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There has been a continuing debate over the relative merits of conventional and nuclear power for U.S. warships. Findings/Conclusions: Most military experts agree that submarines and large aircraft carriers should have nuclear propulsion. Presently the controversy centers over the desirability of nuclear power for cruisers, frigates, and destroyers that accompany the carriers. Nuclear ships are more capable but cost more, and their relative cost-effectiveness cannot be measured because Navy analysts cannot quantify many benefits of nuclear power. In addition, available data on construction and operating costs do not lend themselves to precise comparisons. The Department of Defense estimates that construction of only nuclear-powered ships could result in about 25 to 35 fewer cruisers, frigates, or destroyers than if the same amount of money were to be spent on comparable conventionally powered ships. The advantages of nuclear-powered ships appear to be highly dependent on the perceived nature of future conflicts. Recommendations: The Congress, in reviewing Navy shipbuilding plans for surface combatant ships, should be cognizant that: buying only conventional ships will maximize naval firepower; buying only nuclear ships will provide mobility and greater freedom from logistics support; and buying a mix is a third option providing, to varying degrees, the advantages and disadvantages of the all-nuclear and all-conventional options. (Author/SC)

REPORT TO THE CONGRESS

BY THE COMPTROLLER GENERAL OF THE UNITED STATES

Nuclear Or Conventional Power For Surface Combatant Ships?

Department of the Navy

GAO reviewed the controversy over whether the Navy's major surface combatant ships should be all nuclear powered, all conventionally powered, or a mix of both. Nuclear ships are more capable but cost more and their relative cost-effectiveness cannot be measured because Navy analysts cannot quantify many benefits of nuclear power.

The Congress, in reviewing Navy shipbuilding plans for surface combatant ships, should be cognizant that buying only conventional ships will maximize naval firepower; buying only nuclear ships will provide mobility and greater freedom from logistics support; and buying a mix is a third option providing, to varying degrees, the advantages and disadvantages of the all-nuclear and all-conventional options.

PSAD-77-74

MARCH 21, 1977

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-167184

To the President of the Senate and the
Speaker of the House of Representatives

This report addresses the issues surrounding the controversy over nuclear versus conventional power in major strike force surface combatant ships. The report discusses various cost and effectiveness factors involved and identifies the key issues for congressional attention.

Our review was made pursuant to the Budget and Accounting Act, 1921 (31 U.S.C. 53), and the Accounting and Auditing Act of 1950 (31 U.S.C. 67).

We are sending copies of this report to the Director, Office of Management and Budget, and to the Secretary of Defense.

Comptroller General
of the United States

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

NUCLEAR OR CONVENTIONAL POWER FOR SURFACE COMBATANT SHIPS?

D I G E S T

There has been a continuing debate over the relative merits of conventional and nuclear power for U.S. warships. Most military experts now agree that submarines and large aircraft carriers should have nuclear propulsion. Presently the controversy centers over the desirability of nuclear power for cruisers, frigates, and destroyers that accompany the carriers.

In 1975 the Congress expressed its desire through legislation that all future major surface combatant ships be constructed with nuclear power. Some members of the Congress now want to reverse this statutory position. They believe that the Navy's needs can best be met through a mix of nuclear and conventionally powered ships.

The question is how to provide the most effective naval force within reasonable budgetary constraints. In this report GAO says there is no simple answer to the question.

Nuclear-powered ships are more capable than conventionally powered ships but cost more. The relative cost-effectiveness, however, cannot be measured because Navy analysts cannot quantify many benefits of nuclear power. Furthermore, available data on construction and operating costs do not lend themselves to precise comparisons. (See ch. 6.)

The Department of Defense estimates that construction of only nuclear-powered ships could result in about 25 to 35 fewer cruisers, frigates, or destroyers than if the same amount of money were to be spent on comparable conventionally powered ships. This question of numbers is critical. More ships provide greater firepower and a greater residual force after a specified number of combat losses. (See pp. 7 and 8.)

The advantages of nuclear-powered ships appear to be highly dependent on the perceived nature

of future conflicts. The nuclear advantage is minimized in a conflict where opposing forces are relatively close to one another. Where naval forces need to transit long distances in a short time or are highly dependent on resupply of fuel at sea, nuclear power has a clear advantage. (See p. 26.)

KEY ISSUES FOR CONGRESSIONAL ATTENTION

In evaluating Navy shipbuilding plans for strike force surface combatants, the Congress will be deciding which option will, in the long run, maximize the overall effectiveness of the Navy: all-conventional, all-nuclear, or a mix. In addressing this central question the key issues are:

--The all-conventional option means more ships, thus maximizing total naval firepower. The superior capabilities of nuclear ships, however, are missing.

--The all-nuclear option means mobility and greater freedom from logistics support. The ability to concentrate forces quickly at a scene of conflict (real or threatened) is superior and the vulnerability of providing logistics support is reduced. Ship force levels and the accompanying firepower, however, are at a minimum.

--A mix of conventional and nuclear powered ships is a third option providing, to varying degrees, the advantages and disadvantages of the all-nuclear and all-conventional options.

--The nature of strike force operations over the coming decades bears importantly on the issue. Will the operations be characterized by forces on-station in forward areas; or will strike force operations be more mobile, featuring rapid concentrations and dispersions of forces?

AGENCY COMMENTS

In commenting on this report, Defense stated it was a commendably objective treatment of all sides of this complex and often emotional issue.

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ABBREVIATIONS

AAW	Anti-air warfare
ASW	Antisubmarine warfare
CNO	Chief of Naval Operations
GAO	General Accounting Office
SE/MFE	Supplement on Endurance of the Major Fleet Escort Study

CHAPTER 1

INTRODUCTION

For some 25 years there has been a controversy over the relative merits of nuclear power for U.S. warships. In the fiscal year 1978 Department of Defense budget request, the Congress will again be confronted with the issue of nuclear versus conventional power in major surface combatant ships. The purpose of this report is to assist the Congress in its deliberations on the request. The report presents the cases for conventional and nuclear power and attempts to clarify some issues surrounding the controversy without reaching any conclusion as to the proper course of action.

In the case of submarines the matter was settled early in favor of nuclear power. Most observers apparently found its special advantages in submarines persuasive--essentially unlimited endurance and independence from the atmosphere. In the case of surface ships, however, the nuclear-conventional power issue has been the center of the controversy. The nuclear power debate for large aircraft carriers, particularly intense in the 1960s, appears to have been resolved for the time being in favor of nuclear power. The current debate centers on strike force surface combatants--large cruisers and destroyers required for operations in carrier task groups. The debate does not extend to smaller combatant ships, such as frigates, or to support ships which, it is generally agreed, should be conventionally powered.

In 1974, to resolve the question of nuclear power for future strike force ships, including surface combatants, the Congress enacted Title VIII of the Fiscal Year 1975 Defense Appropriation Authorization Bill. Title VIII requires as a matter of national policy that new construction on "major combatant vessels for the strike forces of the United States Navy" be nuclear-powered. However, Title VIII allows the President to request conventionally powered ships instead of nuclear-powered ones; but before doing so, he must advise the Congress that nuclear power in the case at issue is not in the national interest and must forward an alternative program

Title VIII supporters viewed its enactment as the culmination of a long-time controversy over the merits of nuclear propulsion for Navy strike forces. They considered Title VIII an important victory for those in the Congress who carried the fight for nuclear power strike force ships.

The President exercised the Title VIII provision in the Fiscal Year 1977 budget request by proposing a 5-year (fiscal year 1977 to fiscal year 1981) conventional and nuclear building program for eight conventional guided missile destroyers and two nuclear strike cruisers. Funding for one destroyer and long lead items for a cruiser were in the 1977 budget request. The Congress elected to not authorize this funding, but the House and Senate Armed Services Committee conferees agreed to fully consider any future authorization request for these ships.

SCOPE

The information in this report was obtained by reviewing agency reports, correspondence, and other documents; by reviewing the reasons for enacting Title VIII, and by interviewing officials in both the Department of Defense and the Navy.

CHAPTER 2

A BRIEF HISTORY OF

NUCLEAR POWER IN U.S. WARSHIPS

For the conduct of naval warfare, naval ships are broadly categorized into five types--submarines, carriers, surface combatants, amphibious ships, and support ships. The Navy's policy states that all submarines should be nuclear-powered. Among surface combatants, only carriers and cruisers should be nuclear-powered and only enough of these to constitute a strategically significant segment of the operating forces. Evolution of this policy is discussed in this chapter.

SUBMARINES

Early investigations of the feasibility of nuclear propulsion for warships were begun in 1946 by the Atomic Energy Commission and by the Navy, assisted by private contractors. These studies embraced both submarine and surface ship propulsion and considered two different types of reactors--water-cooled and liquid metal-cooled.

In December 1948 the Atomic Energy Commission contracted with the Atomic Power Division of Westinghouse Electric Corporation to design, construct, test, and operate a submarine reactor. This undertaking led to the first nuclear-powered ship, the submarine U.S.S. Nautilus, commissioned in 1954.

After initial opposition was overcome, nuclear power for submarines gained wide acceptance due to the large and obvious gains in effectiveness realized through freeing the submarine from dependence on the atmosphere. Opposition to nuclear power for surface warships continued, on the other hand, through the 1960's and to the present day. Critics cite high cost while supporters maintain that the enhanced effectiveness more than compensates for the cost differential.

AIRCRAFT CARRIERS

Much early discussion of nuclear power for surface ships centered on aircraft carriers. As early as 1949 a nuclear-powered carrier program was supported by the Chief of Naval Operations but development work did not start officially until 1951--only to be halted in 1953 by a National Security Council order. In late 1954 the program was resumed with the establishment of the large

Ship Reactor Project. This led to development of nuclear-powered ships: the cruiser U.S.S. Long Beach (fiscal year 1957 program), carrier U.S.S. Enterprise (fiscal year 1958 program) and cruiser (ex-frigate) U.S.S. Bainbridge (fiscal year 1959 program).

Despite some support by the Navy and the Congress, the Secretary of Defense and the President did not request nuclear-powered surface warships in the fiscal years 1960, 1961, or 1962 shipbuilding programs. Due to congressional insistence, however, the cruiser (ex-frigate) U.S.S. Truxton was built as part of the 1962 shipbuilding program with nuclear, instead of conventional, propulsion.

For fiscal year 1963 Defense requested a conventionally powered aircraft carrier and a nuclear-powered frigate. There ensued a prolonged fight to change the propulsion of the carrier, later named the U.S.S. John F. Kennedy, to nuclear power. The fight was led by the Chairman of the Joint Committee on Atomic Energy, the Secretary of the Navy, and the Chief of Naval Operations. The Secretary of Defense, whose views prevailed, however, favored conventional power. Effective opposition to nuclear-powered aircraft carriers nevertheless eventually weakened, and all aircraft carriers have since been nuclear-powered, beginning with the U.S.S. Nimitz in the fiscal year 1967 program. Including the U.S.S. Enterprise, a total of four nuclear-powered carriers and long lead items for a fifth have been authorized and budgeted to date.

SURFACE COMBATANTS

Since the mid-1960s, with the question of nuclear power for submarines apparently settled and for carriers at least quiescent, the debate has centered on nuclear-powered cruisers, frigates, and destroyers. The nuclear power proponents pointed to the advantages of these ships, if nuclear-powered, as escorts for nuclear-powered carriers and particularly to the big gain in effectiveness when the task group becomes all nuclear, completely free of the need to replenish propulsion fuel. The critics, however, again cited high cost, claiming either that it was incommensurate with the benefits or that it would prevent attainment of force goals.

Construction of cruisers (U.S.S. Long Beach and former frigates) and larger destroyers (Spruance class and former frigates) since 1956, including those authorized and budgeted but not completed, totals 65 ships. Nine of these ships are nuclear-powered.

In 1974 the U.S. Congress, in Title VIII of the Defense Appropriation Authorization Bill, stated that as a matter of policy all future U.S. warships intended to serve with the strike forces should be nuclear-powered. Exceptions would require a Presidential finding that providing nuclear power was not in the national interest. The Secretary of Defense, however, in the fiscal year 1976 budget request did not present a 5-year surface combatant shipbuilding program. He stated that DOD was still examining a wide range of cost and capability tradeoffs between an all-nuclear major warship acquisition program and a previously planned mix of nuclear and conventional warships.

On February 13, 1976, the President formally made a finding that constructing all-nuclear surface combatants for the strike forces was not in the national interest. This finding was in support of his budget submission for fiscal year 1977 in which he requested a conventional destroyer and long lead items for a nuclear cruiser. His 5-year plan called for eight conventional guided missile destroyers and two nuclear strike cruisers. As previously noted, the Congress decided not to authorize construction funds for fiscal year 1977 for either the conventional or nuclear ship but stated that it would consider future requests.

CHAPTER 3

THE CASE FOR CONVENTIONAL POWER

In general, conventionally powered ships are less costly to procure and operate than nuclear-powered ships. (See pp. 23 and 24.) Because conventionally powered ships are less costly, those favoring conventional surface combatants for strike forces contend that (1) the cost premium for nuclear power is substantial and would, unless additional funding were made available, limit the Navy's ability to rebuild a balanced Navy which is adequate in numbers of platforms and total firepower for the future and (2) while in some situations, such as high-speed transit, an all-nuclear task group may be superior, in important situations, such as on-station sustained operations, it may not.

THE NEED FOR LARGER NUMBERS OF SHIPS

For several reasons Defense and Navy officials believe that the United States needs a larger Navy and cite classified analytic studies of large-scale conflicts to support this contention. These officials point to the U.S. worldwide defense and political commitments and also note the U.S. Navy force level has been cut about in half since 1968.

Hostile submarines' ability to attack friendly forces at any given place along the thousands of miles of sea lanes implies a need for numerous antisubmarine warfare (ASW) forces simply to cover the geographical areas involved. The Secretary of Defense stated in 1975 that, "To protect programmed high-value units in an all-out war with the Warsaw Pact, Navy estimates indicate that a large number of surface combatants would be needed for the numerically more demanding ASW mission." The Deputy Secretary of Defense in May 1975 stated in a letter to the Chairman, Subcommittee on Seapower, House Armed Services Committee:

> "The United States will continue to require a forward deployed peacetime Naval posture with capabilities adequate to the threat, the scope of geography and the variety of contingencies which could involve our vital interests. This, of course, is not consistent with a small Navy. Looking at the drop in our Navy force levels from 960 active ships in the mid-1960s to fewer

than 500 in Fiscal Year 1976, I am convinced that we must view the attainment of increased numbers of ships as a major objective."

According to a 1975 Department of Defense estimate, the long-range impact of buying all nuclear-powered strike force surface combatants could be to reduce the number of strike combatants by about 25 to 35 ships than if the same amount of money were to be spent on comparable conventionally powered ships. For those who believe that a level of about 240 surface combatants is critical to overall fleet effectiveness, this reduction is not desirable and therefore a shipbuilding program of only nuclear surface strike warships should not be pursued.

More recently the Chief of Naval Operations stated that the U.S. Navy should have about 600 ships in the 1980s -- some 20 percent over current levels. He said that this force is necessary to maintain the Navy's capabilities to carry out its missions and tasks with what he described as only "a thin margin of success."

The Senate Armed Services Committee in its May 14, 1976, report on the fiscal year 1977 budget request also noted the need for more ships. In its report the Committee stated,

> "The utility of nuclear power is not in dispute. However, all missions do not require nuclear power for ships. The Committee recognizes both the need for ships superior in all respects and for adequate numbers and believes that a nuclear/conventional mix of ships is the most valid approach to attainment of required future naval forces and capability."

The Committee recommended repeal of Title VIII. The repeal, however, was eventually dropped from the fiscal year 1977 Defense Authorization Bill by the House and Senate conferees.

SUPERIOR EFFECTIVENESS OF ON-STATION CONVENTIONAL FORCES

If a comparison is made between the effectiveness of equal-cost carrier task groups 1/ that are on-station (and do not therefore need mobility or high speeds for an extended period), then the conventional force is more effective than

---

1/Total cost of the groups compared are the same. Effectiveness comparisons are easier to make when the costs are made equal.

the all-nuclear one. That is, less costly conventional ships can be procured in greater quantities, and more ships mean more offensive and defensive systems--in a word, more firepower. (See fig. 1.)

All else being equal, the larger number of ships makes the conventional group more resistant to battle damage. Faced with more targets, the enemy must divide his fire into a larger number of less effective segments, which the more numerous U.S. defensive systems can more easily counter. Fewer enemy hits may be expected because of improved ratio of U.S. defensive systems to hostile offensive systems. Even if the enemy scores the same number of hits on the conventional force as on the nuclear one, the residual combat capability of the conventional force would be superior. The difference can be substantial. Two surface combatants struck by missiles and placed out of action in a conventional force of five (carrier plus four combatants) leaves two combatants; in an equal-cost force of four nuclear ships (carrier plus three combatants) only one combatant would remain after the same number of hits. (See fig. 2.) The high lethality of modern guided weapons makes large numbers of ships even more important.

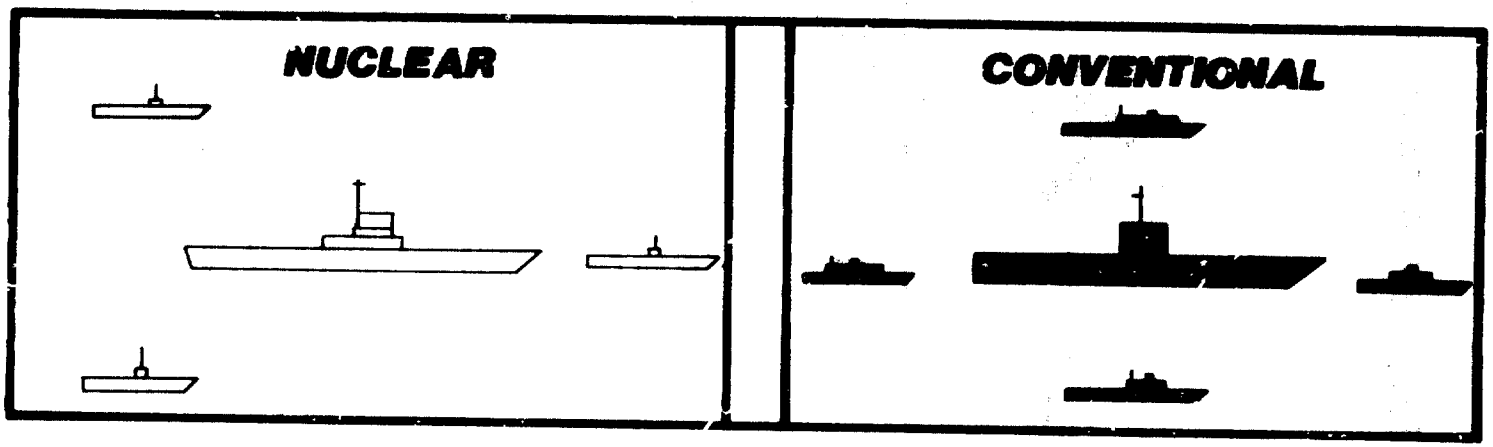
OPPOSING ARGUMENTS

While nuclear power advocates agree that nuclear warships cost more, they also believe the cost premium for nuclear power is sometimes overestimated for a variety of reasons. For example, procurement costs include a 15-year supply of fuel for new nuclear strike force surface combatants but none for conventional ships. Nuclear ships, in addition, are generally bigger, more heavily armed ships containing military features which add to the cost premium. Whatever the case, these advocates consider that the cost premium for nuclear power is worth the price paid for the additional military capability provided to the ship.

The proponents of nuclear power sometimes argue that conventionally powered ships lack the capability to operate in areas of the most intense threat because refueling would be unacceptably hazardous. They claim that the high-capability systems fitted in new U.S. ships indicate an intention to be able to operate in these high threat areas and that, on this basis, conventional power is unacceptable.

FIGURE 1

COMPARISON OF NUCLEAR AND CONVENTIONAL CARRIER TASK GROUPS COMPOSED OF EQUAL-COST SURFACE COMBATANTS

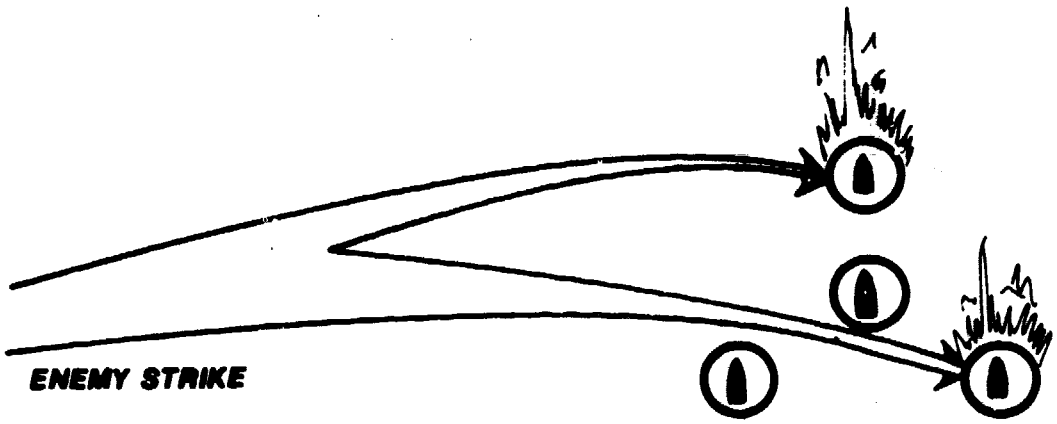


SAMPLE OF COMBINED SURFACE COMBATANT PAYLOAD

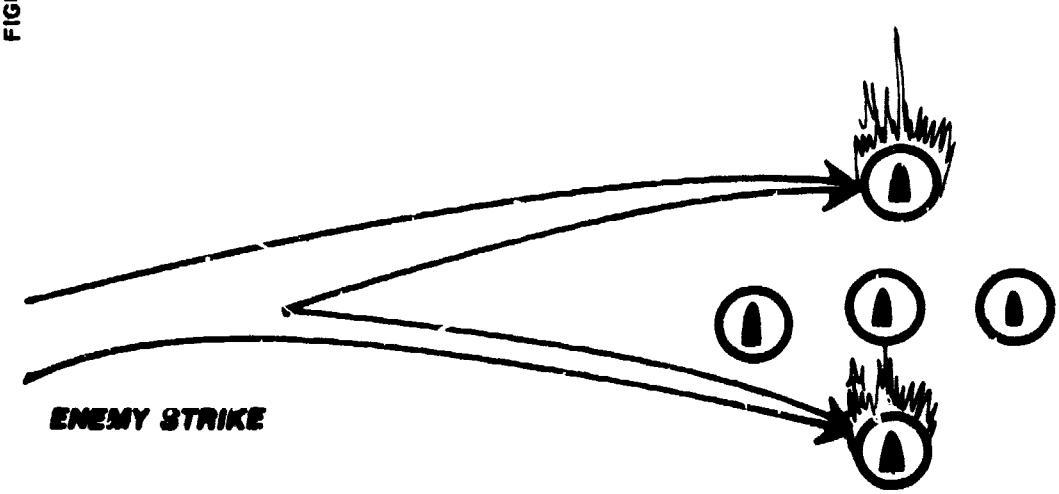
	NUCLEAR	CONVENTIONAL
MISSILE LAUNCHERS	6	8
ILLUMINATORS	12	16
SONARS	3	4
CLOSE-IN WEAPONS SYSTEMS	3	4
HELICOPTERS	6	8
8-INCH GUN	3	4

Note: In this theoritical comparison, all of the surface combatants, nuclear and conventional, are strike cruisers differing only in their propulsion system. The nuclear cruiser is assumed to cost 33 percent more than its conventional counterpart.

FOUR VERSUS THREE SURFACE COMBATANTS



RESIDUAL : CARRIER PLUS ONE



RESIDUAL : CARRIER PLUS TWO

FIGURE 2

CHAPTER 4

THE CASE FOR NUCLEAR POWER

Proponents of nuclear power for strike force combatants contend that the advantages of nuclear power are so substantial that they far outweigh the added cost. These advantages stem principally from the unlimited propulsion endurance and sustained high speed inherent in nuclear-powered ships. The advantages include greater operational capabilities and superior strategic and tactical mobility.

OPERATIONAL CAPABILITIES

Nuclear reactors for new surface combatants will contain enough energy for 15 years of operation without refueling. This essentially unlimited fuel supply enhances the ship's and the task force's operational capabilities in several ways. First, surface combatants are able to continue performing their assigned tasks in the task group, whereas conventional ships must periodically leave their assigned stations to refuel from the carrier. The refueling operation weakens the task group not only by drawing ships off station but also by requiring slow speeds and steady courses that increase the entire task group's vulnerability to attack. The presence of any conventional ships in the task group tends to degrade the effectiveness of the nuclear-powered ships.

Second, in areas where the threat is intense, the hazards of refueling the surface combatants are magnified. If the risks are too high, the task group may be forced to retire prematurely to a safer rear area for the refueling operation. An all-nuclear group could remain on station delivering strikes. Third, nuclear-powered surface combatants in the task group make it possible for the aircraft carrier to carry more fuel for its aircraft, because less is needed to refuel its escorts. The increased fuel capacity improves the carrier's capability for sustained operations with reduced sea-based logistics support.

Along with the unlimited endurance provided by nuclear power, another valuable characteristic inherent to nuclear power is the sustained high speed provided to the ship. The combination of more fuel for aircraft, high speed, and unlimited endurance enable an all-nuclear Nimitz-class carrier group to deploy rapidly to virtually any distant

point; without sea-based logistics support, the carrier group can engage in combat for 1 to 2 weeks under continuous and intense operating conditions or for up to a month or more under intermittent or less intense conditions. If the operation requires sea-based logistics support for the carrier task group, the task group will need less support less often if it is nuclear-powered. The result is reduced requirements for support ships; because they would be required in the replenishment area less often, the support ships would be less exposed to hostile forces. The sustained high speed capabilities of nuclear-powered surface combatants, particularly in an all-nuclear group, also facilitate rapid movement to and from the replenishment area and place the area further to the rear, thus adding still more to the support ships' safety. (See fig. 3.)

STRATEGIC MOBILITY

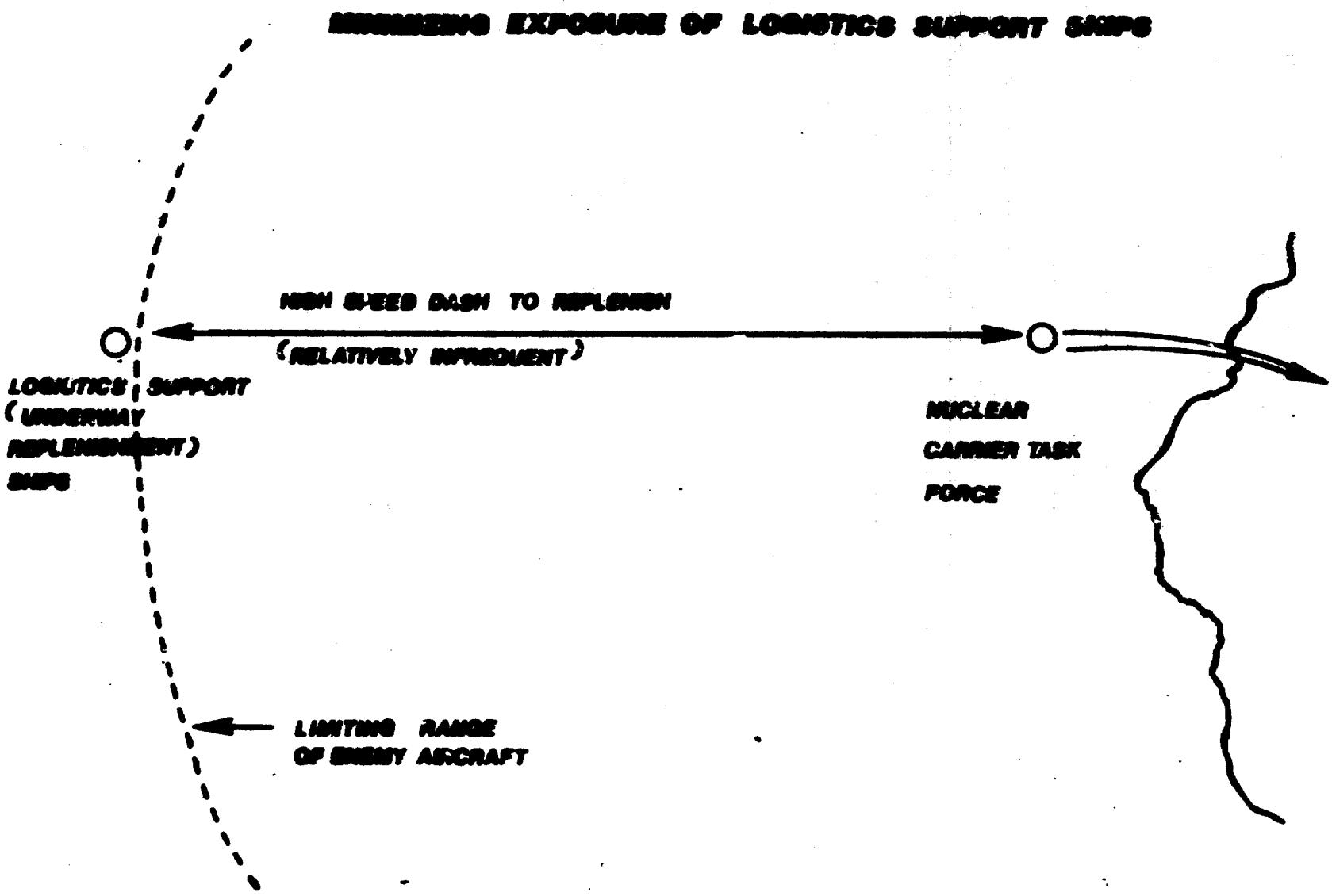
The number of carriers in the U.S. fleet is small, both by historical standards and in relation to the Nation's global commitments. Nuclear-powered carrier task groups, because they can cover wider geographical areas in a given time, are considered by the Navy to be of special value. Weather permitting, the all-nuclear carrier task group can steam for essentially unlimited distances at near top speed, thus substantially reducing response time in an emergency and enlarging the geographical area over which it can influence events.

The 1970 Jordanian crisis furnished an example of how fuel considerations can affect response time. At the time of the crisis U.S.S. John F. Kennedy, a conventionally powered carrier, was ordered to reinforce the U.S. Sixth Fleet in the eastern Mediterranean. When the orders were received, the carrier was near Puerto Rico, some 4,000 miles from the eastern Mediterranean. Fuel limitations restricted its average speed in the long transit to only 23 knots and it had to refuel in the Mediterranean. A nuclear carrier with nuclear surface combatants could have made the same transit at higher speed and arrived about 2 days earlier without the need to refuel. In a real war situation the 2 days could have been decisive.

TACTICAL MOBILITY

The all-nuclear task group has a superior ability to control engagement ranges with an enemy surface force, to

FIGURE 3


MINIMIZING EXPOSURE OF LOGISTICS SUPPORT SHIPS
HIGH SPEED DASH TO REPLENISH
(RELATIVELY INFREQUENT)
LOGISTICS SUPPORT
(UNDERWAY
REPLENISHMENT)
SHIPS
NUCLEAR
CARRIER TASK
FORCE
LIMITING RANGE
OF ENEMY AIRCRAFT

engage or disengage, or to make other tactically advantageous moves requiring prolonged high-speed steaming.

Manuevering in short-of-war confrontations, such a group may establish a tactical advantage, thus enhancing its credibility. During the Indian Ocean operations of the nuclear-powered carrier Enterprise task group during the 1971 India-Pakistan war, the presence of conventionally powered surface combatants in the task group appears to have denied the U.S. commander these capabilities. He stated:

> "Whenever it was tactically desirable to operate at high speed we had to consider our escort's fuel status and they steamed at slower speeds.... Even though Task Force 74 was joined by several units of the Soviet Fleet, some of which remained in close proximity to our forces, the nominal speed of our task force was kept at 15 knots. In spite of the increase in vulnerability, this low speed was accepted because of the logistics constraints on the supply of fuel for the other ships in the task force."

ADDITIONAL ADVANTAGES

One point often advanced in support of nuclear power is that the ship's and task force's vulnerability to the interruption of oil supplies is reduced. The 1973 Middle East War is cited as an instance where U.S. ships were vulnerable to the cutoff of oil supplies. The House Armed Services Committee, advocates of nuclear power for all strike force combatants, cited the problem of dependence on oil for propulsion in its March 26, 1976, Committee Report on the Defense Department's fiscal year 1977 budget request: "The committee believes that prudent planning for the Navy of the future, in view of the uncertainty of future oil supplies, requires that the Congress continue the national policy that future major combatants be nuclear powered."

Another point sometimes advanced is that an advantage is gained in independent operations. Nuclear power provides world-wide operational flexibility. For example, ships planned for the future, such as the strike cruiser, have been designed as multimission ships--ships which could operate independently in some situations without carrier air support. Ships designed for this type of mission can capitalize on nuclear propulsion.

Other advantages of nuclear power include the elimination of combustion gases discharged from the stacks of conventional ships and improved propulsion plant reliability. The heat and turbulence of stack gases could impede safe flight of aircraft that are landing or hovering close aboard. Stack gases can also add to corrosion problems, particularly for embarked aircraft. Propulsion plant reliability is improved because of higher standards for the nuclear plant--which are a part of the nuclear power cost.

OPPOSING ARGUMENTS

Certain aspects of nuclear power may be advanced as reasons for not constructing nuclear warships: the danger of nuclear contamination, limited nuclear shipbuilding capacity, possible shortage of qualified nuclear operating personnel, the problem of nuclear waste disposal, and the adverse reaction in some foreign countries to port visits by nuclear-powered ships.

Those who oppose constructing only nuclear major surface combatants also point out that the U.S. should not plan exclusively for such situations as high-speed transit, where an all-nuclear task group may be superior. There are important situations where larger numbers of ships are required--numbers made possible only within fiscal constraints by less costly conventional power.

Proponents of conventional power also argue that deterrence is founded on both firm military capabilities and perceptions thereof. They believe that the differences between nuclear and conventional power probably haven't much, if any, impact on perceptions of U.S. and Soviet capabilities, either in this or other countries. They believe it is noteworthy that the recent public debate about the relative capabilities of the U.S. and Soviet navies have focused on the number, size, and armament of each nation's ships, not on propulsion. Even official Navy spokesman, they state, seldom claim nuclear power as an important U.S. advantage in the maritime balance.

Conventional power proponents also believe that the often advanced arguments about nonavailability and high price of fuel oil are shallow and misleading. With respect to availability they believe greater stockpiling of oil is the answer; however, the problem may well be having the oil available at the point needed. As to price, they say it should not be ignored, that the U.S. will have to pay higher prices in the future for nuclear fuel as well.

Another important criticism is that the all-nuclear-powered task group is not completely independent logistically. Although they require no fuel oil, nuclear ships are dependent on support ships for ammunition, supplies, and aircraft fuel. They are, however, less dependent on such support than conventional ships.

CHAPTER 5

EVALUATION OF THE PRESIDENT'S 1976 PROPOSAL AND NUCLEAR ALTERNATIVE

The President's proposed shipbuilding program for fiscal years 1978 through 1982 was not available at the time of our review. We did, however, review the program for strike force surface combatants for fiscal years 1977 through 1981 submitted in February 1976. We also compared the costs and capabilities of the nuclear strike cruiser and conventionally powered guided missile destroyer included in the proposal. We found that the nuclear cruiser costs more to buy and operate than the conventional destroyer, but it has greater military features than the destroyer.

PRESIDENT'S PROPOSAL

In a February 13, 1976, letter the President formally advised the Speaker of the House and the President of the Senate that:

> "In view of the urgent need for increased anti-air warfare capability, we want to introduce and rapidly build up the number of ships equipped with the AEGIS area air defense weapon system. Due to the much greater cost and the later delivery date of the nuclear AEGIS ship, I believe it is in the national interest, taking into account fiscal constraints, to pursue a balanced program of nuclear and non-nuclear ships." He proposed a 5-year strike force surface combatant mix of two nuclear-powered strike cruisers (CSGN) and eight conventionally powered guided missile destroyers (DDG-47), all fitted with the AEGIS weapons system.

The alternative all-nuclear program forwarded by the President provides for seven of the strike cruisers over the same 5-year shipbuilding program. The President based his case for the 10-ship mix on two main points:

1. Because it could be started earlier and the construction period is shorter, the first conventional ship could be delivered almost 2 years earlier than the first nuclear ship.

2. The proposed program would provide three more ships than the all-nuclear alternative "at a cost of $1.7 billion less through 1981."

CONGRESSIONAL ACTION

On July 1, 1976, the Congress voted to authorize funds for 17 ships for fiscal year 1977. None of these ships was a strike force surface combatant, but $371.0 million was authorized to partially fund the conversion of the nuclear-powered cruiser U.S.S. Long Beach into a strike cruiser including installation of the AEGIS weapon system.

The Congress will probably be confronted again with decisions in the fiscal year 1978 budget request on funding of the CSGN nuclear strike cruiser and the DDG-47 conventionally powered destroyer. To assist the Congress, we have provided the following evaluation of the costs and characteristics of these two proposed ships.

COSTS

The President's comparison of the estimated program procurement costs erroneously included about $.6 billion of long lead equipment for the all-nuclear strike cruiser program. Adjusting for this error, we estimate that the 10-ship program acquisition cost would be $7.4 billion, $1.1 billion less than the seven-ship, all-nuclear alternative.

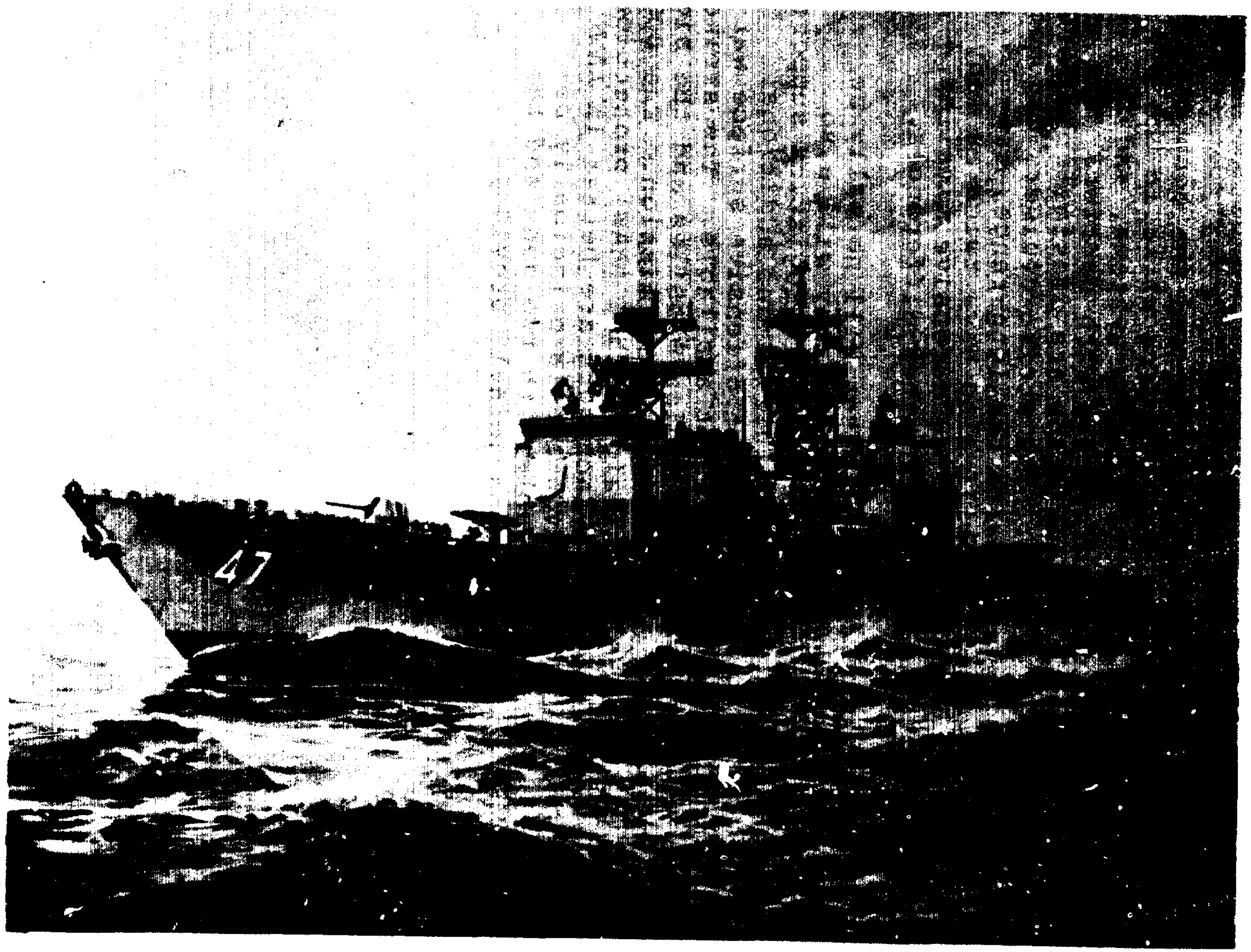
To compare the costs of the DDG-47 and the CSGN, we gathered Navy cost data expressed in constant year dollars, converted into percentages. We compared the lead (initial) ships of each class and the first follow (second) ships of each class. The comparisons showed a cost premium for the CSGN of 50 percent for the lead ship and about 80 percent for the first follow ship. (The Navy estimates the first follow ship costs in fiscal year 1978 dollars to be $567 million for the DDG-47 and $1,014 million for the CSGN.)

The Navy estimates that the strike cruiser will cost about $10 million more per year to operate than the DDG-47 primarily because the strike cruiser is nuclear-powered; is a bigger, more heavily armed ship; and has a higher manning level. On a life-cycle cost basis, which includes the initial procurement costs, annual operating expenses, midlife conversion costs, and recoring costs, the Navy estimates the life-cycle cost of the CSGN to be about 60 to 70 percent higher than the DDG-47.

THE SHIPS

The nuclear-powered strike cruiser and the conventionally powered guided missile destroyer are alike in their primary defensive system, AEGIS, in ASW systems, and in having the necessary speed to operate with carriers. In addition to propulsion, the two ships are dissimilar chiefly in size and offensive systems. The strike cruiser, but not the destroyer, will be armed with the long-range, sea-launched cruise missile. It will also have twice as many HARPOON missiles and 45 percent more defensive missiles. Table 1 on page 22 shows these and other differences.

The DDG-47 and the strike cruiser will normally be deployed with carrier task groups, and they will also operate with amphibious forces and mobile logistics support forces. The strike cruiser will fulfill one additional role--it will operate on independent offensive surface warfare missions where carriers are not available. The strike cruiser will have ship-launched cruise missiles and the bigger 8-inch gun because of its independent mission. The DDG-47 will provide primarily anti-air warfare (AAW) protection, and the Navy found that two 5-inch guns are better in AAW than one 8-inch gun. This advantage is principally because of the redundancy available with two guns and the 360-degree coverage the two guns jointly provide.



ARTIST'S CONCEPT OF THE DDG-47
CLASS GUIDED MISSILE DESTROYER

ARTIST'S CONCEPT OF THE NUCLEAR POWERED STRIKE CRUISER (CSGN)

TABLE 1

THE STRIKE CRUISER VERSUS THE GUIDED MISSILE DESTROYER

SIMILAR IN	DDG-47	CSGN	CSGN DIFFERENCE
PRIMARY DEFENSIVE WEAPONS	AEGIS	AEGIS	
SPEED	ABOUT 30 KNOTS	ABOUT 30 KNOTS	
ASW CAPABILITIES	a/SQS-53/TACTAS ASROC/LAMPS III	a/SQS-53/TACTAS ASROC/LAMPS III	
SIGNIFICANT DIFFERENCES IN			
DISPLACEMENT	9,055 TONS	17,210 TONS	+90%
ARMOR	PARTIAL	SUBSTANTIAL	+ARMOR
LONG RANGE OFFENSIVE MISSILE SYSTEM	NONE	b/8-SLCM	b/+SLCM
MEDIUM RANGE OFFENSIVE MISSILE SYSTEM	c/8 HARPOON	c/16 HARPOON	c/+8 HARPOON
NUMBER OF DEFENSIVE (AAW) MISSILE LAUNCHERS	d/2-MK 26 (MOD 1)	d/2-MK 26 (MOD 2)	d/+45% MORE AAW MISSILES
GUNS	2-5"	1-8"	+8" (1);-5" (2)
AIRCRAFT FACILITIES	2-LAMPS III	e/2-LAMPS III OR 2-VTOL	e/+CHOICE OF LAMPS III or VTOL
MARGINS FOR FUTURE GROWTH	MINIMAL	SUBSTANTIAL	+MARGINS
PROPULSION	CONVENTIONAL	NUCLEAR	+NUCLEAR
UNIT COMMANDER FACILITIES	UNIT	GROUP	+GROUP COMMANDER FACILITIES
CHEMICAL-BIOLOGICAL DEFENSE POTENTIAL	SOME	SUPERIOR	+SUPERIOR DEFENSE POTENTIAL

a/SQS-53 and TACTAS are, respectively, the most advanced hull-mounted active and tactical-towed passive sonars. ASROC is a rocket-propelled antisubmarine weapon. LAMPS III is a shipborne helicopter for long-range localization and attack of hostile submarines.

b/SLCM: Sea Launched Cruise Missile. Also called TOMAHAWK.

c/HARPOON: An antiship missile.

d/The MK 26 (Mod 2) launchers in the strike cruiser carry more missiles than the MK 26 (Mod 1) launchers in the destroyer. The numbers are classified, but the firing rates are the same.

e/VTOL is a vertical take-off and landing aircraft.

CHAPTER 6

WEIGHING PROGRAM ALTERNATIVES

In weighing the alternatives between nuclear and conventional power, the real requirement is to pursue those programs which maximize the overall effectiveness of the Navy. Conventional power proponents believe that large quantities of ships are the immediate need, whereas nuclear power advocates give priority to a high level of mobility and individual ship capability. The positions of each side, however, must be kept in proper perspective, because the magnitude of the cost and effectiveness differences can be overstated.

This chapter discusses cost and effectiveness factors to give a better perspective of the various program alternatives. Included also is an enumeration of the present and planned nuclear surface combatants.

COST FACTORS

In nearly all comparisons of the estimated costs of nuclear and conventional ships, individually and in task groups, nuclear ships cost more to acquire and operate. The cost premium for nuclear power, however, in terms of percentage of conventional power costs, varies widely depending primarily on what is compared and secondarily on how they are compared.

The first follow ship procurement costs premium for the nuclear strike cruiser versus the AEGIS destroyer is estimated to be about 80 percent. The CSGN, however, is not only nuclear-powered, but it is also a bigger, more heavily armed ship containing several military features which add to the cost premium for the ship. Thus we cannot say the cost premium for nuclear power in this comparison is 80 percent.

A better understanding of the cost premium for nuclear power can be gained by comparing the procurement costs of the proposed 17,000-ton nuclear strike cruiser and a hypothetical conventional cruiser equipped with identical weapons systems. On the basis of a February 1976 Navy study, the nuclear-powered strike cruiser costs 30 percent more. See Table 2 on page 25. The conventional strike cruiser, however, is only a concept; the Navy has not proposed building such a ship.

The procurement cost premium is considerably smaller when comparing completely equipped nuclear- and conventionally powered carrier task groups. (See table 2.) In this comparison the carrier and its aircraft were included as well as the surface combatants and logistics support ships. The task groups included different numbers and types of ships but were considered nearly equal in effectiveness in terms of sensors, weapons, and geometry; they differ only in propulsion characteristics.

In addition to evaluating the added cost of nuclear power in terms of the procurement premium paid and comparing task groups and individual ships, one should consider life-cycle costs. Table 2 shows a life-cycle cost premium of 30 percent for nuclear power over conventional power in the strike cruiser. Life-cycle costs include both acquisition costs and operating expenses, such as overhaul, manpower, and fuel costs over the life of the system. Nuclear ships are in general more expensive to operate. For example, the Navy estimates that the annual operating cost of the proposed 17,000-ton strike cruiser would be about $5 to $7 million more than the hypothetical conventional strike cruiser. This is principally because the average annual cost of overhaul (excluding recoring costs) for the CSGN is about 80 percent more than that for the conventional cruiser. The manning requirements of the nuclear cruiser are also greater. The manning level of the strike cruiser is estimated to be 513 with annual manpower costs of $4.94 million per ship. The hypothetical conventional cruiser has a manpower complement of 392 with annual manpower costs of $3.84 million, about $1.1 million less than that for the CSGN.

The life-cycle cost comparison in table 2 of the similarly effective carrier task groups shows little or no cost premium for nuclear power, depending on whether the costs are discounted. This is primarily because the all-nuclear group is composed of three strike ships versus five for the conventional group and because the all-nuclear group has a reduced requirement for support ships.

Most comparisons of nuclear versus conventional power costs in surface combatants are best labeled "ballpark" estimates. The available data on ship construction and operating costs do not lend themselves to precise comparisons. Nuclear and conventional ships also differ in design parameters, ordnance, and electronics, making any cost comparison difficult at best.

TABLE 2

ESTIMATED COST PREMIUM FOR NUCLEAR POWER COMPARED WITH CONVENTIONAL POWER IN SURFACE WARSHIPS

Type of comparison	Premium for nuclear ship over conventional ship cost (note a)
	Percent
Procurement cost	
Nuclear strike cruiser vs. hypothetical conventional strike cruiser	30
Carrier task groups (different numbers and types of ships; the Navy consider them of nearly equal effectiveness in terms of sensors, weapons, and geometry; they differ only in propulsion characteristics)	10
Life-cycle costs	
Nuclear strike cruiser vs. hypothetical conventional strike cruiser	30
Carrier task groups (same as in procurement comparison)	
Costs discounted to achieve present value	3
Costs undiscounted	0

a/These comparisons are based on Navy data which are only "ball park" estimates. Different results may be obtained if the assumptions and methods used are changed. The tabulated values are intended to show the range of values and the general relationships between them.

EFFECTIVENESS FACTORS

While it is generally agreed that a nuclear-powered ship has greater capability than a conventionally powered ship, the advocates of each side cannot agree on the magnitude and nature of this increased capability.

The relative capabilities of nuclear- and conventionally powered task groups depend on the circumstances surrounding each encounter. With opposing fleets on station, within range of each other's weapons at the commencement of hostilities, the importance of the propulsion system is minimized and the issue may be decided primarily on the basis of available firepower. In many other circumstances the high speed endurance, freedom from the need to refuel, and the reduced requirement for sea-based logistics conferred by nuclear power make a large contribution to overall capability. Therefore, the way in which one preceives the nature of future naval warfare, actual or threatened, may affect strongly the appraisal of the propulsion alternatives.

In extreme circumstances (scenario) used to determine force planning, a nuclear-conventional decision is clear. For example, with an on-station scenario in which (1) the U.S. fleet will not engage in prolonged high-speed manuevering for advantage before or during hostilities and (2) the posture of the fleet will not be significantly degraded by refueling requirements, conventional power is the likely choice.

At the other extreme, if on-station forces are outnumbered in a sudden emergency at a distant point, but warning is adequate to permit decisive reinforcement with only nuclear-powered forces, then nuclear power would be the likely choice.

There is a wide range of possible scenarios, each with its own implications for the nuclear-conventional issue. While some are more likely to occur than others, unlikely ones may be important for planning because of their potential effect on U.S. national security. The United States can make choices in naval tactics and strategy that will make some scenarios more likely than others.

Choosing relevant scenarios is made difficult by the longevity of the ships being considered. In the 40 years or so from authorization and appropriation for a new ship until it is retired from active service, the world environment, U.S. Navy strategy and tactics, and significant scenarios may change several times.

COST EFFECTIVENESS STUDIES

We were unable to find any cost-effectiveness studies on nuclear versus conventional power for surface warships since the Supplement on Endurance of the Major Fleet Escort Study (SE/MFE) of 1967. Many later studies have addressed costs only. Others have calculated various performance indices such as combat endurance after steaming various distances.

The SE/MFE study compares two alternative carrier task forces, each consisting of four nuclear-powered carriers with accompanying surface combatants. In one alternative the surface combatants are conventionally powered; in the other they are nuclear-powered. Comparisons are made on the basis of the costs of providing equal capabilities, with capabilities expressed in terms of carrier days on the line. Only three benefits of nuclear power are quantified: (1) high-speed transit without logistic support, (2) better reliability, and (3) decreased vulnerability on station. Nine additional benefits are identified but are too difficult to quantify or use in the analysis. They include:

--Freedom from the requirement to replenish in high-threat areas.

--Increased opportunity to use evasive tracks.

--Ability to extend the attack along a greater perimeter.

--Ability to operate (as under very high-threat conditions) completely free of sea-based logistics support if necessary, including cycling at high speeds between base and operating area.

--Ability to fulfill mission immediately on completion of high-speed transit.

Some assumptions of the study tend to show nuclear power in a particularly favorable light. For example, two of the four carrier task groups are redeployed from the Pacific to the Atlantic Fleet, requiring a very long, high-speed transit around South America. In addition, calculations indicated a major reduction in hits on the nuclear carrier due to the all-nuclear force's higher on-station speed. The vulnerability analysis, however, addressed only the threat from torpedo-firing submarines using straight-running torpedoes. No consideration was given to homing torpedoes, to missile-firing submarines, or to aircraft.

In reviewing the study, the Chief of Naval Operations concluded that when these unquantified factors are considered with the calculated near-equality the results favor the nuclear-powered force.

The only other cost-effectiveness study of which we have knowledge was the 1965 Naval Warship Analysis Group Study 33. This study, "Nuclear Power for Surface Warships," found that nuclear power in aircraft carriers provides more effectiveness for less cost than does conventional power. It also found that substituting nuclear-powered escorts for conventionally powered ones substantially improved the response range of the group and the length of time it could fight without support. Like the SE/MFE study, this study also identified a number of aspects of nuclear power that are important to tactical superiority in wartime but that were too difficult to quantify for use in analysis.

PLANNED ALL-NUCLEAR-POWERED CARRIER TASK GROUPS

There are significant advantages in providing nuclear carriers with all-nuclear-powered surface combatants as escorts. Based on the fiscal year 1977 through fiscal year 1981 planned shipbuilding program, however, there will be only enough nuclear-powered strike force combatants in the fleet to have two all-nuclear carrier task groups.

Admiral Elmo Zumwalt, former Chief of Naval Operations, stated that the desired number of nuclear surface combatants per nuclear carrier is four. Through 1976, however, there were four nuclear carriers (two in the fleet and two under construction) and only nine nuclear combatants (six in the fleet and three under construction). The Five Year Defense Program for fiscal year 1977 through fiscal year 1981 includes funds for one additional nuclear carrier and two nuclear surface combatants. This would result in five nuclear carriers and only 11 nuclear-powered escorts. Thus, through at least the mid 1980s only two all-nuclear task groups with the desired number of escorts will be able to be deployed at one time; the other three nuclear carriers will be burdened with the vulnerabilities and operational disadvantages associated with refueling conventional escorts.

CONCLUSION

Factors governing cost and effectiveness must be considered to keep the differences between nuclear and conventional power in proper perspective. Factors such as program elements compared and costs included affect the magnitude of

cost differences. The scenarios postulated and the capabilities of the threat can have a strong impact on the effectiveness of the forces being compared. Neglectfulness to consider these factors will likely lead to overstatements or understatements of the implications of choosing nuclear or conventional power for strike force combatants.

The relative cost effectiveness of nuclear versus conventional power in surface combatants cannot be measured. Nuclear ships are more capable than conventional ships, but they cost more to acquire and operate. Cost comparisons are difficult at best to make, because (1) nuclear and conventional surface combatants differ in many respects and (2) available data on ship construction and operating costs do not lend themselves to precise comparisons. Additionally, Navy analysts have found it too difficult to quantify many of the benefits of nuclear power.

KEY ISSUES FOR CONGRESSIONAL ATTENTION

In evaluating Navy shipbuilding plans for strike force surface combatants, the Congress will be deciding which option will, in the long run, maximize the overall effectiveness of the Navy: all-nuclear, all-conventional, or a mix. In addressing this central question, the key issues are:

--The all-conventional choice means more ships. Total naval firepower is brought to a maximum. The superior capabilities of nuclear ships, however, are missing.

--The all-nuclear choice brings mobility and greater freedom from logistics support. The ability to concentrate forces quickly at a scene of conflict (real or threatened) is superior. The vulnerability of providing logistics support can be reduced. Ship force levels and the accompanying firepower, however, are at a minimum.

--A mix of nuclear and conventional strike combatants is a third option providing, to varying degrees, the advantages and disadvantages of the all-nuclear and all-conventional options.

--The nature of strike force operations over the coming decades bears importantly on the issue. Will the operations be characterized by forces on-station in forward areas; or will strike force operations be more fluid, featuring rapid concentrations and dispersions of forces?

AGENCY COMMENTS

In commenting on this report, the Department of Defense stated that the report is a high quality product and is a commendably objective treatment of this complex and often emotional issue. They anticipated that the report would serve as a vehicle to clarify and structure the debate among the parties involved. (See app. I.)

APPENDIX I

ASSISTANT SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301

COMPTROLLER

10 JAN 1977

Mr. R. W. Gutmann
Director, Procurement and
Systems Acquisition Division
U.S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Gutmann:

This is in reply to your letter to Secretary Donald Rumsfeld of September 9, 1976 equesting comments on your Draft Report "Nuclear Versus Conventional Power in Major Strike Force Surface Combatant Ships (OSD Case #4447).

The Draft Report is a commendably objective treatment of all sides of this complex and often emotional issue. We anticipate that the Final Report will serve as a vehicle to clarify and structure the debate among the parties involved.

Attached are the specific comments of the Department of Defense on the Draft Report. Due to the high quality of the report, recommendations for deletion have been held to a minimum to only those items considered as both questionable and not germane to the issue. The recommendations for additions and changes are deliberately lengthy in order to fully accommodate all parties and to take advantage of the adversary format.

Sincerely,

Fred P. Wacker

Fred P. Wacker
Assistant Secretary of Defense

Attachments