000 landings in her first years of operation," Rear Admiral Hayward stated. "Her planes are easier and cheaper to maintain and are combat ready mode of the time because they are not subject to the corrosive attack od stack gasses. They can fly more missions because much of her space

normally used for fuel oil tankage is available for ammunition and jet fuel. The rugged reliability designed and built into her propulsion plant gives her a sustained high speed and ever-ready maneuvering rate that greatly enhances air operations. The absence of boiler uptakes has allowed the arrangement of communication and radar systems superior to those on any other carrier."

66. Rear Admiral J. T. Hayward, U.S. Navy, letter to Fred Korth, Secretary of the Navy, 2 January 1963; as reprinted in JCAE 1972, op.cit., pp. 134-135.

67. The USS Enterprise and USS Bainbridge were enroute to an exercise in the Mediterranean, and Rickover thought it might be possible to use the operations to prove that the USS Bainbridge was worth two or even three oil-fired ships; *Rickover and the Nuclear Navy*, op.cit., pp. 133-134.

68. Ibid., p. 151.

69. JCAE 1972, op.cit., pp. 204-205.

70. *Rickover and the Nuclear Navy*, op.cit., pp. 118, 148, 150-153.

71. Jim McNeil, *Charleston's Navy Yard, a picture history* (Charleston, SC.: Naval Civilian Administrators Association, 1985), pp. 167, 168.

72. *Rickover and the Nuclear Navy*, op.cit., pp. 118, 119.

73. *Rickover: Controversy and Genius*, op.cit., p. 242.

74. Ibid., p. 246. Emphasis in original; *Rickover and the Nuclear Navy*, op.cit., p. 148.

75. *Rickover: Controversy and Genius*, op.cit., p. 243.

76. Ibid., p. 248.

77. Long lead funding was authorized by Congress for a 10th nuclear cruiser (CGN-42) intended to be authorized in FY 1975, but the program was delayed after the Navy and the Naval Nuclear Propulsion Program pushed for a more capable nuclear cruiser. This new class, however, was dropped in favor of the non-nuclear Ticonderoga class AEGIS cruiser. The Reagan Administration had included a nuclear cruiser in the last year of the 1983-1987 shipbuilding plan, but total lack of support for building more nuclear cruisers meant that the ship "slipped" into oblivion; *Ships and Aircraft of the U.S. Fleet*, op.cit., pp. 103, 108.

78. Soaring cost overruns in the construction of the first nuclear carrier (USS Enterprise) soon dampened the hopes of realizing the Navy's nuclear vision. The original cost estimated had been $314 million, over twice as expensive as the conventional carrier USS Independence (CV-62) commissioned in 1959. In February 1960 the projected cost had increased by one-third to over $470 million. Of the original cost estimate of $314 million, the nuclear power plant was $90 million (about 28 percent). By February 1960, this had increased by over 33 percent to $133 million (about 28 percent of total ship cost); *Rickover and the Nuclear Navy*, op.cit., pp. 103, 106, 117.

Another source reports estimated construction cost to be $444 million for the USS Enterprise and $265 for a contemporary conventional aircraft carrier; *Ships and Aircraft of the U.S. Fleet*, op.cit., p. 89.

79. *Rickover: Controversy and Genius*, op.cit., p. 234.

80. Vice Admiral Rickover, "Chronological Summary of the History of Nuclear Propulsion for Surface Ships," as reprinted in JCAE 1972, op.cit., p. 143.

81. *Rickover and the Nuclear Navy*, op.cit., p. 157.

82. Admiral Elmo R. Zumwalt, Jr., *On Watch* (New York, NY: Quadrangle, The New York Times Book Co., 1976), p. 65.

83. Vice Admiral Rickover, JCAE 1972, op.cit., p. 270; partially reprinted in Naval Nuclear Propulsion Program hearing, HASC, FY 1979 DOE, 1 March 1978, p. 40.

84. Paul H. Nitze, Secretary of the Navy, letter to the Secretary of Defense, 13 November 1964; partially reprinted in JCAE 1967/1968, op.cit., p. 191.

85. House Armed Services Committee, "The Nuclear Navy," report on hearing concerning nuclear-power for

surface warships, "General Statement" section, HASC Report No. 1536, 16 May 1966; as cited in JCAE 1972, op.cit., p. 168.

86. House Armed Services Committee, "The Nuclear Navy," report on hearing concerning nuclear-power for surface warships, "Committee Position" section, HASC Report No. 1536, 16 May 1966; as cited in JCAE 1972, op.cit., p. 168; Emphasis in original.

87. JCAE 1972, op.cit., p. 192.

88. Robert McNamara, Secretary of Defense, 1 May 1967 letter to the Chairman of the Joint Committee on Atomic Energy; partially reprinted in JCAE 1972, op.cit., p. 179.

89. L. Mendel Rivers, Chairman, House Armed Services Committee, press release 20 December 1967; as reprinted in JCAE 1972, op.cit., p. 205.

90. Admiral Zumwalt, Chief of Naval Operations, Memorandum for the Secretary of the Navy, 23 March 1972; reprinted in JCAE 1972, op.cit., p. 326.

91. Admiral Zumwalt, Chief of Naval Operations, JCAE 1972, op.cit., p. 55.

92. Admiral Moorer, Chairman, Joint Chief of Staff; partially reprinted in JCAE 1972, op.cit., p. 228.

93. Vice Admiral J. H. Doyle, Jr., U.S. Navy, Deputy Chief of Naval Operations, Surface Warfare, SAC, FY 1980 DOD, Part 4, p. 537.

94. USS Virginia (CGN-38), "1986 Command History," 30 March 1987, n.p.; partially declassified and released under the Freedom of Information Act.

95. USS Mississippi (CGN-40), "1987 Command History," 23 July 1989, Enclosure 2, p. 1; partially declassified and released under the Freedom of Information Act.

96. Rear Admiral George A. Huchting, U.S. Navy, Direct Reporting Manager for Aegis Program, "Aegis Ruled in the Littorals, Too," *Proceedings*, October 1993, p. 16.

The USS South Carolina (CGN-37) rejoined the Atlantic Fleet in mid-May 1994 following a three-year $362 million refit; "South Carolina rejoin," *Jane's Defence Weekly*, 21 May 1994, p. 4.

97. "The real potential for the use of nuclear power in surface ships," Defense Secretary Robert McNamara pointed out to Congress in 1963, "is in the literally tens of major ships that will be building other than these two aircraft carriers;" Robert McNamara, Secretary of Defense, statement before the Joint Committee on Atomic Energy, 13 November 1963, as reprinted in JCAE 1972, op.cit., p. 143.

98. John Lehman, Secretary of the Navy, SASC, FY 1988/1989 DOD, Part 6, 12 March 1987, p. 23.

99. Admiral McDonald, Memorandum to the Secretary of the Navy, 26 October 1964; partly reprinted in JCAE 1972, op.cit., p. 150.

100. Nuclear propulsion provides a modern carrier with fuel for at least 15 years of normal operations, the equivalent of some 12.7 million barrels of propulsion fuel oil; Carrier Handbook, op.cit., p. 28.

101. Rear Admiral J. T. Hayward, U.S. Navy, letter to Fred Korth, Secretary of the Navy, 2 January 1963; as reprinted in JCAE 1972, op.cit., pp. 134-135.

102. *Rickover and the Nuclear Navy*, op.cit., pp. 128, 129, 139.

103. USS Nimitz (CVN-68), "1979 Command History," 4 March 1980, p. Enclosure 1, n.p.; emphasis added; partially declassified and released under the Freedom of Information Act.

104. GAO 1993, op.cit., p. 92, footnote 6.

105. Bernard Prézelin (A. D. Baker III, English ed.), *Combat Fleets of the World 1990/1991: Their Ships, Aircraft, and Armament* (Annapolis, Maryland: Naval Institute Press, 1990), p. 759.

Still, being independent is central to the image of nuclear carriers. When the USS George Washington (CVN-73), was commissioned on 4 July 1992, its ceremonial pamphlet pointed out how the ship "will carry approximately three million gallons of fuel for her aircraft and escorts, and enough weapons and stores for extended operations without replenishment;" U.S. Navy, "Commissioning of United States Ship George

Washington CVN 73," Norfolk, Virginia, July 4, 1992.

106. The USS John F. Kennedy (CV-67) and USS Kitty Hawk (CV-63) class conventional carriers store some 5,882 tons of aviation fuel; *Jane's Fighting Ships 1993-94*, op.cit., p. 768.

107. Admiral Rickover, JCAE 1972, op.cit., p. 270.

108. Admiral Zumwalt, Chief of Naval Operations, memorandum to the Secretary of Defense on 23 March 1972; partly reprinted in JCAE 1972, op.cit., p. 327.

109. Carrier Handbook, op.cit., p. 28.

110. Captain, R. S. Crenshaw, Jr., U.S. Navy (Retired), *Naval Shiphandling* (Annapolis: Maryland: Naval Institute Press, 1975), p. 256.

111. Deputy Secretary of Defense David Packard, JCAE 1972, op.cit., p. 103.

112. *Ships and Aircraft of the U.S. Fleet*, op.cit., pp. 83, 107.

113. Curtis Crosby, JO3, U.S. Navy, "Deck Department," *The Rough Rider Familygram*, Vol. 4, No. 4, April 1991, p. 7; released under the Freedom of Information Act.

114. Department of the Navy, "Force 2001; A Program Guide to the U.S. Navy," Chief of Naval Operations, July 1993, p. 48 (hereafter "Force 2001").

115. GAO 1993, op. cit., p. 92.

116. Gerald A. Cann, Assistant Secretary of the Navy for Research, Development and Acquisition, Department of the Navy, prepared statement before the House Armed Services Committee, HASC, FY 1994 DOD, 9 April 1993, p. 331.

117. GAO 1993, op.cit., p. 93.

118. *Jane's Fighting Ships 1991-92*, op.cit., p. 767.

119. Carrier Force 2001, .op.cit., p. 2.

120. Ibid., p. 2.

121. USS Carl Vinson (CVN-70), "1984 Command History," 1 October 1986, Enclosure 2, p. 1; Enclosure 3, pp. 1-2; partially declassified and released under the Freedom of Information Act.

122. USS Carl Vinson (CVN-70) 1985 Command History, 30 November 1988, Enclosure 1, pp. 1; Enclosure 2, pp. 1-2, 5; partially declassified and released under the Freedom of Information Act.

123. USS Carl Vinson (CVN-70), "1986 Command History," 3 December 1988, Enclosure 1, p. 1; Enclosure 2, pp. 1-2; Enclosure 4, pp. 2, 3; partially declassified and released under the Freedom of Information Act.

Despite this manifest dependency on supply ships, Admiral James Lyons, Commander In Chief of the Pacific Fleet, later used the USS Vinson deployment to demonstrate an increased endurance of nuclear-powered carriers. "The *Vinson* was there in support of the amphibious operation and used up in those 5 days 21 percent of the total fuel that a normal carrier would have carried. In other words, we could have operated three times longer than a fossil-fueled *forrestal*-class carrier in this weather;" Admiral James A. Lyons, Jr., U.S. Navy, Commander In Chief, U.S. Pacific Fleet, SAC, FY 1988 DOD, 4 March 1987, Part 1, p. 429.

The transit from U.S. through the Bering Sea to South Korea lasted from 16 August to 1 September, or 17 days.

124. USS Carl Vinson (CVN-70), "1987 Command History," 6 December 1988, Enclosure 1, p. 1; Enclosure 2, p. 1; Enclosure 4, p. 2; partially declassified and released under the Freedom of Information Act.

125. Slower designs were retired in favor of faster ships, in theory to keep up with nuclear operations, thus increasing the cost of the support ships as well.

126. Department of Defense, "Procurement Programs (P-1)," Department of Defense Budget For Fiscal Year 1994, 1993, p. N-21.

In FY 1994, two ships were added to anticipated shipbuilding levels; "Summary Explanations of Significant Navy SAR Cost Changes (As of December 31, 1992)," *Inside the Navy*, 14 June 1993, p. 16.

127. Force 2001, op.cit., p. 48.

128. Gerald A. Cann, Assistant Secretary of the Navy for Research, Development and Acquisition, Department of the Navy, HASC, FY 1994 DOD, 9 April 1993, p. 332.

In August 1993, the Navy terminated its contracts with the Tampa shipyard for construction of two T-AO's; Margo MacFarland and Tanya Bielski, "Navy Officials Consider Canceling Tampa's Contract for TAGOS," *Inside the Navy*, 30 August 1993, p. 1. The cancellation, however, seemed to be related the shipyard, not the oilers, and was based on "failure to make progress which endangered performance of the contract. Specifically, there were severe financial and performance problems," the Navy said; "Navy cancels oiler contracts," *Jane's Defence Weekly*, 4 September 1993, p. 20.

129. Carrier Handbook, op.cit., p. 28.

130. Ibid., p. 12; emphasis in original.

The USS Nimitz class is built with a new torpedo (or side) protective system, which is shallower (for more internal volume) and therefore accommodates less fuel than earlier designs for escorts or aircraft.

131. Admiral Zumwalt, Chief of Naval Operations, JCAE 1972, op.cit., p. 84.

132. Carrier Handbook, op.cit., p. 11.

133. Paul H. Nitze, Secretary of the Navy, letter to the Secretary of Defense, 26 October 1965; partially reprinted in JCAE 1967/1968, op.cit., p. 196.

134. U.S. Navy, "Commissioning of United States Ship George Washington CVN-73, Norfolk, Virginia, July 4, 1992," July 1992, n.p.

135. Non-nuclear carriers are as fast as nuclear ones. Nuclear carriers are all rated as able to produce 280,000 shaft-horsepower. Yet so are many of the large conventional carriers: the USS Kitty Hawk class carriers all produce 280,000 shaft-horsepower, as does the USS Saratoga, USS Ranger, and USS Independence of the Forrestal class. During sea trials following overhaul in 1984, one of the U.S. Navy's older carriers, the USS Constellation (CV-64), achieved sustained full power runs in excess of 30 knots. It is total displacement, the shape of the hull, and the design of propellers which determine the maneuver speed, not uniquely the type of propulsion; *Ships and Aircraft of the U.S. Fleet*, op.cit., pp. 83, 86, 89, 91; USS Constellation (CV-64), "1984 Command History," n.d., Enclosure 2, p. 1.

136. The Navy may be reluctant to "push" the speed of its nuclear-powered aircraft carriers too much and too frequently. A nuclear reactor core has a "fixed" life which is determined by the burn-up rate of the uranium fuel. When a certain depletion is achieved, the core must be replaced. Pushing the carrier to flank speed means "burning" more uranium fuel, thus pushing the ship nearer to its expensive and time consuming refueling overhaul.

137. Helicopter Anti-Submarine Squadron Light Four Four, "HSL-44 Detachment Five End of Cruise Report," 24 April 1991, Enclosure 1, p. 1; partially declassified and released under the Freedom of Information Act.

138. Helicopter Anti-Submarine Squadron Light Four Two, "HLS-42 Det Three End of Cruise Report for Med 1-91," 22 July 1991, Enclosure 7, p. 8; partially declassified and released under the Freedom of Information Act.

139. Department of the Navy, Chief of Naval Operations, "The United States Navy in 'Desert Shield', 'Desert Storm'," Washington DC, 15 May 1991, p. A-56 (hereafter "Navy Gulf War").

140. Center for Naval Analysis, Adam Siegel, et.al., "Deployment of U.S. Navy Aircraft Carriers And Other Surface Ships, 1976-1988," CIM 51/July 1989, pp. 7-10 (hereafter "CNA 1989"); partially declassified and released under the Freedom of Information Act.

141. GAO 1993, op.cit., p. 74.

142. The cycle begins after the carrier has been launched or has completed a major overhaul or a nuclear refueling, and continues through completion of the next major overhaul.

143. GAO 1993, op.cit., p. 101.

144. Ibid., pp. 101, 104.

145. Ibid., p. 101.

146. Ibid., p. 102, footnote 2.

147. Ibid., p. 104 footnote 5.

148. Vice Admiral Hyman Rickover, Director, Naval Nuclear Propulsion Program, Seapower Subcommittee hearing on the FY 1979 Naval Nuclear Propulsion Program, HASC, FY 1979 DOE, 1 March 1979, p. 90.

149. Center for Naval Analysis, Adam B. Siegel, "The Use of Naval Forces in the Post-War Era: U.S. Navy and U.S. Marine Corps Crisis Response Activity, 1946-1990," CRM 90-246/February 1991, pp. 36-38 (hereafter "CNA 1991"); released under the Freedom of Information Act.

150. Captain E. E. Tissot, U.S. Navy, report on Indian Ocean deployment partially reprinted in Naval Nuclear propulsion Program hearing, HASC, FY 1979 DOE, 1 March 1978, p. 39.

151. Admiral James A. Lyons, Commander In Chief, Pacific Fleet, SAC, FY 1988 DOD, 4 March 1987, Part 1, p. 476; Emphasis in original.

152. Admiral Zumwalt, JCAE 1972, op.cit., p. 51.

153. The refractory in the super-heater cavity of #1A Boiler failed; USS John F. Kennedy (CV-67), "1970 Command History," Engineering Department, n.d., n.p.; Moreover, during the deployment, the carrier also experimented with so-called "economy runs" lasting for six hours; USS John F. Kennedy (CV-67), "1971 Command History," n.d. (1972), Enclosure 2, p. 1.

154. Department of the Navy, *United States Naval Aviation 1910-1980* (Washington, DC: 1981), NAVAIR 00-80P-1, p. 282 (hereafter "United States Naval Aviation").

155. The group consisted of the USS Nimitz (CVN-68) and the cruisers USS South Carolina (CGN-36) and USS Texas (CGN-39); Brent Baker, "Naval and Maritime Events 1979," *Proceedings*, Naval Review, May 1980, p. 230.

156. USS Nimitz (CVN-68), "1980 Command History," 7 March 1981, Enclosure 1, pp. 1, 4, 5, 7; partially declassified and released under the Freedom of Information Act.

157. Curiously, the USS Nimitz's deployment to the Indian Ocean is not listed by Center for Naval Analysis as part of the Afghan/Iran Hostage crisis response; CNA 1991, op.cit., p. 42.

Surprisingly, during the transit, the nuclear task force actually conducted two major underway replenishments, personnel transfers, and major propulsion plant drills; Letter from Commanding Officer, USS Nimitz (CVN-68), to Chief of Naval Operations, 21 July 1980, partially reprinted in 1981 Naval Nuclear Propulsion Program hearing, HASC, FY 1981 DOE, 9 March 1981, p. 28.

158. USS Kitty Hawk (CV-63), "1979 Command History," 22 March 1982, Enclosure 1, pp. 1-2; USS Kitty Hawk (CV-63), "1980 Command History," Enclosure 1, p. 1.

The arrival of the Nimitz was delayed because the carrier was forced to sail around Africa because the Canal had not yet been dredged to accommodate aircraft carrier size ships; U.S. Navy, CINCUSNAVEUR, "1980 Command History," 25 February 1981, p. III-11; partially declassified and released under the Freedom of Information Act.

But even if the Canal had been open to carriers at the time, Egypt prohibited nuclear-powered ships from using it.

159. See: Operational Archives, U.S. Naval History Division, Barbara Gilmore, "Chronology of U.S. Naval Events, 1979," 7 and 16 March and 7 and 16 April entries.

160. USS Nimitz (CVN-68), "1980 Command History," 7 March 1981, p. Enclosure 1, pp. 1, 4, 5, 7; partially declassified and released under the Freedom of Information Act.

161. Ironically, the USS Nimitz made a faster transit home than it accomplished to the Indian Ocean (the

average speed of the USS Nimitz was 1.3 knots faster during its home-trip (26.3 knots) than during its transit to the Indian Ocean)); USS Nimitz (CVN-68), "1980 Command History," 7 March 1981, p. Enclosure 1, pp. 1, 4, 5, 7; partially declassified and released under the Freedom of Information Act; Brent Baker, "Naval and Maritime Events 1980," *Proceedings*, Naval Review, May 1981, p. 64.

162. Brent Baker, "Naval and Maritime Events 1980," *Proceedings*, Naval Review, May 1981, p. 60.

163. *United States Naval Aviation*, op.cit., p. 325.

164. *Tonkin Gulf Yacht Club*, op.cit., p. 45.

165. Admiral T. B. Hayward, U.S. Navy, Chief of Naval Operations, SASC, FY 1981 DOD, Appropriation Hearing, Part 2, 27 February 1980, p. 786.

166. *United States Naval Aviation*, op.cit., p. 325.

167. Admiral T. B. Hayward, U.S. Navy, Chief of Naval Operations, HAC, FY 1981 DOD, Part 2, 19 February 1980, p. 619.

168. SAC, FY 1980 DOD, Part 4, p. 984; emphasis in original.

169. U.S. Navy, CINCUSNAVEUR, "1981 Command History," 13 April 1982, p. III-11; partially declassified and released under the Freedom of Information Act; USS Independent (CV-62), "Indian Ocean Deployment (U) 19 Nov 80-10 Jun 81," n.a. (1981), p. II-B-3; partially declassified and released under the Freedom of Information Act; Center for Naval Analysis, John D. Perse, "U.S. Naval Responses to International Incidents and Crises, 1976-1984 (U)," CRM 85-71/August 1985, pp. 22, 32, 33 (hereafter "CNA 1985"); released under the Freedom of Information Act.

170. CNA 1985, op.cit., pp. 33, 36, 37; U.S. Navy, CINCUSNAVEUR, "1982 Command History," 29 March 1983, p. III-7; partially declassified and released under the Freedom of Information Act.

171. CNA 1985, op.cit., pp. 33, 36, 37.

172. U.S. Navy, CINCUSNAVEUR, "1983 Command History," 31 May 1984, p. III-13; partially declassified and released under the Freedom of Information Act.

173. Fred Hiatt, "U.S. Nuclear Ship Uses Canal," *The Washington Post*, 6 November 1984, p. A28; Christopher C. Wright, "U.S. Naval Operations in 1984," *Proceedings*, Naval Review, May 1985, p. 44.

174. "Egypt Bars U.S. Carrier From Suez," *The Washington Post* (Reuters), 4 July 1986, p. 21.

175. Admiral Kinnaird McKee, U.S. Navy, Director Naval Nuclear Propulsion Program, Naval Nuclear Propulsion Program hearing, HASC, FY 1988 DOE, 26 February 1987, pp. 7-8.

176. Department of Defense, "Conduct of the Persian Gulf War: Final Report to Congress," April 1992, p. 28; Bob Woodward, *The Commanders* (New York, NY: Simon & Schuster, 1991), pp. 275-276.

177. Desert Storm Reconstruction Report, Volume IX, op.cit., p. 6-2.

178. *Reuter* (Cairo), "U.S. carrier transits Suez Canal into Mediterranean," 15 July 1993; "Shadowhawks' 'incredible journey' ends," *The Hook*, Winter 1993, p. 38.

179. *Tonkin Gulf Yacht Club*, op.cit., pp. 24, 26.

180. Ibid., pp. 27-28.

181. *United States Naval Aviation*, op.cit., p. 252.

182. Admiral Zumwalt, JCAE 1972, op.cit., p. 61.

183. *United States Naval Aviation*, op.cit., p. 253.

184. *Tonkin Gulf Yacht Club*, op.cit., p. 45.

185. The nuclear reactors reportedly were completely renovated during the 1964-1965 refueling; *USS Enterprise*, op.cit., p. 13; Admiral Rickover, JCAE 1972, op.cit., p. 150.

186. *Tonkin Gulf Yacht Club*, op.cit., p. 46.

187. *Tonkin Gulf Yacht Club*, op.cit., pp. 46, 72.

The USS Enterprise deployed once more after 15 August, as did seven other carriers; Naval Historical Center, Aviation History Branch, "Order of Battle for Carrier Forces in WESTPAC/Vietnam (1964-1975)," 21 November 1990 update, pp. 24-26 (hereafter "Order of Battle").

188. "Chronological Summary Concerning Nuclear Propulsion For Major Surface Warships," Joint Committee on Atomic Energy, 19 February 1968; as reprinted in JCAE 1967/1968, op.cit., p. 203; emphasis in original.

189. Rear Admiral Henry L. Miller, "Advantages of Nuclear Power and Its Utilization in a Combat Environment," 3 January 1966; as described in JCAE 1972, op.cit., p. 161.

This claim was restated by Admiral Rickover six years later in 1972, during the Congressional procurement debate for the USS Carl Vinson (CVN-70).

190. The USS Enterprise did deploy the largest all-jet Air Wing in the Navy at the time. But the larger jet-aircraft complement was a result of the size of the ship enabling the Wing to muster more sorties; USS Enterprise (CVAN-65), "USS Enterprise Cruise Report," 29 June 1966, Enclosure 1, p. XII-2, Serial 0489, Operational Archives, Naval Historical Center, Washington, D.C.

191. Order of Battle, op.cit., pp. 24, 25.

192. During deployment, carriers would often alter their air wings and take onboard additional squadrons or detachments from time to time. This would normally involve helicopters, tankers, or reconnaissance aircraft, but also could involve attack aircraft. The USS Enterprise -- like all carriers -- would sometimes have one or two extra detachments coming onboard during a deployment, but it did not take onboard more than other carriers. In fact, the carrier that took onboard most additional detachments during the war was the USS Ticonderoga, which from April to December 1964 took onboard as many as six squadrons/detachments in addition to the eight of its own airwing (note that the extra squadrons/detachments may not necessarily have come onboard at the same time); Ibid., pp. 1-2.

193. Rear Admiral Henry L. Miller, "Advantages of Nuclear Power and Its Utilization in a Combat Environment," 3 January 1966; as described in JCAE 1972, op.cit., p. 161.

194. Though both USS America and USS Independence in these instances spent more time than the USS Enterprise between in-chop and going on-station, this was due to operational circumstances unrelated to their propulsion.

195. *Tonkin Gulf Yacht Club*, op.cit., pp. 118, 132, 141, 161.

196. USS Enterprise (CVAN-65), "USS Enterprise Cruise Report," 29 June 1966, Enclosure 1, pp. XII-2, VI-5, Serial 0489, Operational Archives, Naval Historical Center, Washington, D.C.

197. Department of Defense News Release, OASD (Public Affairs), "Navy to transfer nuclear ships from Atlantic to Pacific," 22 March 1965.

198. Department of Defense News Release, OASD (Public Affairs), "Navy to transfer nuclear ships from Atlantic to Pacific," 22 March 1965; and Department of Defense News Release, OASD (Public Affairs), "Nuclear powered ships transfer to Pacific Fleet," 1 October 1965.

199. Paul Nitze, Secretary of the Navy, speech to the Navy League in Chicago, 27 October 1967; partially reprinted in JCAE 1972, op.cit., p. 200.

200. *Tonkin Gulf Yacht Club*, op.cit., pp. 132-135.

201. Ibid., pp. 135, 150, 163.

202. *Tonkin Gulf Yacht Club*, op.cit., pp. 17, 56, 60, 64.

203. Memorandum for the Secretary of the Navy from the Chief of Naval Operations concerning nuclear power for surface ships, "Appendix 1: Comparison of Advantages and Costs of Nuclear Carriers, Frigates, and Destroyers to Their Conventional Counterparts," 14 April 1966, as reprinted in JCAE 1967/1968, op.cit., p. 351.

204. *Tonkin Gulf Yacht Club*, op.cit., pp. 34, 45, 132.

205. Ibid., pp. 34, 45.

206. Ibid., pp. 34, 45, 135.

207. Ibid., pp. 34, 45, 134-135.

208. Ibid., p. 79; The numbers have been corrected from printing errors in the table listed by the source by using the figures from the detailed deployment chronology instead of the summery table.

209. *Tonkin Gulf Yacht Club*, op.cit., pp. 45, 97, 104.

210. *USS Enterprise*, op.cit., p. 10.

211. *United States Naval Aviation*, op.cit., p. 284.

212. USS Enterprise (CVAN-65), "USS Enterprise Cruise Report," 29 June 1966, Enclosure 1, p. XII-2, Serial 0489, Operational Archives, Naval Historical Center, Washington, D.C.

213. David Steigman, "Carrier concentration breaks 'Old' strategy," *Navy Times*, 26 November 1990, p. 22.

214. Patrick Pexton, "Navy leaves Gulf without a carrier," *Navy Times*, 5 July 1993, p. 4.

215. On 2 August, the JCS issued a Deployment Order for selected active components, including orders to the USS Independence to move to the North Arabian Sea; Department of the Army, After Action Report, Volume II, September 1991, Chronology, p. 1, partially declassified and released under the Freedom of Information Act.

216. "I also asked permission to pass one of our aircraft carriers through the Suez Canal," Cheney later described. "The carrier was the Eisenhower, which was deployed in the Med, and we wanted to immediately move it down to the Red Sea just north of the Saudi coast and provide air cover in case Saddam Hussein did make a move south. President Mubarak said when do you want to move the carrier? I said tonight. He said okay, and immediately signed up for it;" Department of Defense, Conduct of the Persian Gulf War: Final Report to Congress, April 1992, p. 28.

See also Bob Woodward, *The Commanders* (New York: Simon & Schuster, 1991), pp. 275-276.

217. Navy Gulf War, op.cit., pp. A-2, A-5.

218. Patrick Pexton, "Navy leaves Gulf without a carrier," *Navy Times*, 5 July 1993, p. 4.

219. Navy Gulf War, op.cit., pp. 30, A-2, A-3.

220. The ship arrived on station in the Red Sea on 12 January; Ibid., pp. A-9, A-13.

221. Ibid., pp. A-8, A-11.

222. USS John F. Kennedy (CV-67), "1990 Command History," 21 February 1991, Enclosure 2, p. 3; "Airwing chronology of events," Fighter Squadron 32 (FV-32), "End of Cruise Report," Enclosure 1, n.d.; partially declassified and released under the Freedom of Information Act.

Another Navy source reports the transit began on 23 August; Helicopter Anti-Submarine Squadron Light Four Four, "HSL-44 Detachment Five End of Cruise Report," 24 April 1991, Enclosure 1, p. 1; partially declassified and released under the Freedom of Information Act.

223. Navy Gulf War, op.cit., p. A-11.

224. USS America (CV-66), "1990 Command History," 29 March 1992, Enclosure 2, pp. 2, 3.

225. USS Theodore Roosevelt (CVN-71), "Green Sheet," Operations and Training Schedule, Tuesday, 8 Jan 1991, n.p.; partially declassified and released under the Freedom of Information Act.

226. Navy Gulf War, op.cit., pp. A-11, A-13.

227. David Steigman, "Carrier concentration breaks 'Old' strategy," *Navy Times*, 26 November 1990, p. 22.

The Nimitz group also included the nuclear-powered cruiser USS Texas (CGN-39), but was still assigned a fast combat support ship; Commander, US Seventh Fleet, "1991 Command History," 1992, p. 34; partially declassified and released under the Freedom of Information Act.

228. Department of Defense, "Conduct of the Persian Gulf War," (Title V), Chapter I through VIII, April 1992, p. 253 (hereafter "Title V").

229. The aircraft carrier that stayed in the Persian Gulf longest was the USS Ranger, which remained there from 15 January through 10 April; Center for Naval Analysis, Marvin A. Pokrant, "A View of Desert Shield and Desert Storm as Seen From COMUSNAVCENT (U)," CRM 91-271/October 1991, pp. 1-9, 1-10 (hereafter "A View of Desert Storm"); partially declassified and released under the Freedom of Information Act.

230. A View of Desert Storm, op.cit., pp. 4-6, 4-7.

231. Ibid., pp. 1-9, 1-10, 4-6, 4-7; USS Theodore Roosevelt (CVN-71), "Green Sheet," Operations and Training Schedule, Saturday, 19 January 1991; partially declassified and released under the Freedom of Information Act.

232. A daylight strike by EA-6B planes with HARM missiles on 20 January reportedly fired the first ordnance of the war from the USS Roosevelt. See VAQ-141, "Shaddowhawk War Cruise '91," (Briefing), n.d.; released under the Freedom of Information Act.

233. Though the Navy claims nuclear carriers are always ready to go on-station immediately after arrival in a theater, the USS Roosevelt did not begin flying sorties into Iraq or the Kuwait Theater of Operation until day five of the war (21 January) despite it being in striking range of Iraq from 15 January. Clearly not ready to begin combat after its Atlantic transit, the USS Roosevelt devoted a little over half of its sorties on 17 and 18 January for practice and training missions; Center for Naval Analysis, Frank Schwamb, et.al., "Desert Storm Reconstruction Report (U)," Volume II: Strike Warfare (U), CRM 91-178/October 1991, p. 1-12 (hereafter "Desert Storm Reconstruction Report, Volume II"); partially declassified and released under the Freedom of Information Act.

234. When the USS America left the Red Sea, the cycle changed to six days on-station and two days off for USS Kennedy and USS Saratoga, with overlap to provide some period of dual carrier operations. When one of the two carriers was in "gasoline alley" for the two-day replenishment, the other carrier stood all alerts. In addition to launching strikes, the on-cycle carrier flew combat air patrol aircraft and stood CTTG, while the off-cycle carrier stood AAW, AEW, CTTG, and ASUW alerts when both carriers were on-station. See: USS John F, Kennedy (CV-67), "1991 Command History," 24 February 1992, Enclosure 3, p. 2. Note that this schedule is only approximate.

235. Desert Storm Reconstruction Report, Volume II, op.cit., p. 1-18.

236. A View of Desert Storm, op.cit., pp. 1-9, 1-10, 3-3, 5-6.

237. Title V, op.cit., p. 252; emphasis in original.

238. The conventionally powered cruiser USS Princeton (CG-59) nearly broke its back when a mine exploded under it, and the amphibious carrier USS Tripoli (LPH-10) had a big hole blown in one side. The USS Princeton is only a thousand tons smaller than the two nuclear-powered cruisers participating in the war, USS Virginia and USS Mississippi. The USS Tripoli is several thousand tons bigger than any of the nuclear cruisers.

239. Desert Storm Reconstruction Report, Volume II, op.cit., p. D-1.

240. The USS Midway deployed with a "Coral Sea" air wing composition centered around F/A-18s and A-6Es, but with no F-14As.

241. The USS Ranger was scheduled to be modified in FY 1993 to operate F/A-18s, but the carrier has now been retired. Instead the USS Ranger deployed with the smallest air wing of the war -- only 54 fixed-wing aircraft -- centered around 14 A-6E Intruders and 20 F-14A Tomcats, more like a reduced Kennedy type air wing. The USS Saratoga and USS America both deployed with standard Transitional air wings, while the USS Kennedy deployed with what can be described as a modified Transitional wing with A-7E Corsair instead of F/A-18A Hornets. The USS Roosevelt deployed with a Transitional air wing.

242. Desert Storm Reconstruction Report, Volume IX, op.cit., p. 3-9.

243. Desert Storm Reconstruction Report, Volume II, op.cit., p. 1-4.

244. The USS America did not fly strike sorties on the first two days of the war, but conducted defensive air operations over the northern Red Sea and western Saudi Arabia. The carrier was first assigned strike tasking on 19 January when it conducted two strikes; Desert Storm Reconstruction Report, Volume II, op.cit., pp. 1-52, 1-53, 1-55, 1-56.

245. Navy Gulf War, op.cit., p. 39.

246. Ibid., pp. 35. 39.

247. USS John F, Kennedy (CV-67), "1991 Command History," 24 February 1992, Enclosure 3, p. 2.

248. Desert Storm Reconstruction Report, Volume II, op.cit., pp. xiii, 1-55, 7-35.

249. Ibid., p. 1-44.

250. Ibid., p. 1-46.

251. Carrier Handbook, op.cit., p. 28.

The extra fuel and ordnance capacity of the USS Roosevelt compared to the USS Kennedy claimed by the U.S. Navy is significantly higher than what is listed in the open military literature, which only credits nuclear carriers with about 35 percent extra jet fuel and ordnance storage capacity; *Combat Fleets of the World 1993*, op.cit., pp. 791-793, 794; *Jane's Fighting Ships 1993-94*, op.cit., pp. 766, 768; *Ships and Aircraft of the U.S. Fleet*, op.cit., pp. 83-84, 86-88.

252. Open military literature credit USS Roosevelt and USS Kennedy with the following approximate capacities:

	USS Roosevelt	USS Kennedy	Difference	Increase
Displacement*	96300	80940	15360	16%
Jet Fuel*	9000	5920	3080	34%
Ordnance*	1954	1250	704	36%
Crew	6200	5200	1000	16%

* In metric tons. Sources: *Combat Fleets of the World 1993*, op.cit., pp. 791-793, 794; *Jane's Fighting Ships 1993-94*, op.cit., pp. 766, 768; *Ships and Aircraft of the U.S. Fleet*, op.cit., pp. 83-84, 86-88.

253. Desert Storm Reconstruction Report, Volume II, op.cit., p. xvi.

254. Admiral Zumwalt, JCAE 1972, op.cit., p. 52.

255. *Jane's Fighting Ships 1990-91* (Alexandria, VA: Jane's Information Group Inc, 1990), pp. 728, 735.

256. Desert Storm Reconstruction Report, Volume II, op.cit., pp. xv, 5-4, 9-6, 9-7, 1-42, 1-43.

257. Ibid., p. 6-20.

258. Ibid., p. 3-9.

259. CAP missions were flown over the entire Persian Gulf, not just over carrier battle groups themselves; Rear Admiral Riley D. Mixson, U.S. Navy, Director Air Warfare, "Twilight of the Supercarrier," *Proceedings*, September 1993, p. 14.

260. Other sorties may also have been defensive in nature, since as many as 54 percent of the nuclear carrier's overall sorties were reported to have been expended on fleet defenses; Desert Storm Reconstruction Report, Volume II, op.cit., pp. 9-6--9-7.

261. Desert Storm Reconstruction Report, Volume II, op.cit., pp. xv, 9-6, 9-7.

262. A View of Desert Storm, op.cit., p. 1-14.

263. Desert Storm Reconstruction Report, Volume IX, op.cit., pp. 1-5, 4-21.

264. Ibid., pp. 7-13.

265. Admiral T. H. Moorer, Chairman, Joint Chiefs of Staff, report prepared by Systems Analysis Division and forwarded to the Secretary of the Navy on 15 September 1967; as cited in JCAE 1972, op.cit., p. 197.

266. As reflected in "C3 and C4 CASREP" status reports; Desert Storm Reconstruction Report, Volume IX, op.cit., pp. 6-3/4, 6-6.

During the first month of its deployment with the USS Kennedy carrier battle group in August 1990, the nuclear cruiser USS Mississippi was only free of C3 and C4 CASREPs 63 percent of the time. While this was not unusual compared with other conventional ships, the example shows that nuclear propulsion did not result in a ship being more ready for operations than non-nuclear ships.

267. A View of Desert Storm, op.cit., p. 4-24.

268. The peak included 22 CLF ships and 24 ships by 24 February; Desert Storm Reconstruction Report, Volume IX, op.cit., pp. 5-4, 5-5.

269. Ibid., p. 5-6.

270. Navy Gulf War, op.cit., p. 31.

271. Desert Storm Reconstruction Report, Volume IX, op.cit., p. 5-6.

272. Ibid., p. 2-1.

273. Ibid., pp. 1-1, 1-4, 5-1.

274. Ibid., p. 6-2.

275. The Roosevelt group was assigned two supply ships -- the ammunition ship USS Santa Barbara (AE-28) and the oiler USS Platte (AO-186). In addition, the USS San Diego (AFS-6) was assigned as material control office (MATCONOFF) and commodity manager for the group; Ibid., p. 5-7.

None of these ships can go faster than 20 knots; *Ships and Aircraft of the U.S. Fleet*, op.cit., pp. 223, 224, 259, and 265.

276. Desert Storm Reconstruction Report, Volume IX, op.cit., pp. 7-1, 7-2.

277. A View of Desert Storm, op.cit., pp. 3-3, 4-6.

278. Rear Admiral Riley D. Mixson, U.S. Navy, Director Air Warfare, "Twilight of the Supercarrier," *Proceedings*, September 1993, p. 14.

279. Desert Storm Reconstruction Report, Volume II, op.cit., pp. xiv, 7-35, 9-3.

280. Desert Storm Reconstruction Report, Volume IX, op.cit., pp. 5-10, 5-14.

281. Navy Gulf War, op.cit., p. 30.

282. Desert Storm Reconstruction Report, Volume IX, op.cit., pp. 1-1, 1-6.

283. Desert Storm Reconstruction Report, Volume II, op.cit., p. 6-7.

284. "CVW-8/CVN-71: CVW-8 Provides Comfort After Desert Storm," *The Hook*, Fall 1991, p. 62.

285. Desert Storm Reconstruction Report, Volume IX, op.cit., pp. 5-11, 5-12, 5-13, 5-14.

286. By January 1991, there were four station ships -- two AOEs, one AE, and one AOR (until it redeployed to the Persian Gulf in early February) -- available to rearm the Red Sea carrier battle force. When their ammunition loads were depleted through issues, the USS Seattle (AOE-3) and USS Santa Barbara (AE-28) replenished their cargo ordnance from two RRF ships configured as ammunition ships that were pre-positioned in January and February in the Red Sea; Ibid., pp. 5-13, 5-14.

287. USS John F. Kennedy (CV-67), "End of Tour Report 1991," Supply Department, 19 March 1991, n.p.; partially declassified and released under the Freedom of Information Act.

288. Desert Storm Reconstruction Report, Volume II, op.cit., p. 1-29.

289. Navy Gulf War, op.cit., p. A-25.

290. A variety of estimates of procurement, support cost, and life-cycle costs have been reported over the

years.

In 1970, the procurement costs of a Nimitz class nuclear carrier was estimated at about $950 million compared with $650 for a Kennedy class conventional carrier. The average procurement and operating costs of an attack carrier in the fleet in 1972 were reported at $184 million and $40 million per year, respectively, excluding the air wing. For comparison, Naval Shipbuilding and Conversion (SCN) funding for a *nuclear* carrier, assuming an optimum five-year program (1972-1976) to build three Nimitz class carriers, was estimated by the Naval Nuclear Propulsion Program in 1970 to be $1.814 billion, or $362.8 million a year; See: Admiral Elmo Zumwalt, Jr., Chief of Naval Operations, JCAE 1972, op.cit., pp. 72, 73; Vice Admiral Hyman Rickover, memorandum for the Chief of Naval Operations, 28 October 1970, as reprinted in JCAE 1972, op.cit., p. 280; Aircraft Carrier fact sheet reprinted in JCAE 1972, op.cit., p. 327.

In 1979, the Chief of Naval Operations told Congress that the 30-year life-cycle costs, excluding aircraft operations costs but including mid-life conversion of the ship, was nearly 10 percent greater for a nuclear carrier than for a conventional carrier ($6.31 billion versus $5.56 billion), corresponding to an average of over $210 million versus approximately $185 million per year, respectively; Admiral Thomas Hayward, Chief of Naval Operation, answers submitted to Congress in response to questions by Senator John Tower, SASC, FY 1980 DOD, Part 2, p. 582.

In 1986, the Navy stated that procurement of a conventional carrier would have cost approximately 50 percent less than the USS Theodore Roosevelt (CVN-71) if construction begun in FY 1979. However, the higher investment cost would be directly offset by the "elimination" of the cost of buying and delivering propulsion fuel oil, and the reduced cost of the logistic support forces due to less frequent replenishment of combat consumables stemming from the larger capacity of the CVN-71 for aviation fuel and ordnance." These savings, the Navy stated without providing details, would decrease the life-cycle cost difference so the nuclear carrier would be 2-5 percent greater than a modified Kennedy class carrier, corresponding to $86 million to $215 million more assuming one CVN costing $4.3 billion; Carrier Handbook, op.cit., pp. 28-29.

In 1993, the General Accounting Office estimated the annualized cost of a Nimitz class nuclear carrier is about $210 million compared with $180 million for a Kennedy class conventional carrier. Including procurement costs would increase the annual cost of the nuclear carrier additionally by over $60 million; GAO 1993, op.cit., pp. 54, 56, 57, 94.

Also in 1993, the Department of Defense told the Congress that the annual operating cost of the newest nuclear carrier is about $225 million; John Deutch, Under Secretary of Defense for Acquisition, prepared statement before the Senate Appropriations Subcommittee, 12 May 1993, SASC, FY 1994 DOD, Part 2, p. 599.

One recent source estimates the annual operating and support cost is higher for a conventional (Kennedy class) than a nuclear (Nimitz class) carrier, $185 million vs. 180 million. Yet even this estimate concludes that the annualized cost of a nuclear carrier is approximately 40 million higher than for a conventional carrier over a 30-50 year service period, or up to $2 billion in total; Ronald O'Rourke, Congressional Research Service, "Table 2: Procurement CV compared to procure CVN," p. CRS-4, information obtained from interview on 31 March 1994.

291. Department of Defense, "Adequacy of the Shipbuilding Industrial Base," Undersecretary of Defense (Acquisition & Technology), March 1994, p. 12 (hereafter "Shipbuilding Industrial Base").

292. In addition to nuclear carriers, nuclear attack submarine costs double the money allocated annually for nuclear surface ships construction, amounting to $1.2 billion in FY 1995 through FY 1999, and $2.2 billion beyond the year 2000. Combined, nuclear carriers and nuclear submarines account for nearly 40 percent ($2.4 billion) of the annual shipbuilding budget in FY 1995-1999, and 50 percent ($4.2 billion) beyond FY 2000. In FY 1994, however, nuclear-powered aircraft carriers and nuclear submarines accounted for only 15 percent of the 97 hulls the Navy plan to build; See: "Navy Estimates $600 Million per Year for A-6 Replacement Buy," *Inside the Navy*, 24 January 1994, p. 11; "Budget Squeeze brings howls," *Navy News & Undersea Technology*,

24 January 1994, p. 2; Shipbuilding Industrial Base, op.cit., p. 12.

For comparison, in 1972, the projected average Navy Shipbuilding and Conversion (SCN) funding for attack carriers over the following five years was reported at about 10 percent of the total projected SCN account, or one percent of the total projected Navy budget; Admiral Elmo Zumwalt, Jr., Chief of Naval Operations, JCAE 1972, op.cit., p. 72.

293. Nearly $830 was appropriated in FY 1993, but total long-lead funding was nearly $850 million; O'Rourke 1994, op.cit., p. 2; Department of Defense, "Program Acquisition Costs by Weapon System," Department of Defense Budget For Fiscal Year 1995, February 1995, p. 45.

294. Frank C. Conahan, Assistant Comptroller General for National Security and International Affairs, General Accounting Office, SASC, FY 1988 and 1989 DOD Authorization, Part 6, 7 April 1987, p. 3116.

295. Admiral Rickover, JCAE 1972, op.cit., pp. 113, 146.

296. Rear Admiral Richard D. Milligan, Director, Office of Budget and Reports, Department of the Navy, prepared statement before the Seapower and Critical Materials Subcommittee, HASC, FY 1993 DOD, 2 April 1992, p. 198.

297. "Cheney's final budget good for the Navy," *Navy News & Undersea Technology*, 25 January 1993, p. 5.

298. Admiral Hyman Rickover, Director, Naval Nuclear Propulsion Program, 1981 Naval Nuclear Propulsion Program hearing, HASC, FY 1982 DOE, 9 March 1981, p. 39.

299. Aspin 1994, op.cit., p. 104.

300. In February 1993, the General Accounting Office (GAO) reported operating and support costs for the USS Kennedy (the newest conventional carrier) at $180 million a year (not including costs associated with the air wing), compared with $210 for a Nimitz class carrier. This includes major maintenance and modernization, which is approximately $54 million and $80 million a year, respectively, for the USS Kennedy and USS Nimitz classes. Fourteen years earlier, in 1979, Admiral Hyman Rickover reported to Congress that the 30-year life-cycle cost of the USS Kennedy would be $5.5 billion, or $183 million a year (excluding the air wing), compared with "only" $5.7 billion ($190 million) for the USS Theodore Roosevelt (CVN-71) class carrier, or substantially lower than the GAO 1993 estimate; Vice Admiral Hyman Rickover, Director, Naval Nuclear Propulsion Program, Naval Nuclear Propulsion Program hearing, HASC, FY 1979 DOE, 1 March 1978, p. 78; GAO 1993, op.cit., pp. 54, 56, 57.

Conventional carriers are not subject to refueling overhauls but undergo Complex Overhauls (COH) normally lasting about 14 months and costing up to $1 billion. In addition, at the end of their 30-year service life, some conventional carriers have undergone SLEP (Service Life Extension Program) overhauls lasting 2-3 years, adding another 15 years to the ship's service life. USS Constellation began a SLEP in 1990 as the last conventional carrier to do so, and the USS Kennedy was scheduled to begin SLEP in 1993, but this was canceled although some modernization is scheduled to take place maintaining the ship as a training/reserve carrier under the Bottom-Up Review force level of 11 + 1 aircraft carriers; *Ships and Aircraft of the U.S. Fleet* op.cit., pp. 87, 91, 92; Bottom-Up Review, op.cit., pp. 28, 54.

301. The USS Nimitz (CVN-68) will begin a three-year refueling overhaul in 1998. See Aspin 1994, op.cit., p. 165.

302. Including subsequent availabilities, the nuclear refueling overhaul is estimated to reach $2.2 billion before the USS Enterprise can join the fleet again in mid-1995; U.S. Navy information from 8 April 1992 contained in House Appropriations Committee hearing (HAC, FY 1993 DOD), Part 5, p. 387; "Hotline allegations claimed $100 million; DOD IG Says Enterprise Nuclear Spill Will Cost Under $10 Million to Clean Up," *Inside the Navy*, 26 April 1993, p. 3.

303. GAO 1993, op.cit., pp. 54, 55, 56, 57, 77.

304. Vice Admiral Earl B. Fowler. Jr., Commander, U.S. Navy, Naval Sea Systems Command, prepared statement, SAC, DOD FY 1983, Part 2, p. 440.

305. This factor is particularly important at a time when the total number of carriers in the fleet continues to decline.

306. Admiral Hyman Rickover, Director, Naval Nuclear Propulsion Program, 1981 Naval Nuclear Propulsion Program hearing, HASC, FY 1982 DOE, 9 March 1981, pp. 14, 39.

307. O'Rourke 1994, op.cit., pp. 2, 4.

308. Navy testimony before the Congress in 1989, as quoted in GAO 1993, op.cit., p. 95; O'Rourke 1994, op.cit., p. 10.

309. Data collected is in then-year-dollars and is taken from annual Naval Nuclear Propulsion Program hearings in Congress, 1978-1993; DOE Congressional Budget Request, Naval Reactors, FY 1994 and 1995.

These activities are not necessarily earmarked for carriers but also include submarines, cruisers, land-based prototype reactors, and management. Nonetheless, the construction of CVN-76 as well as nuclear submarines is closely intertwined in maintaining a nuclear industrial base.

310. This does not include construction, operation, or decommissioning of nuclear-powered warships; Department of Energy, "FY 1995 Congressional Budget Request," Atomic Energy Defense Activities, Volume 1, February 1994, p. 502; Department of Defense, "Procurement Programs (P-1)," Department of Defense Budget For Fiscal Year 1995, February 1994, p. N-26, N-27; Department of Defense, "RDT&E Program (R-1)," Department of Defense Budget For Fiscal Year 1995, February 1994, pp. N-2, N-3, N-10.

311. Force 2001, op.cit., p. 52.

312. During a Congressional hearing in July 1993 on the shipment of spent nuclear fuel to INEL, Admiral Bruce DeMars was asked to provide the total cost of the facility for the record. In the final minutes from the hearing, however, his response is referring to the estimate provided at the hearing by the DOE; Thomas, P. Grumbly, Assistant Secretary of Energy for Environmental Restoration and Waste Management, SASC, hearing on the Shipment of Spent Nuclear Fuel From U.S. Navy Ships and Submarines to the Idaho National Engineering Laboratory (INEL), 28 July 1993, p. 120 (hereafter "Idaho Hearing").

Another $40 million is currently being spent on a dry cell project at the Expended Core Facility; ibid, p. 109.

313. Admiral Bruce DeMars, Idaho Hearing, op.cit., p. 109.

314. Department of Energy, "Information Regarding Costs Related to Spent Naval Reactor Fuel," letter to Greenpeace, 10 May 1993, in response to Freedom of Information Act request.

315. Admiral Bruce DeMars, Idaho Hearing, op.cit., p. 105.

316. Department of the Navy, "Report on Upgrading Naval Station Mayport to Homeport Nuclear-Powered Aircraft Carriers," 2 April 1993, p. 1; released under the Freedom of Information Act.

317. Governor Cecil D. Andrus, "ANDRUS: Agreement Radically Reduces Waste Volume To INEL; Navy Agrees To Comply With Court Mandates," Office of the Governor, Press Release, 9 August 1993, p. 1; Thomas P. Grumbly, assistant secretary of energy for environmental restoration and waste management, Idaho Hearing, op.cit., p. 157.

Of the approximately 1000 tons shipped to INEL, over 600 tons was reprocessed until the DOE's April 1992 decision to cease reprocessing of spent naval nuclear fuel. Reprocessing "creates enormous amounts of hazardous waste in addition to highly enriched uranium you reclaim which then has to be processed to a degree which causes radioactivity to go up the smokestack," Admiral DeMars told Congress in 1993. All of the extra waste generated from the reprocessing process remains at INEL; Idaho Hearing, pp. 119, 157.

318. Ibid., p. 149.

The cooling pond at INEL is currently being upgraded because of environmental concern. But while the Navy continues building nuclear-powered warships that will produce spent nuclear fuel well into the middle of the next century, the new pond will only be able to store spent naval fuel scheduled to be sent there through 2025; ibid., p. 105.

319. This does not include "classified radioactive components."

The amount produced annually has varied considerably, mainly depending upon the number of nuclear refueling/decommissioning work taking place that year. After a peak of nearly 120,000 cubic feet of waste produced in 1971, the production dropped to 25,000-55,000 cubic feet a year in the mid-1970s and early 1980s, but has continued to increase since then to over 100,000 cubic feet of waste produced in 1993. The annual volume is approximately nine (9) percent of the solid low-level radioactive waste generated annually by all [U.S.] nuclear electric power reactors and approximately seven (7) percent of the total volume of solid low-level radioactive waste buried in all U.S. commercial burial grounds each year; Department of the Navy, Naval Nuclear Propulsion Program, "Environmental Monitoring and Disposal of Radioactive Wastes From U.S. Naval Nuclear Powered Ships and Their Support Facilities," Report NT-93-1, February 1993, pp. 10, 12 (hereafter "Environmental Monitoring"); see also Senate Standing Committee on Foreign Affairs, Defense and Trade, "Visits to Australia by Nuclear Powered or Armed Vessels: Contingency planning for the accidental release of ionizing radiation," The Parliament of the Commonwealth of Australia, 1989, p. 67.

320. Department of Defense, Office of the Inspector General, "Hotline Allegations Relating to the Overhaul of the USS Enterprise," Audit Report No. 93-054, 19 February 1993, p. 6.

321. An investigation found "no fault" within the Navy's internal procedures for minimizing the risk of nuclear accidents; "Hotline allegations claimed $100 million; DOD IG Says Enterprise Nuclear Spill Will Cost Under $10 Million to Clean Up," *Inside the Navy*, 26 April 1993, p. 3; Department of Defense, Office of the Inspector General, "Hotline Allegations Relating to the Overhaul of the USS Enterprise," Audit Report No. 93-054, 19 February 1993, p. 3.

The nuclear reactors on the ship reportedly were not involved in the incident; Department of Defense, Office of the Inspector General, "Additional Hotline Allegations Relating to the Overhaul of the USS Enterprise," Audit Report No. 93-081, 2 April 1993, p. 3.

322. The record does not account for Tritium (half-life 12 years) or Carbon 14 (half-life 5,730 years), both of which the Navy says already exist in the natural environment in such large quantities that its own discharges would not raise the level "measurably." The amount of Tritium and Carbon 14 released annually is "less than 200 curies" and "less than 100 curies," respectively, "most of which" has been released more than 12 miles from shore; Environmental Monitoring, op.cit., pp. 6, 7, 8.

In terms of procedures and limits for ocean releases, the Navy specifically refers to recommendations made in two reports by the National Academy of Science--National Research Council and the International Atomic Energy Agency (IAEA), and states that actual releases have contained much less radioactivity than these reports considered would be acceptable. The two reports, however, are from 1959 and 1961, respectively.

323. T. Iltis and M. Miles, Nuclear Propulsion Division, Bureau of Ships, Department of the Navy, "Radioactive Waste Disposal From U.S. Naval Nuclear-Powered Ships," January 1959, as reprinted in International Agreements for Cooperation, 1967-68, Joint Committee on Atomic Energy, March 20, 1967, and June 25, 1968, Washington 1969, p. 157.

324. AP (San Diego), "Leaking Ship," 27 November 1992.

325. For an account of the situation, see Idaho Hearing, op.cit.

326. This includes naval shipyards at Portsmouth, ME, Norfolk, VA, Puget Sound, WA, and Pearl Harbor, HI. Of these, Norfolk and Puget Sound will remove a larger amount of spent nuclear fuel than other naval shipyards. The private shipyard at Newport News, VA, also defuel nuclear-powered warships. In addition to the shipyards, Environmental Impact Statements are also underway for the Kesselring site in West Milton, NY, where three land-based test reactors are operating, the Oak Ridge Reservation in Tennessee, as well as the Nevada Test Site; "New homes for spent fuel?," *Defense Cleanup*, 25 March 1994, p. 3.

327. Department of the Navy, Naval Nuclear Propulsion Program, "Environmental Assessment: Short Term Storage of Naval Spent Fuel," December 1993, p. 10.

328. Department of the Navy, "Procedures and Reporting Requirements for Nuclear Reactor and Radiological Accidents," OPNAV INSTRUCTION 3040.5B, 3 April 1981, pp. 1-2, For Official Use Only; partially declassified and released under the Freedom of Information Act.

329. Admiral Bruce DeMars, Idaho Hearing, op.cit., pp. 102-103.

330. Ibid., p. 110.

331. "Nuclear Navy avoids Clean Water Act," *Defense Cleanup*, 1 April 1994, pp. 1, 8.

332. Danish procedures demand that before a nuclear-powered ship is granted permission to enter a Danish port or Danish internal waters, the following documents must be available:

1) a safety report, approved by the authorities responsible for the vessel, providing a technical description of the nuclear plant onboard the ship which will enable the Danish authorities to evaluate the safety-related standards of the ship;

2) an emergency plan, approved by the Danish authorities, which specifies what measures to be implemented for the protection of the population in the event of its exposure to radiation, radioactive substances or other nuclear dangers;

3) a satisfactory liability agreement between the Danish authorities and the authorities responsible for the vessels, which covers such nuclear incidents as might be caused by the vessel and provides for objective liability and a high ceiling on the amount of damage;" "Subject: Danish policy on visits by nuclear-powered warships (NPW)," telegram from the U.S. Embassy in Copenhagen, Denmark, to the U.S. Embassy in Wellington, New Zealand, 25 May 1982, 11:43Z. Confidential; partially declassified and released under the Freedom of Information Act.

333. USS Nimitz (CVN-68), "1982 Command History," 9 April 1983, Enclosure 1, p. 1; partially declassified and released under the Freedom of Information Act.

334. USS Nimitz (CVN-68), "1983 Command History," 8 March 1984, Enclosure 1, p. 1; partially declassified and released under the Freedom of Information Act.

335. Admiral Bruce DeMars, Director, Naval Nuclear Propulsion, in Congress, HASC FY 1993 DOD, 7 April 1992, p. 84.

336. W. H. Wright, IV, Director, Operations, Plans and Politico-Military Affairs (N31/N52), Office of the Chief of Naval Operations, Department of the Navy, letter to Greenpeace in response to Freedom of Information Act request, 11 March 1993, p. 1.

Some ports were visited more than once, and between June 1991 and June 1992, nuclear submarines alone "conducted more than 200 port visits to more than 50 cities around the world"; Vice Admiral Roger F. Bacon, U.S. Navy, Assistant Chief of Naval Operations for Undersea Warfare, "Submarine Warfare It's A-Changing," *Proceedings*, June 1992, p. 52.

337. Fred Hiatt, "U.S. Nuclear Ship Uses Canal," *The Washington Post*, 6 November 1984, p. A28; Christopher C. Wright, "U.S. Naval Operations in 1984," *Proceedings*, Naval Review, May 1985, p. 44.

338. Admiral Kinnaird McKee, U.S. Navy, Director Naval Nuclear Propulsion Program, Naval Nuclear Propulsion Program hearing, HASC, FY 1988 DOE, 26 February 1987, pp. 7-8.

339. Other large warships were severely crippled by sea mines. The conventionally powered cruiser USS Princeton (CG-59) nearly broke its back when a mine exploded under it, and the amphibious carrier USS Tripoli (LPH-10) had a big hole blown in one side. The USS Princeton is only a thousand tons smaller than the two nuclear-powered cruisers participating in the war, USS Virginia and USS Mississippi. The USS Tripoli is several thousand tons bigger than any of the nuclear cruisers.

It is doubtful that salvage would have been possible if the USS Virginia or USS Mississippi -- or for that matter the USS Roosevelt -- had sunk and ended up on the bottom of the Persian Gulf with its nuclear reactors. According to the CNA, the "salvage assets put in place during the war would have been only marginally adequate to provide salvage support and assistance for naval forces if the Iraqi threat against these forces had

been more aggressive;" Desert Storm Reconstruction Report, Volume IX, op.cit., p. 1-5.

During its transit from the Red Sea to the Persian Gulf, the USS Roosevelt was illuminated by a Yemeni OSA II class missile patrol boat fire control radar for SSN-2-C missile; Helicopter Anti-Submarine Squadron Light Four Two, "HLS-42 Det Three End of Cruise Report for Med 1-91," 22 July 1991, Enclosure 7, p. 8; partially declassified and released under the Freedom of Information Act.

340. Bert Kinzey, *The USS Enterprise: The World's First Nuclear Powered Aircraft Carrier* (Blue Ridge Summit, PA.: TAB Books, Detail & Scale, INC, 1991), p. 11; *Tonkin Gulf Yacht Club*, op.cit., p. 64.

341. Admiral Elmo Zumwalt, JCAE 1972, pp. 68-69, 81.

342. Vice Admiral Kent L. Lee, U.S. Navy (Retired), "As I recall…Inferno in the Enterprise," *Proceedings*, December 1988, p. 133.

Following the accident, the Naval Weapons Evaluation Facility (NWEF) at Kirtland Air Force Base in Albuquerque, MN, was asked to standardize ordnance handling and storage procedures. Soldiers particularly needed to know how to protect nuclear weapons and nuclear propulsion plants from conventional weapons accidents; William M. Arkin and Robert S. Norris, "Naval base goes into dry dock," Nuclear Notebook, *Bulletin of the Atomic Scientists*, September 1993, p. 56.

343. Carrier Handbook, op.cit., p. 12.

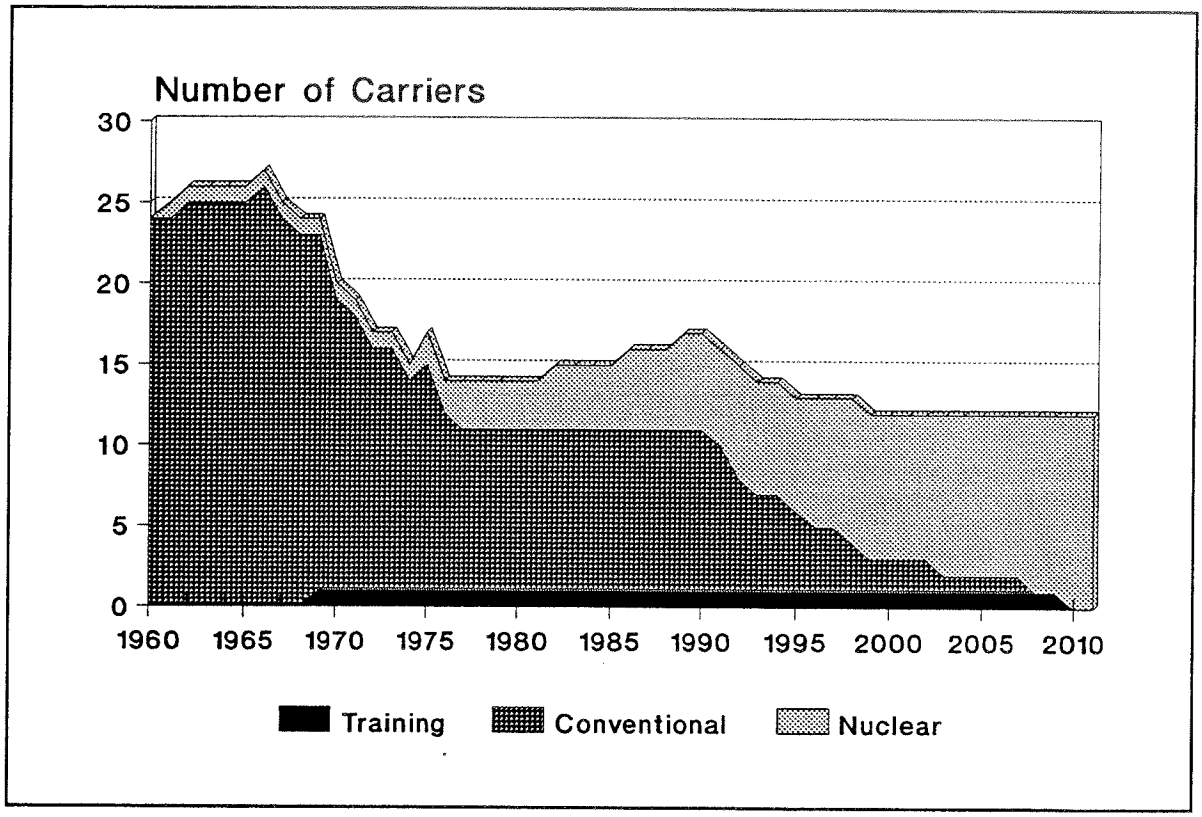
344. O'Rourke 1994, op.cit., p. 9.

345. *Carrier 21*, op.cit., p. 87.

346. Ibid., p. 82.

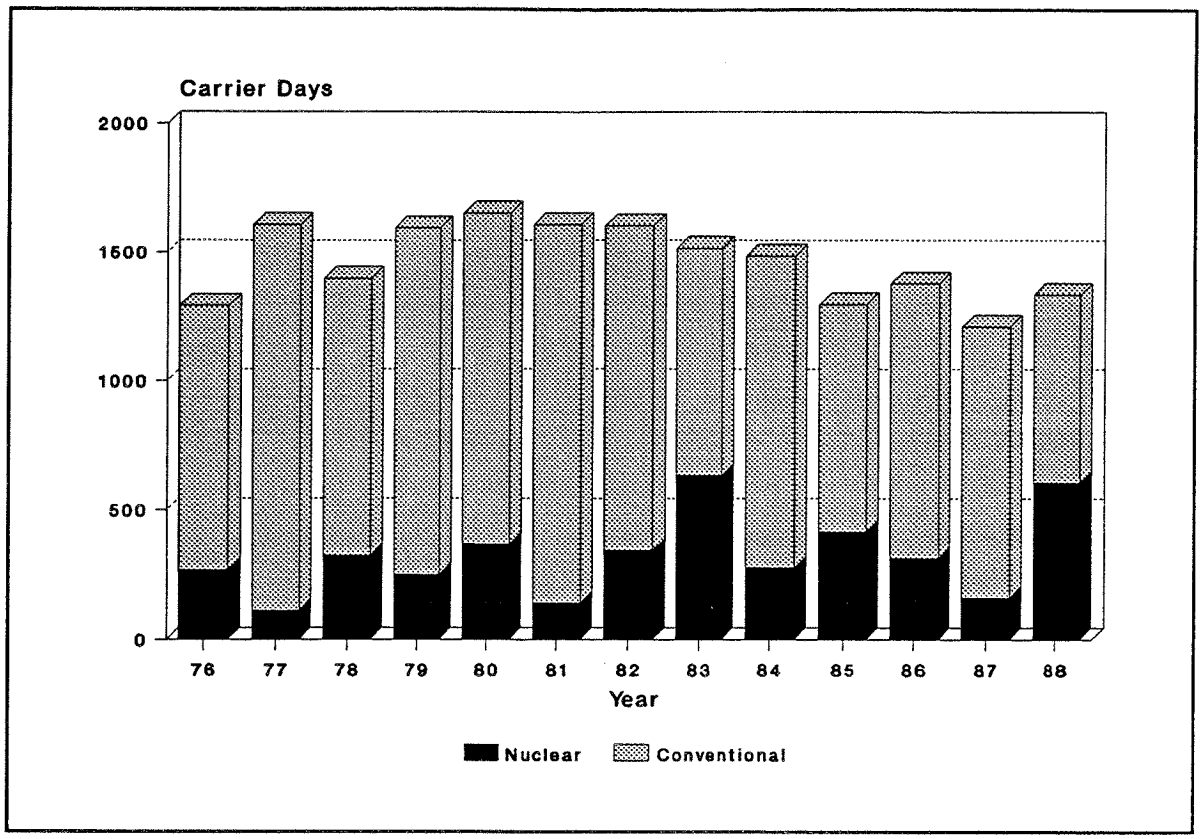
Tables

Table 1:
Carrier Force Composition (1960-2011)



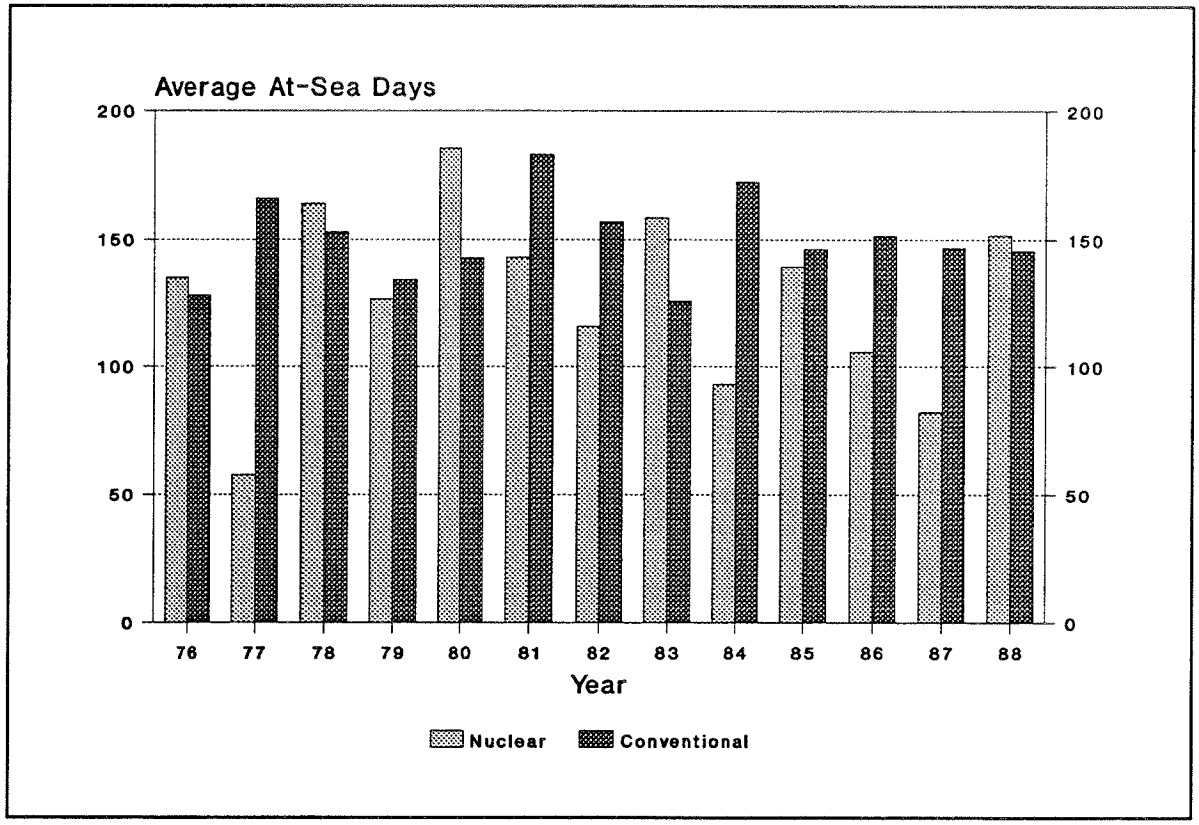
Note: Under current plans as of 1994.

Table 2:
Total Carrier Deployment-Days (1976-1988)



Note: Total at-sea days accumulated by nuclear and conventional aircraft carriers.

Table 3:
Average At-Sea Days Per Carrier Type (1976-1988)



Note: Average at-sea days per carrier type is calculated by dividing total at-sea days for a particular year by the number of nuclear or conventional carriers deploying that year.

Table 4:
Deployments of Nuclear and Conventional Carriers in Major Crises and Exercises (1980-1992)[1]

Crisis and Exercise	Year	Carrier(s) Deployed (Nuclear)	(Conventional)
Iran Hostage Taking/ Afghanistan	1979	none	USS Midway (CV-41)[2] USS Kitty Hawk (CV-63)[3]
South Korea/assassination	1979	none	USS Kitty Hawk (CV-63)[4]
Iran/Indian Ocean[5]	1980	USS Nimitz (CVN-68)[6] USS Eisenhower (CVN-69)	USS Midway (CV-41) USS Coral Sea (CV-43) USS Independence (CV-62) USS Kitty Hawk (CV-63) USS Constellation (CV-64)
Teamwork 80	1980	USS Nimitz (CVN-68)	none
Israel/Syria crisis	1981	none	USS Forrestal (CV-59) USS Independence (CV-62)
Ocean Safari 81	1981	USS Eisenhower (CVN-69)	none
Northern Wedding 82	1982	none	USS America (CV-66)
Libya/Sudan crisis	1983	USS Nimitz (CVN-68)	none
Honduras/Nicaragua crisis	1983	none	USS Coral Sea (CV-43) USS Ranger (CV-61)
Libya/Chad crisis	1983	USS Eisenhower (CVN-69)	USS Coral Sea (CV-43)
Beirut barracks bombing	1983	USS Eisenhower (CVN-69)[7]	USS Ranger (CV-61)[8]
Team Spirit 83[9]	1983	USS Enterprise (CVN-65)	USS Midway (CV-41)
Iran/Iraq crisis	1983	none	USS Ranger (CV-61)[10]
Korea/Burma crisis	1983	USS Carl Vinson (CVN-70)[11]	none
FleetEx 83[12]	1983	USS Enterprise (CVN-65)	USS Midway (CV-41) USS Coral Sea (CV-43)
Grenada	1983	none	USS Independence (CV-62)[13]
US/Syria crisis[14]	1983	none	USS Independence (CV-62) USS John F. Kennedy (CV-67)
El Salvador/Nicaragua	1984	none	USS America (CV-66)
Teamwork 84	1984	none	USS Independence (CV-62)[15]
FleetEx 84[16]	1984	USS Enterprise (CVN-65) USS Carl Vinson (CVN-70)	USS Ranger (CV-61) USS Kitty Hawk (CV-63)
Saudi airline hijacking	1984	USS Enterprise (CVN-65)[17]	none
Beirut embassy evacuation	1985	USS Eisenhower (CVN-69)[18]	none
TWA airline hijacking	1985	USS Nimitz (CVN-68)[19]	none
Ocean Safari 85[20]	1985	USS Eisenhower (CVN-69)	USS Saratoga (CV-60) USS America (CV-66)
Achille Lauro hijacking	1985	none	USS Saratoga (CV-60)[21]
Egypt Air hijacking	1985	none	USS Coral Sea (CV-43)[22]
Libya Bombing	1986	none	USS Coral Sea (CV-43)[23] USS America (CV-66)
Pakistan hijacking	1986	none	USS Forrestal (CV-59)[24]
Northern Wedding 86	1986	USS Nimitz (CVN-68)	none
Lebanon hostage crisis	1987	none	USS John F. Kennedy (CV-67)[25]
Northern Wedding 87	1987	none	USS Forrestal (CV-59)
Seoul Olympics[26]	1988	USS Nimitz (CVN-68)	USS Midway (CV-41)

Teamwork 88	1988	USS Roosevelt (CVN-71)	USS Forrestal (CV-59)
Maldives/Coup	1988	USS Nimitz (CVN-68)[27]	none
Lebanon crisis	1989	USS Roosevelt (CVN-71)[28]	none
North Star 89	1989	none	USS America (CV-66)
Panama elections	1989	USS Eisenhower (CVN-69)[29]	none
Hostages/Lebanon[30]	1989	none	USS Coral Sea (CV-43) USS America (CV-66)
Philippine/Coup	1989	USS Enterprise (CVN-65)	USS Midway (CV-41)
Just Cause/Panama[31]	1990	none	none
Liberia evacuation[32]	1990	none	none
Somalia evacuation[33]	1991	none	none
Desert Storm/Iraq	1991	USS Roosevelt (CVN-71)	USS Midway (CV-41) USS Saratoga (CV-60) USS Ranger (CV-61) USS America (CV-66) USS John F. Kennedy (CV-67)
North Star 91	1991	none	USS America (CV-66)
Teamwork 92	1992	USS Eisenhower (CVN-69)	none

Endnotes:

1. Unless noted, data is from Center for Naval Analysis, Adam B. Siegel, "The Use of Naval Forces in the Post-War Era: U.S. Navy and U.S. Marine Corps Crisis Response Activity, 1946-1990," CRM 90-246/February 1991, pp. 42-51; released under the Freedom of Information Act.

2. On 9 November 1979, USS Midway was ordered to deploy to the region by 20 October.

3. The USS Kitty Hawk was ordered into the region on 20 November 1979.

4. The USS Kitty Hawk was ordered to a position south of Korea following the assassination of South Korean President Park Chung Hee. DEFCON 3 was declared on 26 October, and returned to normal on 5 November.

5. Department of the Navy, *United States Naval Aviation 1910-1980* (Washington, DC: 1981), NAVAIR 00-80P-1, p. 325.

6. Helicopters from the USS Nimitz carried out the ill-fated hostage rescue attempt that was aborted after two helicopters crashed in Iran.

7. On 29 August, the USS Eisenhower was ordered to return to the Eastern Mediterranean at "best speed" as the Beirut situation worsened, with gun battles and a growing number of USMC casualties. U.S. Marines had retaliated the day before, and the first naval gunfire support was provided by USS Bowen (FF-1079). The Pacific Amphibious Ready Group (ARG) arrived on 12 September, and the USS New Jersey (BB-62) arrived on 25 September to provide naval gunfire support. The USS Eisenhower has authorized to leave the Beirut area on 4 October, preceding the ARG which returned to the PACOM via the Suez Canal on 9 October.

8. After a suicide bomber struck the Marine Corps barracks in Beirut on 23 October, killing 241, the USS Ranger was diverted from port calls in Australia to the North Arabian Sea, where it operated for 122 days.

9. Glen Jochum, U.S. Navy, "Team Spirit '83 Amphibious Assault Operations," *Asia-Pacific Defense Forum*, Fall 1983, p. 16.

10. Following an 18 September Iranian threat to block oil exports from the Persian Gulf, and Amphibious Ready Group (ARG) was deployed to the Indian Ocean on 8 October. Two days later, USS Ranger arrived in the northern Arabian Sea. The carrier, which had been scheduled to depart the region on 18 October, remained through the new year.

11. The USS Carl Vinson's return to the United States was delayed during the U.S. Secretary of Defense's attendance at funeral ceremonies for the 21 South Korean officials killed by a North Korean bomb in Burma. The carrier operated in waters off Pusan, South Korea, to underscore the U.S. commitment to South Korea.

12. Australian National University, "Eyeball to Eyeball: US & Soviet Naval & Air Operations In The North Pacific, 1981-1990," Pauline Kerr, Peace Research Centre, Research School of Pacific Studies, 1991, p. 70.

13. On 20 October, the USS Independence was enroute to the Mediterranean together with an Amphibious Ready Group (ARG) when it was diverted to sail to the vicinity of Grenada to signal U.S. concern about events on the island. On 25 October, Marines and U.S. Army rangers landed on the island, and by 27 October, all major objectives had been secured. On 4 November, USS Independence and the ARG renewed their transit to the Mediterranean.

14. After two F-14s flying over Lebanon were fired upon by anti-aircraft artillery on 3 December, aircraft from USS Independence and USS Kennedy retaliated the following day with strikes against antiaircraft positions.

15. Teamwork 84 was reported as "the largest amphibious exercise ever conducted in NATO's history and the first large-scale one conducted under arctic conditions;" "NATO's Largest Amphibious Exercise," *Marine Corps Gazette*, May 1984, p. 8.

16. A total of five carrier battle groups took part in the Fleetex operations; Christopher C. Wright, "U.S. Naval Operations in 1984," *Proceedings*, Naval Review, May 1985, pp. 44, 297.

17. The USS Enterprise was ordered to the northern Arabian Sea on 5 November following a Saudi airliner to Iran. The order was canceled the following day.

18. Following threats against U.S. personnel at the U.S. Embassy in Beirut, the USS Eisenhower was diverted from Mallorca, Spain, to the eastern Mediterranean while U.S. personnel were evacuated by helicopter to Cyprus.

19. After TWA Flight 847 was hijacked to Beirut by Shiite terrorists, the USS Nimitz was ordered from Italy to the eastern Mediterranean on 14 June, along with the Mediterranean Amphibious Ready Group (MARG), where it stayed on station until 24 July following the release of passengers and aircraft.

20. The exercise was described as "the most ambitious peacetime exercise in the protection of merchant shipping ever held, approaching the kind of scale which might apply in real period of tension;" "NATO EXERCISES," *NATO's Sixteen Nations*, 5 September 1985, p. 81.

21. On 7 October, the USS Saratoga was ordered to the easter Mediterranean in response to the Palestinian terrorist hijacking of the Italian cruise ship Achille Lauro. Three days later, F-14 aircraft from the USS Saratoga forced an Egyptian airliner with the hijackers aboard to land in Italy.

22. After an Egyptian airliner was hijacked to Malta on 23 November, USS Coral Sea was moved toward Malta for contingency purposes.

23. On 14 April 1986, in response to the bombing of La Belle Discotheque in Berlin on 5 April, aircraft from the USS Coral Sea and USS America, as well as USAF FB-111s from Lakenheath AFB in England, bombed targets in Libya. Elements of the Mediterranean Amphibious Reaction Group stood off the coast for rescue operations in necessary.

24. Following the hijacking of a Pakistani airliner, the USS Forrestal was ordered to head toward the eastern Mediterranean in case the aircraft took off for Cyprus or Beirut. Because this didn't happen, the carrier was soon released for normal operations.

25. The USS Kennedy was ordered to a MODLOC (Modified Location) off Lebanon for potential evacuation operations in response to growing tension over hostages in Lebanon.

26. Fear of North Korean disrupter of the Summer Olympics in Seoul prompted the U.S. to deploy naval forces off the Peninsula as deterrence. At one point both USS Nimitz and USS Midway were operating in the Sea of Japan.

27. The USS Nimitz was put on alert to provide a U.S. presence near the Maldives, but the movement was canceled after Indian troops sent to the island chain repelled the attempted coup.

28. In mid-February, following intensified fighting near the U.S. Embassy, a Mediterranean Amphibious Ready Group was ordered to the easter Mediterranean for potential evacuation operations with the USS Roosevelt providing covering force.

29. The USS Eisenhower formed part of the U.S. naval contingency alert in response to a violent election campaign in Panama and annulment of the results by Panamanian President Noreiga.

30. Following the Israeli capture of Sheik Obeid and Shiite claims that Lt.Col. William R. Higgins, USMC, had been killed in Lebanon, U.S. naval forces were ordered to steam toward Lebanon and Iran. The USS Coral Sea left a port call in Alexandria, Egypt, ahead of time, and the USS America was ordered from Singapore to the Arabian Sea.

31. The operation included the largest special force operations since the Vietnam War, involving more than 4,000 troops including a large number of Navy SEALs, but no aircraft carrier took part.

32. The evacuation, the largest since the U.S. evacuation from Saigon in 1975, only involved amphibious forces.

33. Two weeks before the attack against Iraqi forces began in Operation Desert Storm on 17 January, the amphibious ships USS Guam (LPH-9) and USS Trenton (LPD-14) were ordered from the North Arabian Sea to Mogadishu to evacuate the U.S. Embassy. By 6 January, 281 people were evacuated to the ships. No aircraft carrier took part in the operation.

Table 5:
Squadrons Per Carrier Deployment (Vietnam War)

Ship Name (hull-number)	Squadrons on Deployment[a] Nine	Ten	Total Deployments
USS Enterprise (CVN-65)	4	2	6
USS Ticonderoga (CV-14)	4	1[b]	5
USS Bon Homme Richard (CV-31)	5	0	6[c]
USS Oriskany (CV-34)	6	0	7[c]
USS Midway (CV-41)	3	0	3
USS Coral Sea (CV-43)	6	1	7
USS Ranger (CV-61)	4	3	7
USS Independense (CV-62)	1	0	1
USS Kitty Hawk (CV-63)	5	1	6
USS Constellation (CV-64)	6	1	7
USS America (CV-66)	2	1	3

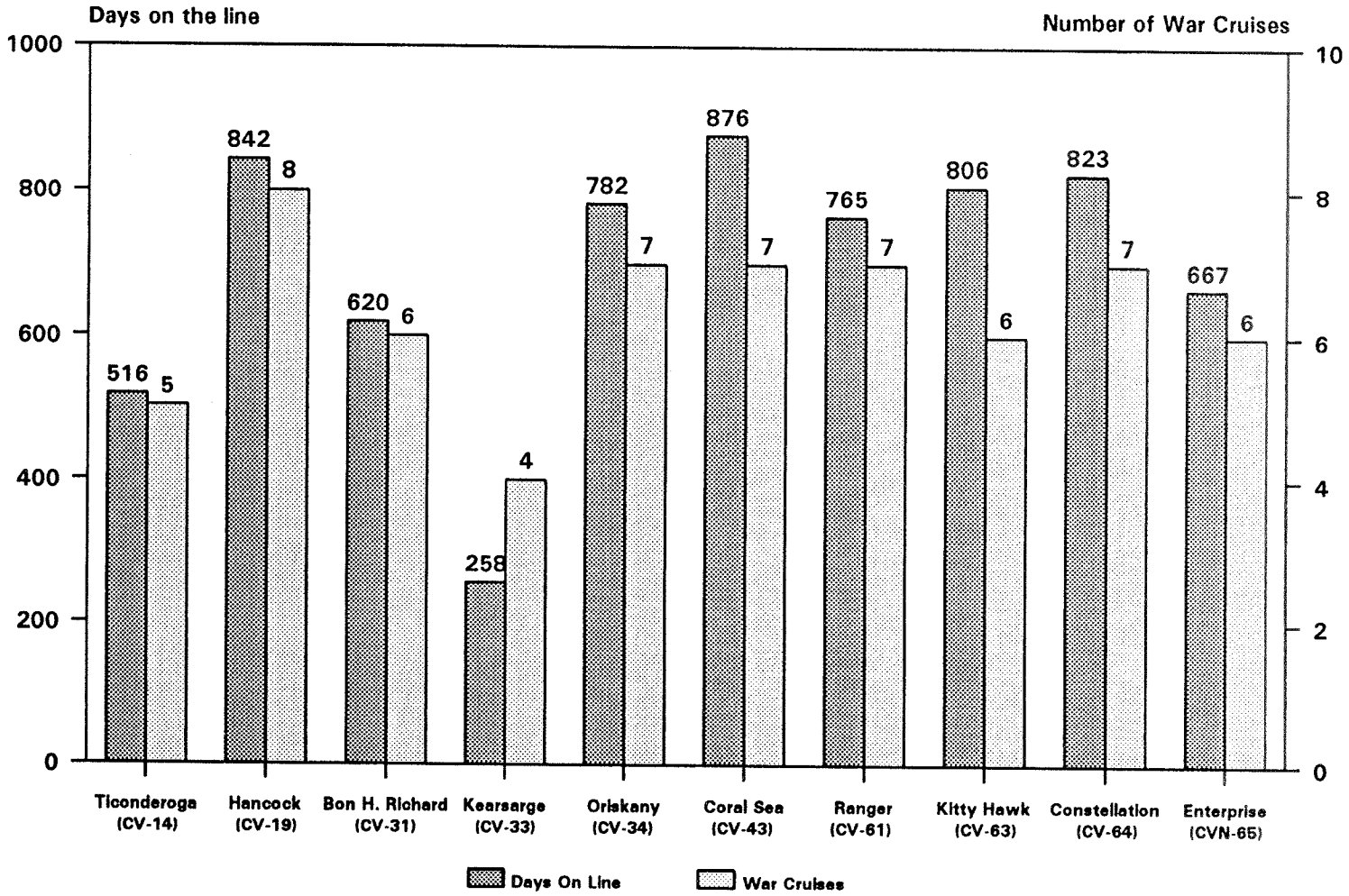
[a] Naval Historical Center, Aviation History Branch, "Order of Battle for Carrier Forces in WESTPAC/Vietnam (1964-1975)," 21 November 1990 update.
[b] Another source lists this deployment with only nine squadrons (*Tonkin Gulf Yacht Club*, op.cit., p. 164).
[c] One of these was with eight squadrons.

Table 6:
Carrier Group Effectiveness (Vietnam War)

Ship Name (hull-number)	# On-Line Percent Time Max	Min	Average
USS Kitty Hawk (CV-63)	79.3	55.2	69.5
USS Coral Sea (CV-43)	76.8	64.0	67.6
USS Enterprise (CVN-65)	77.8	44.9	66.3
USS Oriskany (CV-34)	73.1	58.8	66.1
USS Constellation (CV-64)	75.7	49.7	65.7
USS Hancock (CV-19)	74.5	43.3	64.8
USS Ranger (CV-61)	69.1	55.7	63.4

Note: Effectiveness is a measure of the time recorded on-line during combat operations, excluding steaming time to and from the theater.

Table 7:
Carrier Operations (Vietnam War)



Source: René J. Francillon, "Tonkin Gulf Yacht Club," Annapolis, MD: Naval Institute Press, 1988, p. 79.

Note: The on-line numbers have been corrected for printing errors in the table listed by the source

Table 8:
Nuclear vs. Conventional Carrier On-Line Periods (Vietnam War)[1]

	USS Enterprise (CVN-65)	USS Hancock (CV-19)	USS Oriskany (CV-34)	USS Coral Sea (CV-43)	USS Ranger (CV-61)	USS Kitty Hawk (CV-63)	USS Constellation (CV-64)
Number of War Deployments (Rank)	6 (#3)	8 (#1)	7(#2)	7 (#2)	7 (#2)	6 (#3)	7 (#2)
Total Days Deployed	1365 (#7)	1892 (#1)	1595 (#5)	1793 (#2)	1630 (#4)	1442 (#6)	1771 (#3)
Average per deployment	227.5 (#7)	236.5 (#4)	227.9 (#6)	256.1 (#1)	232.9 (#5)	240.3 (#3)	253.0 (#2)
Days On-line	667 (#7)	842 (#2)	782 (#5)	876 (#1)	765 (#6)	806 (#4)	823 (#3)
Average per deployment	111.2 (#5)	105.3 (#7)	111.7 (#4)	125.1 (#2)	109.3 (#6)	134.3 (#1)	117.6 (#3)
Days Off-line	339 (#7)	458 (#1)	401 (#5)	419 (#4)	442 (#2)	344 (6)	429 (#3)
Average per deployment	56.5 (#5)	57.3 (#4)	57.3 (#4)	59.9 (#3)	63.1 (#1)	57.3 (#4)	61.3 (#2)
Number of On-line Periods	28 (#6)	41 (#1)	36 (#3)	36 (#3)	34 (#4)	31 (#5)	40 (#2)
Average per deployment	4.7 (#5)	5.1 (#3)	5.1 (#3)	5.1 (#3)	4.9 (#4)	5.2 (#2)	5.7 (#1)

[1] Data compiled from René J. Francillon, *Tonkin Gulf Yacht Club* (Annapolis, MD: Naval Institute Press, 1988), Appendix 1: Combat Cruises, pp. 116-171.

Table 9:
Carriers Deployments to Persian Gulf Region (Gulf War and Afterwards)
(August 1990 - June 1993)[1]

Ship Name (hull-number)	Number of Deployments	Length of Deployments[2]	Percentage of type deployed	Percentage of all deployed
Conventional Carriers				
USS Midway (CV-41)	1	5.0	13.2	9.1
USS Saratoga (CV-60)	2	7.5	19.7	13.6
USS Ranger (CV-61)	2	5.0	13.2	9.1
USS Independence (CV-62)	2	7.0	18.4	12.7
USS Kitty Hawk (CV-63)	1	3.0	7.9	5.5
USS America (CV-66)	2	5.5	14.5	10.0
USS John F. Kennedy (CV-67)	2	5.0	13.2	9.1
Subtotal	12	38	100[3]	69.10
Nuclear Carriers				
USS Nimitz (CVN-68)	2	7.0	41.2	12.7
USS Dwight D. Eisenhower (CVN-69)	2	5.5	32.4	10.0
USS Theodore Roosevelt (CVN-71)	1	2.0	11.8	3.6
USS Abraham Lincoln (CVN-72)	1	2.5	14.7	4.5
Subtotal	6	17	100[3]	30.80
Total	18	55	100[3]	100[2]

[1] Source: Patric Pexton, "Navy leaves Gulf without a carrier," *Navy Times*, 5 July 1993, p. 4.
[2] Length listed in months.
[3] Numbers do not add up due to rounding.

Table 10:
Aircraft Sorties From Carriers (Gulf War)[1]

Ship (hull-number)	Sorties				Performance	
	Strike[2]	Defense[3]	Other[4]	Total	Bombing Days[5]	Sorties per Day
Red Sea						
USS Saratoga (CV-60)	923	712	739	2374	32	74.2
USS John F. Kennedy (CV-67)	1148	611	815	2574	33	78.0
Subtotal	2071	1323	1554	4948	32.5	76.1
Persian Gulf						
USS Midway (CV-41)[6]	1660	665	694	3019	34	88.8
USS Ranger (CV-61)	1278	1004	1047	3329	39	85.4
USS America (CV-66)[7]	1013	633	1026	2672	31	86.2
USS Theodore Roosevelt (CVN-71)	1624	1240	1285	4149	39	106.4
Subtotal	5575	3542	4052	13169	35.8	91.7
Total	**7646**	**4865**	**5606**	**18117**	**34.7**	**86.5**

[1] Center for Naval Analysis, Ronald Nickel, et.al., "Desert Storm Reconstruction Report (U)," Appendix IX: Statistics of Carrier Fixed-Wing Flight Operations During Operation Desert Storm (U), CRM 91-185/October 1991, pp. D-1-35; partially declassified and released under the Freedom of Information Act.

[2] Includes Offensive Counter Air (OCA), theater strike, maritime strike, and SEAD/EW. F-14 OCA sorties, however, are not counted since F-14 did not drop bombs.

[3] Includes Defense Counter Air (DCA) and F-14 Offensive Counter Air (OCA).

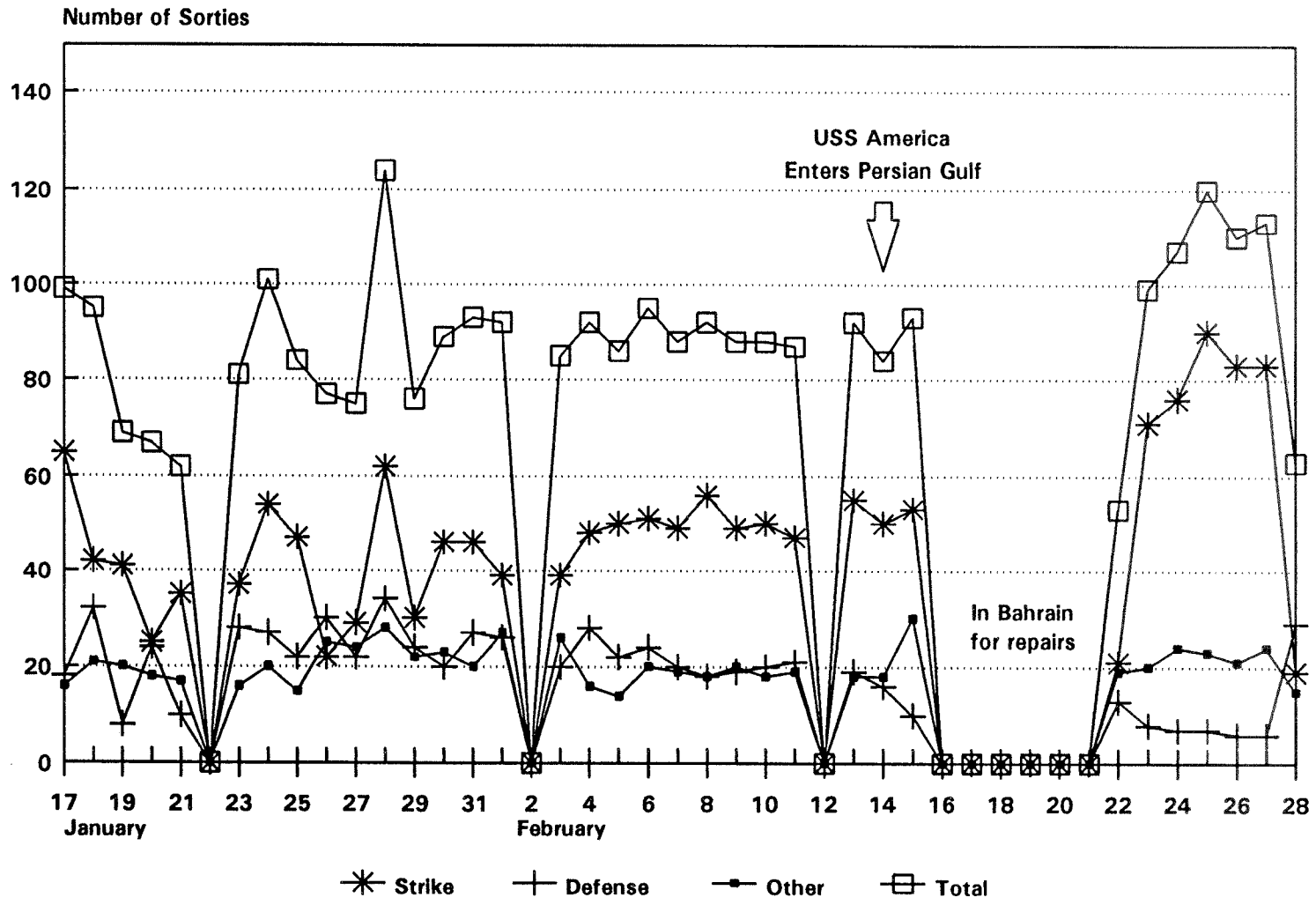
[4] Includes tanking, combat support, general support, and unknown missions.

[5] Those days on-line or not in transit. Days with less than 10 sorties are not included.

[6] Unlike the other carriers, which are equipped with four steam catapults, USS Midway has only two.

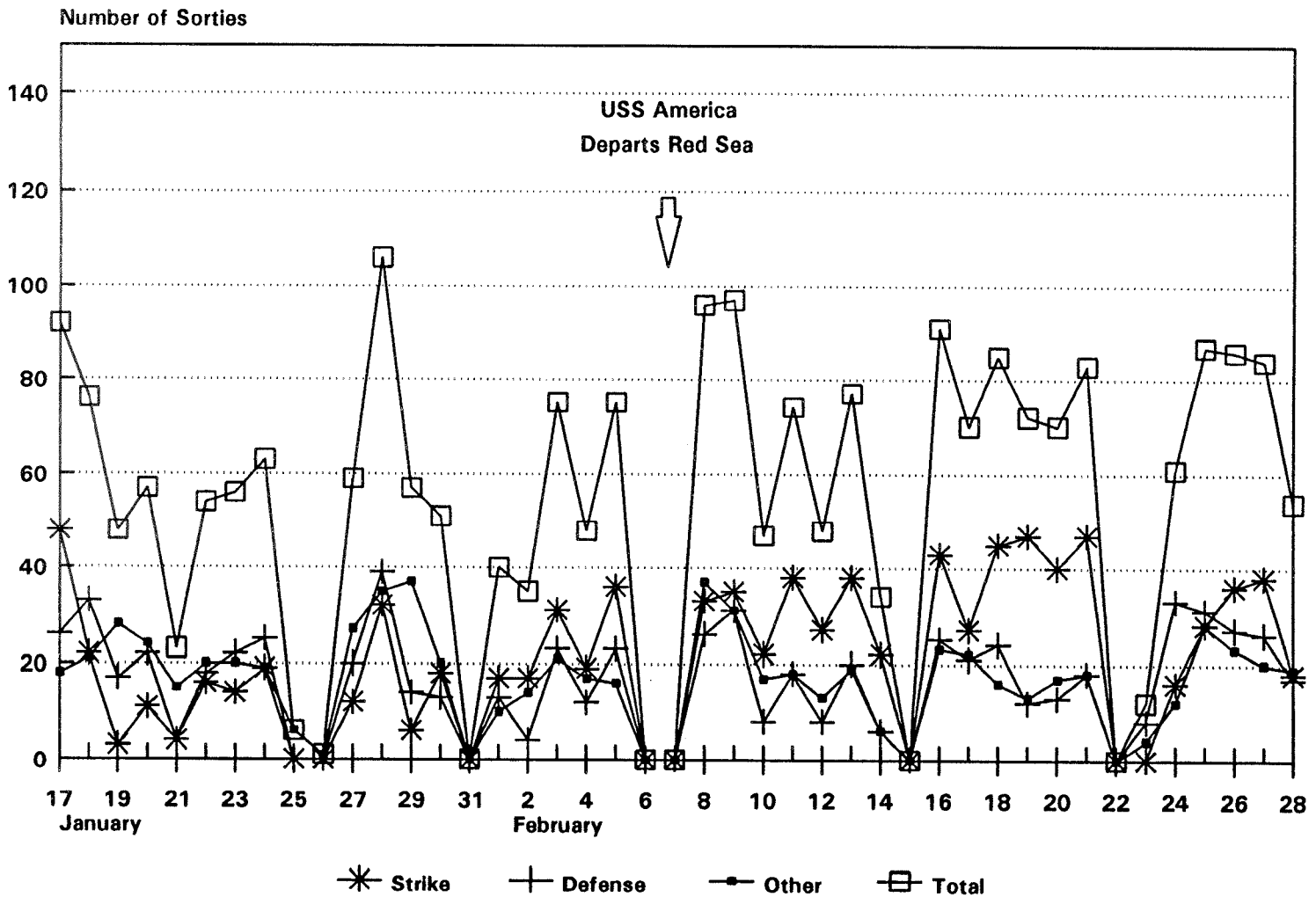
[7] USS America spent the first part of its deployment in the Red Sea before transiting to the Persian Gulf.

Table 11: On-Line Periods (Gulf War)
USS Midway (CV-41)



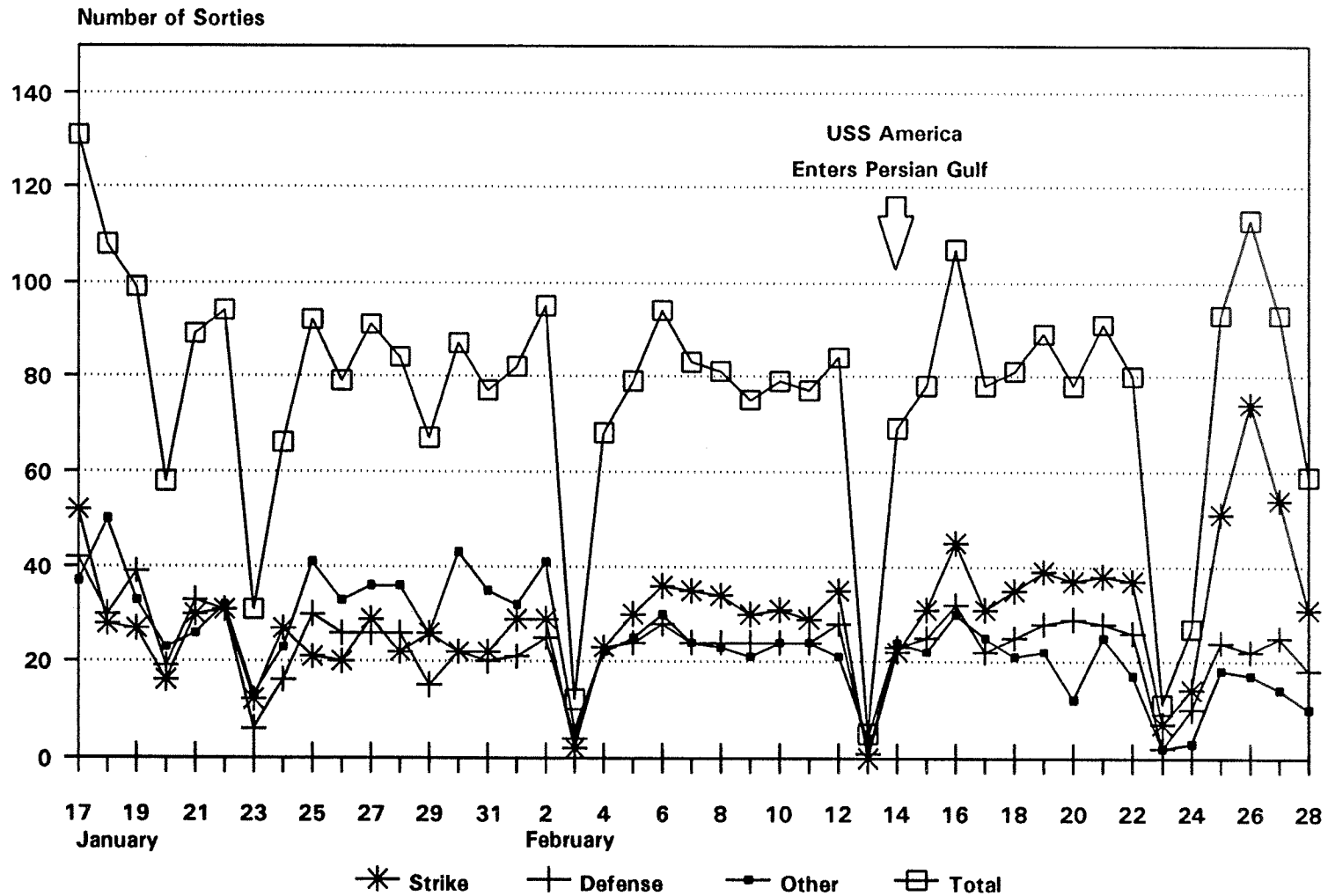
Source: CNA

Table 12: On-Line Periods (Gulf War)
USS Saratoga (CV-60)



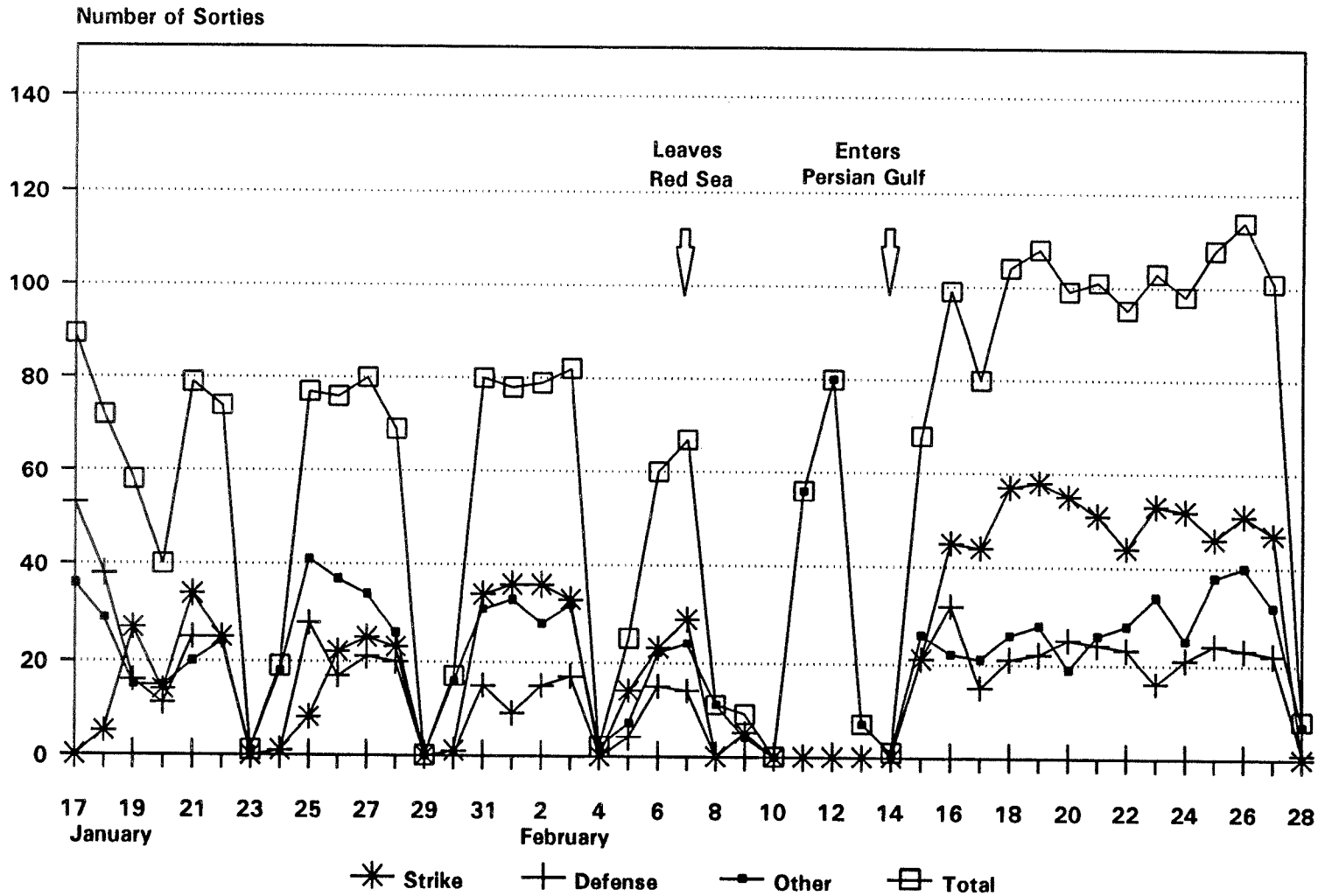
Source: CNA

Table 13: On-Line Periods (Gulf War)
USS Ranger (CV-61)



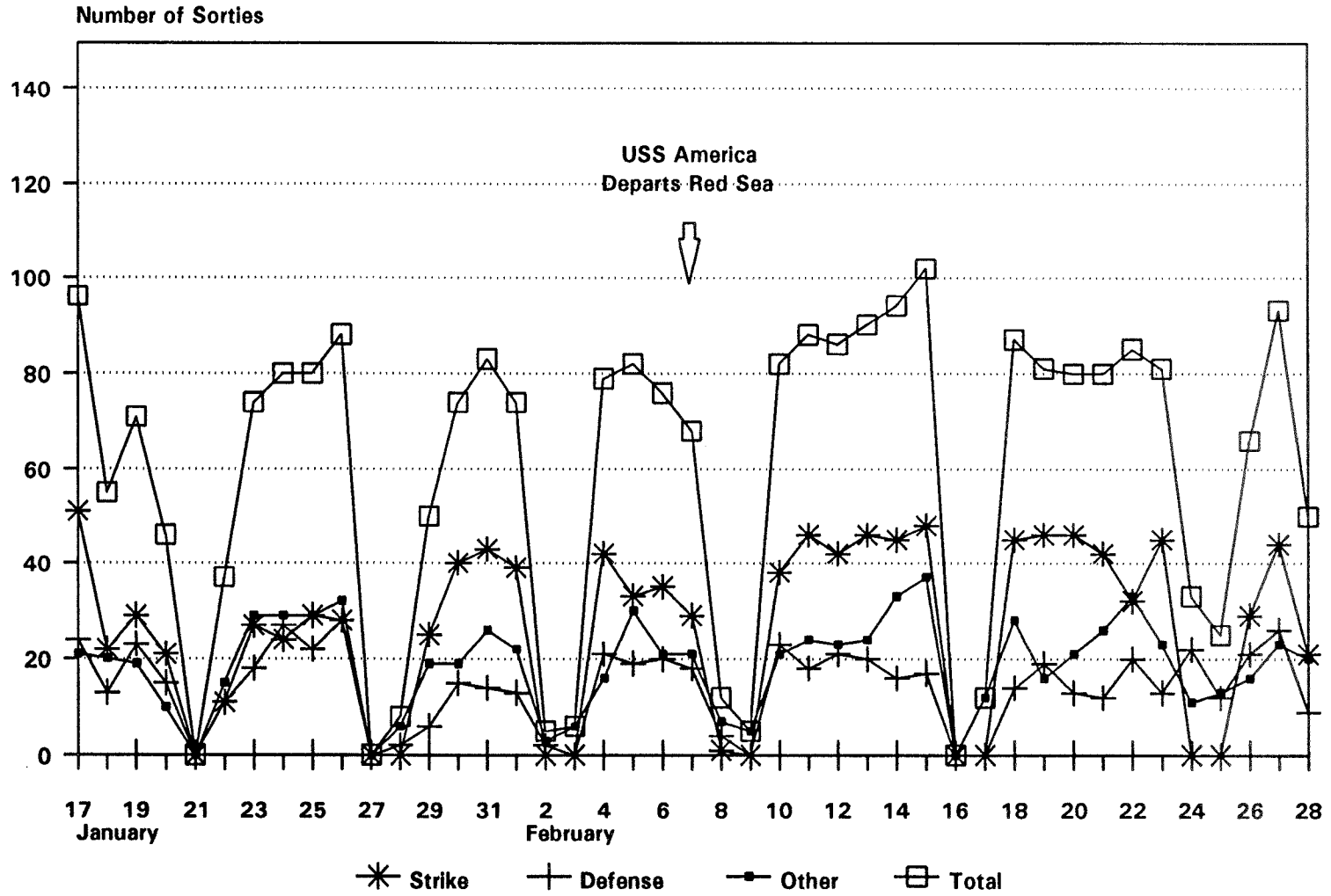
Source: CNA

Table 14: On-Line Periods (Gulf War)
USS America (CV-66)



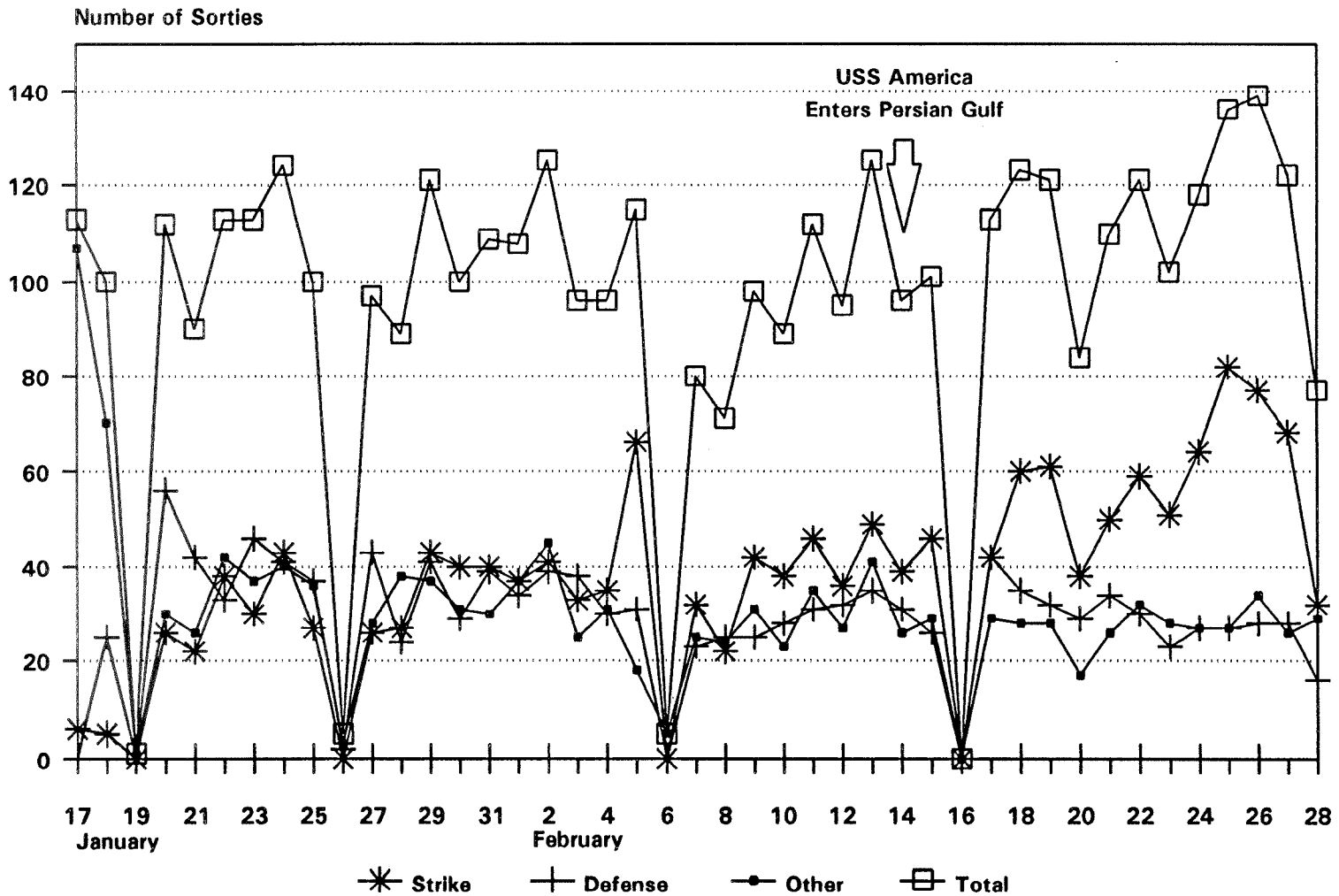
Source: CNA

Table 15: On-Line Periods (Gulf War)
USS John F. Kennedy (CV-67)



Source: CNA

Table 16: On-Line Periods (Gulf War)
USS Theodore Roosevelt (CVN-71)



Source: CNA

Table 17:
Carrier Air Wing Composition (Gulf War)

Type of Aircraft	CV-41	CV-60	CV-61	CV-66	CV-67	CVN-71	Total
Strike							
A-6E Intruder	14	14	14	14	13	14	83
EA-6B Prowler	4	4	4	5	5	4	26
A-7E Corsair	0	0	0	0	22	0	22
F/A-18A Hornet	30	18	0	18	0	18	84
Subtotal[a]	48	36	18	37	40	36	215
Air Defense							
F-14A Tomcat	0	20	20	20	20	20	100
Other							
KA-6D (tanker)	6	4	4	4	4	4	26
E-2C Hawkeye	4	4	4	4	4	4	24
S-3A Viking	0	0	8	0	0	8	16
S-3B Viking	0	8	0	8	8	0	24
Subtotal	10	16	16	16	16	16	90
Total	**58**	**72**	**54**	**73**	**76**	**72**	**405**

Source: CNA

[a] Note that elsewhere in its reconstruction report, the CNA lists the total strike aircraft onboard carriers during Operation Desert Storm as follows: CV-41, 44; CV-60, 28; CV-61, 24; CV-66, 35; CV-67, 37; and CVN-71, 39.

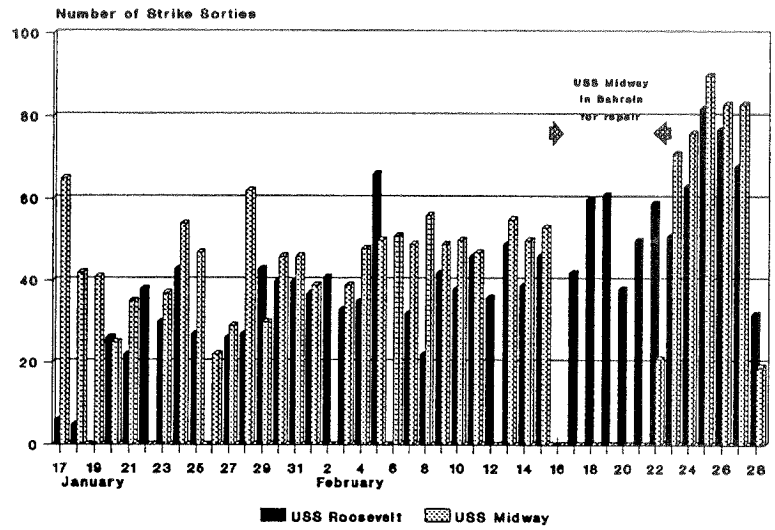
Table 18:
Strike Missions Per Carrier (Gulf War)

Ship Name (hull-number)	Strike Missions	Rank
USS Midway (CV-41)[a]	155	2[b]
USS Saratoga (CV-60)	80	6
USS Ranger (CV-61)	136	3
USS America (CV-66)	127	4
USS John F. Kennedy (CV-67)	83	5
USS Theodore Roosevelt (CVN-71)	160	1
Total	**741**	

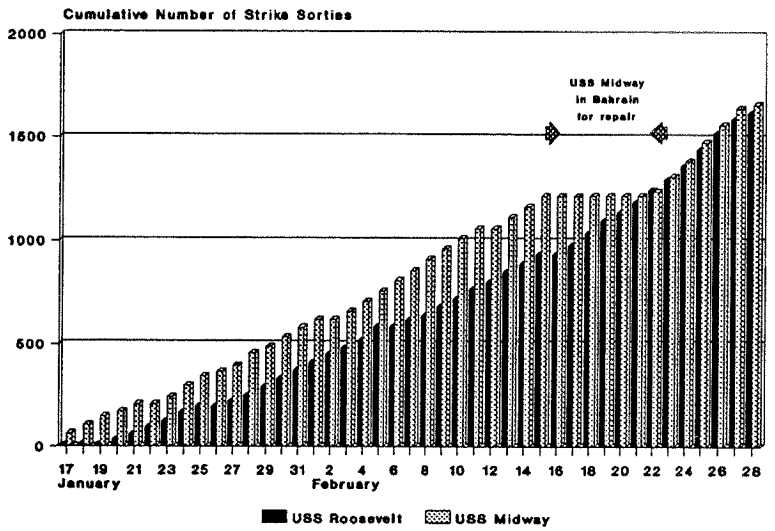
[a] The USS Midway only had two steam catapults unlike the other carriers, which are equipped with four catapults each.

[b] The USS Midway stood down for six days, thus "loosing" about 24 strike missions that would otherwise had ranked the carrier first.

Table 19:
Carrier Strikes (Roosevelt vs Midway)(Gulf War)[1]



A: Total Strike Sorties



B: Cumulative Strike Sorties

[1] Note that USS Midway had only two steam catapults, unlike USS Theodore Roosevelt, which is equipped with four.

Table 20:
Carrier "Kill-Box" Missions (Gulf War)

Ship Name (hull-number)	Profile	Rate per Day
USS Midway (CV-41)	38 missions in 14 days	2.7
USS Saratoga (CV-60)	32 missions in 21 days	1.5
USS Ranger (CV-61)	64 missions in 22 days	2.9
USS America (CV-66)	62 missions in 17 days	3.6
USS John F. Kennedy (CV-67)	34 missions in 20 days	1.7
USS Theodore Roosevelt (CVN-71)	57 missions in 22 days	2.6

Table 21:
Replenishment of Nuclear and Conventional Carriers (Gulf War)

USS Theodore Roosevelt (CVN-71) Replenishments[1]

Date	Replenishment	Ship Status
28 Dec	Departs Norfolk, Va.	
31 Dec	UNREP with USS Santa Barbara (AR-28)	underway, Atlantic
1 Jan	VERTREP (weapons) with USS Santa Barbara (AE-28)	underway, Atlantic
7 Jan	RAS/CONREP with USS Joshua Humphries (TAO-188)	underway, Atlantic
11 Jan	UNREP with USS Kaiser (unknown)	underway, Mediterranean
13 Jan	VERTREP/CONREP with USS San Diego (AFS-6)	underway, Mediterranean
16 Jan	FAS with USS Leyte Gulf (CG-55)	underway, Mediterranean
21 Jan	UNREP with USS Kansas City (AOR-3)	on station, Persian Gulf
26 Jan	UNREP (weapons) with USS Sacramento (AOE-1)	standing down, Persian Gulf
30 Jan	VERTREP (weapons) with USS Nitro (AE-23)	on station, Persian Gulf
30 Jan	FAS with USS Passumpsic (TAO-107)	on station, Persian Gulf
3 Feb	VERTREP with USS Nitro (AE-23)	on station, Persian Gulf
3 Feb	FAS/RAS/VERTREP with USS Sacramento (AOE-1)	on station, Persian Gulf
6 Feb	VERTREP with USS San Diego (AFS-6)	standing down, Persian Gulf
7 Feb	CONREP/VERTREP/RAS with USS Sacramento (AOE-1)	on station, Persian Gulf
11 Feb	VERTREP/RAS with USS Platte (AO-186)	on station, Persian Gulf
11 Feb	VERTREP with USNS Kilauea (TAE-26)	on station, Persian Gulf
12 Feb	VERTREP with USNS Kilauea (TAE-26)	on station, Persian Gulf
15 Feb	VERTREP (ammo) with USNS Kilauea (TAE-26)	on station, Persian Gulf
15 Feb	RAS with USS Sacramento (AOE-1)	on station, Persian Gulf
16 Feb	VERTREP/CONREP with USS San Diego (AFS-6)	standing down, Persian Gulf
20 Feb	VERTREP with USNS Kilauea (TAE-26)	on station, Persian Gulf
20 Feb	RAS with USNS Passumpsic (TAO-107)	on station, Persian Gulf
24 Feb	VERTREP/CONREP (ammo) with USNS Kilauea (TAE-26)	on station, Persian Gulf
26 Feb	VERTREP/RAS with USS Kalamazoo (AOR-6)	on station, Persian Gulf
27 Feb	VERTREP with USNS Kilauea (TAE-26)	on station, Persian Gulf
?	1-2 unknown ammo onload with USS Kilauea (TAE-26)[2]	on station, Persian Gulf
1 Mar	UNREP (fuel/ammo) Ship TBA	n.a.
1 Mar	RAS with USS Platte (AO-186)	on station, Persian Gulf
2 Mar	VERTREP with USS San Diego (AFS-6)	on station, Persian Gulf
2 Mar	VERTREP with USNS Kilauea (TAE-26)	on station, Persian Gulf
7 Mar	VERTREP with USS San Diego (AFS-6)	on station, Persian Gulf
8 Mar	VERTREP/RAS with USS Sacramento (AOE-1)	on station, Persian Gulf
9 Mar	VERTREP/CONREP with USS Nitro (AE-23)	on station, Persian Gulf
11 Mar	VERTREP/RAS with USS Passumpsic (TAO-107)	on station, Persian Gulf
17 Mar	RAS with USS San Diego (AFS-6)	on station, Persian Gulf
18 Mar	VERTREP/CONREP with USS San Diego (AFS-6)	on station, Persian Gulf
19 Mar	RAS with USS Platte (AO-186)	on station, Persian Gulf
27 Mar	RAS with USS Platte (AO-186)	underway, Persian Gulf
1 Apr	RAS with USS San Diego (AFS-6)	underway, Gulf of Arden
7 Apr	VERTREP/CONREP with USS Santa Barbara (AE-28)	underway, Red Sea

7 Apr	RAS with USNS Joshua Humphreys (TAO-188)	underway, Red Sea
12 Apr	USNS Joshua Humphreys (TAO-188)	underway, Red Sea
15 Apr	DD FAS with HCMS Huron (281)	underway, Red Sea
16 Apr	VERTREP/RAS with USNS Saturn (TAFS-10)	underway, Red Sea
17 Apr	RAS with USNS Joshua Humphreys (TAO-188)	underway, Red Sea
23 Apr	RAS/CONREP with USNS John Lenthall (TAO-189)	underway, Mediterranean
29 Apr	RAS with USNS Joshua Humphreys (TAO-188)	underway, Mediterranean
4 May	VERTREP/RAS with USS Saturn (TAFS-10)	underway, Mediterranean
7 May	VERTREP/RAS with USS Platte (AO-186)	underway, Mediterranean
7 May	VERTREP with USNS Saturn (TAFS-10)	underway, Mediterranean
10 May	VERTREP with USNS Saturn (TAFS-10)	underway, Mediterranean
17 May	RAS with USS Platte (AO-186)	underway, Mediterranean
19 May	RAS with USNS Saturn (TAFS-10)	
20 May	VERTREP/RAS with USS Platte (AO-186)	underway, Mediterranean
20 May	VERTREP with USNS Saturn (TAFS-10)	underway, Mediterranean
21 May	VERTREP/CONREP with USS Saturn (TAFS-10)	underway, Mediterranean
22 May	VERTREP with USS Saturn (TAFS-10)	underway, Mediterranean
08 Jun	VERTREP/CONREP with USS Saturn (TAFS-10)	underway, Mediterranean
09 Jun	RAS with USNS John Lenthall (TAO-189)	underway, Mediterranean
14 Jun	VERTREP with USS Forrestal (CV-59)	underway, Mediterranean
14 Jun	VERTREP with USS Milwaukee (AOR-2)	underway, Mediterranean
15 Jun	VERTREP commenced (ship unknown)	n.a.
28 Jun	Arrives at Norfolk, Va.	
Total	63 Replenishments in 183 days, or and average of one every 2.9 days. Average during war of one replenishment every 2 days (21 replenishments in 43 days)	

USS John F. Kennedy (CV-67) Replenishments[3]

Date	Replenishment	Ship Status
15 Aug 1990	Departs Norfolk, Va.	
16 Aug	Refueled by USNS Joshua Humphreys (T-AO-188)	underway, Atlantic
21 Aug	Refueled by USS Monongahela (AO-178)	underway, Atlantic
24 Aug	Refueled by USS Seattle (AOE-3)	underway, Atlantic
25 Aug	Refueled USS Thomas S. Gates (CG-51)	underway, Atlantic
30 Aug	Refueled by USS Seattle (AOE-3)	underway, Mediterranean
02 Sep	Refueled by USS Seattle (AOE-3)	underway, Mediterranean
05 Sep	Refueled by USS Seattle (AOE-3)	underway, Mediterranean
07 Sep	Refueled by USS Seattle (AOE-3)	underway, Mediterranean
08 Sep	Replenished by USS Sylvania (AFS-2)	underway, Mediterranean
17 Sep	Refueled by USS Detroit (AOE-4)	underway, Red Sea
17 Sep	Refueled by USS Seattle (AOE-3)	underway, Red Sea
21 Sep	Refueled by USS Seattle (AOE-3)	underway, Red Sea
25 Sep	Refueled by USS Seattle (AOE-3)	underway, Red Sea
29 Sep	Refueled by USS Seattle (AOE-3)	underway, Red Sea
4 Oct	Refueled by USS Seattle (AOE-3)	underway, Red Sea
8 Oct	Refueled by USS Seattle (AOE-3)	underway, Red Sea
10 Oct	Replenished by USS Sylvania (AFS-2)	underway, Red Sea
13 Oct	Received fuel and cargo from USS Seattle (AOE-3)	underway, Red Sea

17 Oct	Refueled by USS Seattle (AOE-3)	underway, Red Sea
23 Oct	Received fuel and cargo from USS Seattle (AOE-3)	underway, Red Sea
26 Oct	Refueled by USS Seattle (AOE-3)	underway, Red Sea
28 Oct	Replenished by USS Sylvania (AFS-2)	underway, Mediterranean
31 Oct	Refueled by USNS Neosho (TAO-143)	underway, Mediterranean
2 Nov	VERTREP by USS Sylvania (AFS-2)	underway, Mediterranean
4 Nov	Refueled by USNS Neosho (TAO-143)	underway, Mediterranean
15 Nov	Refueled by USS Seattle (AOE-3)	underway, Mediterranean
18 Nov	Refueled by USS Henry J. Kaiser (TAO-187)	underway, Mediterranean
18 Nov	Replenished by USS Sylvania (AFS-2)	underway, Mediterranean
28 Nov	Refueled by USS Henry J. Kaiser (TAO-187)	underway, Mediterranean
1 Dec	Refueled by USS Henry J. Kaiser (TAO-187)	underway, Mediterranean
5 Dec	Refueled by USS Detroit (AOE-4)	underway, Red Sea
9 Dec	Refueled USS Thomas C. Hart (FF-1092)	underway, Red Sea
10 Dec	Refueled by USS Detroit (AOE-4)	underway, Red Sea
14 Dec	Refueled by USS Detroit (AOE-4)	underway, Red Sea
17 Dec	Logistic replenishment by USS Sylvania (AFS-2)	underway, Red Sea
18 Dec	Refueled by USS Seattle (AOE-3)	underway, Red Sea
23 Dec	Refueled/replenished by USS Seattle (AOE-3)	underway, Red Sea
26 Dec	Refueled by USS Seattle (AOE-3)	underway, Red Sea
28 Dec	Refueled by USS Seattle (AOE-3)	underway, Red Sea
4 Jan 1991	UNREP with USS Seattle (AOE-3)	underway, Red Sea
7 Jan	UNREP with USS Seattle (AOE-3)	underway, Red Sea
11 Jan	UNREP with USS Seattle (AOE-3)	underway, Red Sea
15 Jan	UNREP with USS Detroit (AOE-4)	underway, Red Sea
17 Jan	VERTREP with USS Santa Barbara (AE-28)	on station, Northern Red Sea
18 Jan	UNREP with USS Seattle (AOE-3)	on station, Northern Red Sea
19 Jan	VERTREP (ammo) with USS Santa Barbara (AE-28)	on station, Northern Red Sea
21 Jan	UNREP with USS Sylvania (AFS-2)	in "Gasoline Alley", Red Sea
21 Jan	UNREP with USS Seattle (AOE-3)	in "Gasoline Alley", Red Sea
22 Jan	UNREP with USNS Joshua Humphreys (TAO-188)	on station, Northern Red Sea
24 Jan	UNREP with USS Seattle (AOE-3)	on station, Northern Red Sea
27 Jan	UNREP with USS Seattle (AOE-3)	in "Gasoline Alley", Red Sea
30 Jan	UNREP with USS Seattle (AOE-3)	on station, Northern Red Sea
31 Jan	UNREP with USS Detroit (AOR-4)	on station, Northern Red Sea
31 Jan	UNREP with USNS Joshua Humphreys (TAO-188)	on station, Northern Red Sea
2 Feb	UNREP with USS Detroit (AOE-4)	on station, Northern Red Sea[4]
2 Feb	UNREP with USS Santa Barbara (AE-28)	on station, Northern Red Sea
5 Feb	UNREP with USS Kalamazoo (AOR-6)	on station, Northern Red Sea
5 Feb	Retrograde VERTREP with USS Santa Barbara (AE-28)	on station, Northern Red Sea
6 Feb	VERTREP with USS Kalamazoo (AOE-6)	on station, Northern Red Sea
7 Feb	VERTREP with USS Santa Barbara (AE-28)	on station, Northern Red Sea
8 Feb	UNREP with USS Detroit (AOE-4)	in "Gasoline Alley", Red Sea
11 Feb	UNREP with USS Seattle (AOE-3)	on station, Northern Red Sea
13 Feb	VERTREP with USS Santa Barbara (AE-28)	on station, Northern Red Sea
13 Feb	VERTREP with SS Cape Archway	on station, Northern Red Sea
14 Feb	UNREP with USNS Joshua Humphreys (TAO-188)	on station, Northern Red Sea
14 Feb	VERTREP with USS Santa Barbara (AE-28)	on station, Northern Red Sea
16 Feb	UNREP with USNS Sirius (T-AFS-8)	in "Gasoline Alley", Red Sea
17 Feb	UNREP with USS Seattle (AOE-3)	on station, Northern Red Sea
17 Feb	UNREP with USS Santa Barbara (AE-28)	on station, Northern Red Sea
20 Feb	UNREP with USS Seattle (AOE-3)	on station, Northern Red Sea
24 Feb	UNREP with USS Seattle (AOE-3)	on station, Northern Red Sea[5]

24 Feb	UNREP with USS Santa Barbara (AE-28)	on station, Northern Red Sea
27 Feb	UNREP with USS Detroit (AOE-3)	on station, Northern Red Sea
27 Feb	UNREP with USS Santa Barbara (AE-28)	on station, Northern Red Sea
27 Feb	UNREP with USNS Sirius (T-AFS-8)	on station, Northern Red Sea
9 Mar	Ammo Off-Load to USS Seattle (AOE-1) and USS Santa Barbara (AE-28)	anchored at Hurghada, Egypt
14 Mar	UNREP with USNS John Lenthall (TAO-189)	underway, Mediterranean Sea
15-16 Mar	VERTREP (ammo off-load) with USS Seattle (AOE-3)	underway, Mediterranean Sea
28 Mar	Arrived back in Norfolk, VA.	
Total	78 replenishments in 226 days, or an average of one every 2.9 days. Average during war is one replenishment every 1.3 days (32 replenishments in 43 days).	

Endnotes:

1. Records taken from "Green Sheets" and "Pink Sheets" on the USS Theodore Roosevelt (CVN-71) Operations and Training Schedule, January-June 1991; partially declassified and released under the Freedom of Information Act; Pink and Green sheets list scheduled replenishment some of which can be altered.

2. The USS Roosevelt's command history reports a total of eight ammo onloads with the USNS Kilauea (TAE-26) during February. Only five are accounted for in the Green Sheet (USS Theodore Roosevelt (CVN-71), "1991 Command History," Weapons Department Command History - 1991, 2 October 1992, n.p.; partially declassified and released under the Freedom of Information Act). The Center for Naval Analysis, however, reports seven rearmings of the USS Roosevelt by USS Kilauea (TAE-26) in the last 20 days of February (Center for Naval Analysis, Ronald Nickel, et.al., "Desert Storm Reconstruction Report (U)," Volume IX: Logistics (U), CRM 91-185/October 1991, p. 5-13; partially declassified and released under the Freedom of Information Act).

3. Records taken from USS John F. Kennedy (CV-67), "1990 Command History," Enclosure II, pp. 1-6; and USS John F. Kennedy (CV-67), "1991 Command History," 24 February 1992, Enclosure 2, pp. 1-5.

4. The USS Kennedy virtually did not fly sorties on 2nd and 3rd February, although the ship's annual history does not identify the carrier being "in Gasoline Alley.

5. The USS Kennedy did not fly strike sorties on 24 and 25 February, although the ship's annual history does not say the carrier was "in Gasoline Alley". A small number of non-strike sorties were flown.

Table 22:
Carrier Aerial Refueling Sorties (Gulf War)

Ship Name (hull-number)	Sorties	Rank
USS Midway (CV-41)	453	3
USS Saratoga (CV-60)	338	5
USS Ranger (CV-61)	584	2
USS America (CV-66)	399	4
USS John F. Kennedy (CV-67)	338	5
USS Theodore Roosevelt (CVN-71)	670	1
Total	**2782**	

Table 23:
Ordnance Expenditure per Carrier (Gulf War)

Ship Name (hull-number)	Tons[a]	Rank
USS Midway (CV-41)	(1540)[b]	6
USS Saratoga (CV-60)	2023	3
USS Ranger (CV-61)	2100	2
USS America (CV-66)	2000	4
USS John F. Kennedy (CV-67)	1886	5
USS Theodore Roosevelt (CVN-71)	2450	1
Total	**~12000**	

[a] All figures are approximate.
[b] The figure remains officially classified. Note that USS Midway stood down for six days for repair. Without this drop-out, the carrier would have dropped some 250 tons more.