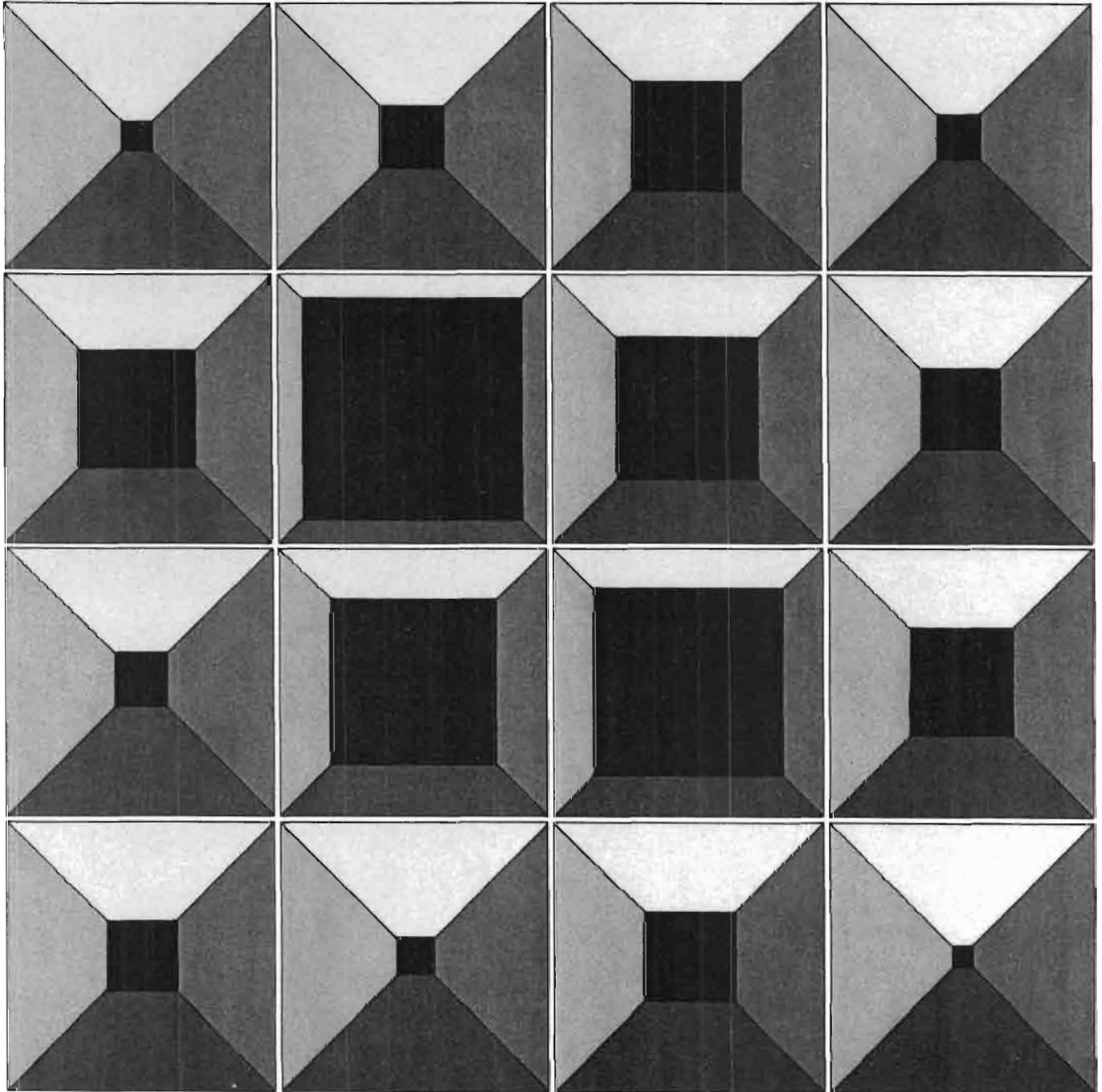
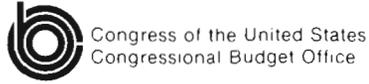


The U.S. Sea—Based Strategic Force: February 1980
Costs of the Trident
Submarine and Missile Programs
and Alternatives



THE U.S. SEA-BASED STRATEGIC FORCE:
COSTS OF THE TRIDENT SUBMARINE
AND MISSILE PROGRAMS AND ALTERNATIVES

The Congress of the United States
Congressional Budget Office

PREFACE

As the Congress considers the defense budget for fiscal year 1981, the Members will confront key issues affecting the sea-based strategic nuclear forces of the United States. They will decide whether--and if so, at what pace--to develop the Trident II missile, a weapon larger and more accurate than any of its predecessors. They may also consider proposals to develop a smaller, cheaper missile-carrying submarine as an alternative to the Trident ship now being procured.

This paper, prepared at the request of the Subcommittee on Research and Development of the Senate Committee on Armed Services, assesses the long-term costs and other aspects of variously constituted sea-based strategic forces. In particular, the study compares Trident submarine forces with several possible alternatives, examining options that would involve developing and deploying the Trident II missile or continuing deployment of the Trident I missile. The paper also considers the effects on costs of possible future vulnerability of the strategic submarine fleet.

The paper was prepared by Richard H. Davison, Beth S. Bloomfield, and Harold W. Furchtgott of the National Security and International Affairs Division of the Congressional Budget Office, under the general supervision of David S.C. Chu and Robert F. Hale. The authors gratefully acknowledge the assistance of John J. Hamre, David M. Moskowitz, Robert R. Soule, Edward A. Swoboda, Nancy J. Swope, Peter T. Tarpgaard, and Dov S. Zakheim. Helpful comments on an early draft were provided by Norman Polmar of the Santa Fe Corporation. (The assistance of external reviewers implies no responsibility for the final product, which rests solely with CBO.) Johanna Zacharias edited the manuscript; Nancy H. Brooks prepared it for publication. In keeping with CBO's mandate to provide nonpartisan and objective analysis, the paper offers no recommendations.

Alice M. Rivlin
Director

February 1980

NOTE

Unless otherwise stated, all dollar figures cited in this study are expressed in constant fiscal year 1980 dollars.

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SUBMARINE AND MISSILE COMPONENTS OF ALTERNATIVE FORCES

The analysis in this study discusses four types of submarines and two types of missiles. For the reader's convenience, the possible force components are described here.

Trident SSBN: A submarine already in production, the Trident SSBN measures 560 feet in length, has a diameter of 42 feet, and displaces 18,700 tons when submerged. It can carry 24 Trident I or II missiles.

New "Necked-Down" Trident-Class SSBN: A proposed modification of the Trident submarine, this ship's principal difference is a hull narrowing to 33 feet aft of the missile compartment, lessening the submerged displacement to 15,000 tons. This ship could carry 24 Trident II missiles.

New "Long" Poseidon-Class SSBN: A hypothetical modification of the Poseidon submarine in operation today, this ship might measure nearly 500 feet in length, have a 33-foot diameter, and a displacement of roughly 10,000 tons when submerged. It could carry 24 Trident I missiles.

New Poseidon-Class SSBN: A hypothetical modernization of the Poseidon submarine designed to allow for some new equipment, this ship might measure about 450 feet in length, have a 33-foot diameter, and a submerged displacement close to 9,000 tons. It could carry 16 Trident I missiles.

Trident I SLBM: A missile now in production, the Trident I is roughly 34 feet long and could be carried by the Trident SSBN, the new "Long" Poseidon-class SSBN, or the new Poseidon-class SSBN. It can deliver a reported payload of eight MK-4 warheads to a range of 4,000 nautical miles.

Trident II SLBM: A planned missile not yet developed, the Trident II might be 44 feet long and could therefore be carried only by the Trident SSBN or a new, "Necked-down" Trident-class SSBN. It might be able to deliver a payload of up to 14 MK-4 warheads and could be designed to achieve greater accuracy than the Trident I SLBM. It could also deliver a reported payload of seven MK-12A warheads, each with greater explosive power than the MK-4.

SUMMARY

At present, 41 nuclear-powered ballistic missile submarines (SSBNs) make up the sea-based portion of the U.S. strategic nuclear "triad." These ships--10 Polaris-class and 31 Poseidon-class--are aging, and the Navy intends to replace them within the next 10 to 15 years. Indeed, the Navy plans to retire all the Polaris SSBNs by the end of fiscal year 1981.

The Congress has already taken action to begin replacing this fleet by authorizing procurement of eight Trident submarines (described opposite). More than twice the size of Polaris or Poseidon ships, each Trident SSBN has 24 launch tubes, eight more than either of the older SSBNs. The Trident's tubes are designed to carry a new, large submarine-launched ballistic missile (SLBM)--the Trident II--which has not yet been developed. For the interim, the Congress has authorized procurement of 312 of the existing Trident I missiles, which will be deployed both on new Trident SSBNs and on some of the Poseidon submarines now in operation. The Trident I missile carries a larger nuclear payload to a greater range than any missile in the SSBN force today.

Significant cost increases and major delays in the Trident shipbuilding program have prompted both the Congress and the Navy to look into the possibility of constructing smaller, cheaper submarines than the Trident. Doubts have also arisen about the need to develop the Trident II missile, in part because of its high near-term costs. The Trident II SLBM, however, would take full advantage of the Trident ship's large launch tubes, carrying a greater nuclear payload than the Trident I missile and probably incorporating greater accuracy. The conferees of the Senate and House Armed Services Committees have asked the Secretary of Defense to report by March 1, 1980, on the requirement for the Trident II missile and to submit a potential funding schedule.

Thus, in authorizing ships and missiles to succeed the Polaris/Poseidon fleet, the Congress faces two major decisions:

- o Should development of the Trident II missile proceed?
- o Should the Congress authorize design and procurement of a smaller, less expensive submarine rather than continue to authorize procurement of Trident ships?

These two questions relate closely to one another. A decision to develop the Trident II missile would logically preclude selection of any submarine alternative too small to carry a missile that size, and construction of very small submarines could likewise preclude future development of the Trident II missile.

MAJOR FINDINGS

Answers to the questions stated above might depend in part on what level of sea-based nuclear retaliatory capability is desired. For purposes of analysis, this study considers three possible levels of capability: 2,000, 3,000, and 4,000 MK-4 warhead equivalents maintained at sea. (The MK-4 warhead was chosen as a common measure because it could be carried on either Trident I or Trident II missiles; its exact explosive power is classified.) The level of capability at sea in today's SSBN force is roughly equivalent to 2,000 MK-4 warheads.

Should the Trident II Missile Be Deployed?

If a need to increase significantly the United States' sea-based retaliatory capability were determined, deploying the Trident II missile could result in lowest total program costs. At double today's capability level (that is, to keep 4,000 warheads at sea), a submarine force armed with Trident II missiles might be roughly 6 to 7 percent less expensive than a Trident I-equipped fleet, a savings of \$4 billion to \$5 billion over the next 30 years. This conclusion rests on an assumption that U.S. SSBNs at sea are now and would remain invulnerable to Soviet attack. Even against a possible future Soviet antisubmarine (ASW) threat, deployment of the Trident II missile would in most cases represent a cheaper hedge than a Trident I-equipped force at this high capability level.

A need to increase the U.S. sea-based deterrent could occur if the MX missile system were to be delayed or cancelled. In such a case, the Trident II SLBM system would offer advantages other than cost. If design objectives for greater accuracy are met, deployment of the Trident II missile would greatly increase the ability of the SSBN force to destroy targets "hardened" against nuclear blast, such as missile silos and command bunkers, though the ability would still be less than that of an MX missile system. Deployment of the Trident II missile would also maximize retaliatory capability for a given number of missile launchers in the

SSBN fleet. This could be especially important if expanding the sea-based deterrent, coupled with possible future SALT limitations, dictated holding down numbers of launchers.

On cost grounds, deploying the Trident II missile would appear relatively less appropriate if the United States is to maintain its current level of sea-based retaliatory capability. At today's level (2,000 warheads), a Trident II-equipped fleet could cost 6 percent more in total program costs (or \$2 billion over 30 years) than an SSBN force armed with Trident I missiles. In most cases at the 2,000-warhead level, the Trident I force would also be a cheaper way to insure against a possible Soviet ASW threat than would a Trident II-equipped force.

In addition, near-term budgetary constraints might militate against developing the Trident II missile over the next few years. Its development could cost some \$8 billion over a period of eight to ten years.

Should a Smaller SSBN Be Designed If the Trident II Missile Is Deployed?

Whether to build a new, small submarine depends largely on the status of the Trident II SLBM. If the missile is deployed, a small submarine would yield little if any savings in total program costs. Development of a smaller SSBN that could still carry the Trident II missile might lower total costs by less than 2 percent (less than \$1 billion over 30 years) at twice today's capability level. No smaller SSBNs would even be deployed at today's level of capability, since only nine Trident ships (one more than the eight already authorized) armed with Trident II missiles are required to maintain 2,000 warheads at sea.

These conclusions rest on an assumption that all SSBNs at sea could survive an attack. If, in anticipation of future ASW threats, extra submarines were procured, construction of a smaller ship that could carry Trident II missiles would reduce total program costs at most by 5 percent at the 4,000-warhead level.

Because the potential cost savings appear small, continuing to authorize current Trident SSBNs might seem prudent if the Trident II missile is deployed. Doing so would avoid the risks of cost escalation and delay that could affect a new development

program. It would also help alleviate the need for the multiple training programs and logistics systems required to maintain several submarine types in one fleet.

Should a Smaller SSBN Be Designed If Trident II Missile Development Is Cancelled?

If the Trident II SLBM is not to be deployed, construction of small submarines able to carry only Trident I missiles might appear desirable, particularly at capability levels higher than the present one. To be practical from a cost standpoint, such ships would need more than the 16 launch tubes built into today's SSBNs. At the present capability level, a force of such newly designed SSBNs--smaller than the Trident SSBN and able to carry 24 Trident I SLBMs--might save about 3 percent (\$1 billion) of total program costs. If capability at sea were increased to 3,000 warheads, this force could prove about 9 percent (\$5 billion) cheaper than a Trident submarine fleet, however, and about 13 percent (\$10 billion) less expensive at double today's level. In addition, were the United States to procure extra SSBNs in anticipation of a future Soviet ASW threat, a new submarine type would appear the least costly alternative at any of the three capability levels examined if the Trident II SLBM is not deployed.

Introducing a new submarine type into the fleet, however, would involve additional training and logistics support. Also, cost escalation could consume some of the savings from a new submarine, particularly should the average procurement cost for a new SSBN type prove 25 percent greater than originally estimated, as happened in the mid-1970s to the Trident SSBN program. These potential problems might argue for continued procurement of the current Trident SSBN, especially at today's capability level, from which potential savings appear smallest.

Continued procurement of the Trident SSBN would also serve as a hedge against future requirements. A decision to construct a smaller ship capable of carrying only the Trident I missile might effectively preclude deployment of a larger SLBM at any time over the next three decades, the probable lifetime of a new, small SSBN. Although a large missile could be deployed on all Trident submarines built, developing a missile that could not be carried by a large fraction of the fleet might be impractical. Continuing authorization of Trident ships, on the other hand, would keep open the option of deploying a large Trident II missile at a later date, though doing so would lead to higher force costs if the Trident II missile were never deployed.

THE FORCE ALTERNATIVES CONSIDERED

The above findings were reached by examining five options consisting of submarines and missiles that might succeed today's force. (The submarines and missiles are described in detail on page xii.) Two options would deploy the Trident II missile:

- o Option I. Current Trident SSBNs, each armed with 24 Trident II missiles.
- o Option II. New "Necked-down" Trident-class SSBNs, each armed with 24 Trident II missiles. (Now under study, this SSBN alternative would probably be proposed by the Administration if a decision is made to halt authorization of Trident submarines.)

Force alternatives armed with Trident I missiles include:

- o Option III. Current Trident SSBNs, each armed with 24 Trident I missiles.
- o Option IV. New "Long" Poseidon-class SSBNs, each armed with 24 Trident I missiles. (Their narrow diameter would prohibit deployment of the Trident II missile.)
- o Option V. New Poseidon-class SSBNs, each carrying 16 Trident I missiles. (These ships would also be unable to carry large Trident II missiles.)

The study is based on an assumption that any force containing a new SSBN type would also contain ten Trident submarines. Since procurement of a newly designed submarine would probably not be authorized before 1984, it is assumed that at least two additional Trident submarines would be authorized in the interim.

COST RANKING OF FORCE ALTERNATIVES

The total cost of a force includes not only near-term development and procurement expenditures but also operation and maintenance costs over the submarines' lifetime. To take account of all these factors, total program cost is defined in this study as all spending required to develop, procure, and operate an SSBN force from fiscal year 1981 through fiscal year 2011 (when the first Trident SSBN would reach the end of its anticipated lifetime). Costs to operate Poseidon submarines until their phased retirement from the fleet are also included.

To ensure that costs apply to comparable force options, each force was assumed to have to maintain a constant number of warheads at sea on a day-to-day basis over a period of 25 years. As mentioned above, three capability levels were considered. The lowest level--2,000 warheads at sea--roughly approximates the retaliatory capability in today's force. Escalation to higher levels might be of interest if the United States chose to rely more heavily on its sea-based deterrent force.

While the five force alternatives could maintain similar numbers of warheads at sea, they would not be comparable in all respects. They would vary, for example, in their ability to destroy certain targets. Options involving the Trident II missile could have a significantly greater likelihood of destroying hard targets than would forces carrying the Trident I missile. This increased capability would stem from both expected improvements in accuracy and the ability to carry warheads with a higher explosive yield. This greater capability, although not included in the measure, remains an important criterion in choosing among the force options.

Costs Assuming No Vulnerability

The table below shows the approximate costs of the force alternatives at each level of retaliatory capability examined. (The figures are calculated on the assumption that all U.S. SSBNs at sea will remain invulnerable to detection and destruction.) Uncertainty about procurement and operating costs and other cost factors suggests that small differences in estimated costs should not be regarded as significant.

The costs shown in the table lead to the major conclusions reported above. The table also indicates that a force of new ships built with only 16 missile tubes--Option V--would clearly represent the most expensive option, costing from 12 to 31 percent more than the cheapest force alternative, depending on the level of capability desired.

The table also shows that, assuming the Trident II missile is deployed, a decision to procure the new, "Necked-down" Trident-class SSBN implies a decision to expand U.S. retaliatory capability at sea. This is so because, at the 2,000-warhead level, no "Necked-down" Trident-class submarines need be procured; if all submarines at sea survived an attack, only nine Trident SSBNs (one more than the eight already authorized) armed with Trident II SLBMs would be needed to provide 2,000 surviving warheads.

SUMMARY TABLE. COSTS OF BALLISTIC MISSILE SUBMARINE FORCE ALTERNATIVES AT THREE LEVELS OF RETALIATORY CAPABILITY: IN BILLIONS OF DOLLARS a/

Force Options	Force Levels Expressed in Numbers of Warheads Maintained at Sea		
	2,000	3,000	4,000
Option I: Trident SSBNs Carrying 24 Trident II Missiles	36	53	66
Option II: New "Necked-Down" Trident- Class SSBNs Carrying 24 Trident II Missiles	<u>b/</u>	53	65
Option III: Trident SSBNs Carrying 24 Trident I Missiles	35	58	80
Option IV: New "Long" Poseidon-Class SSBNs Carrying 24 Trident I Missiles	34	53	70
Option V: New Poseidon-Class SSBNs Carrying 16 Trident I Missiles	38	63	85

SOURCE: Congressional Budget Office.

a/ All costs are expressed in fiscal year 1980 dollars.

b/ No "Necked-down" Trident-class SSBNs would be procured at the 2,000-warhead level.

Future SSBN Vulnerability and the Effects on Cost Ranking of Force Alternatives

Although U.S. SSBNs at sea are currently considered invulnerable to attack, it is uncertain whether they will remain so for the next 20 to 30 years. The nature of a future Soviet ASW threat is unknown, and different types of threat--either "area search" or "trailing"--could lead to different choices among the force alternatives. The Soviets might, for example, become able to search large ocean areas and attack U.S. SSBNs as they are detected. In theory, if SSBNs are randomly distributed over all potential operating areas, the fraction of the force destroyed would be in proportion to the fraction of operating area searched. Thus, distributing a fixed amount of retaliatory capability among more ships should have no effect against an area-search threat. And accordingly, fewer ships armed with greater-capacity missiles (Trident IIs) would be at no disadvantage.

On the other hand, the Soviets might develop the ability to trail U.S. submarines as they leave port and destroy them at will. Given a fixed inventory of Soviet ASW assets, this implies that a specific number of U.S. SSBNs might be in jeopardy. If two forces carried the same number of warheads, the one with the greater number of ships might ensure the survival of more retaliatory capability when faced with a trailing threat.

If one assumes that U.S. SSBNs at sea will become vulnerable in future, the United States could deploy additional ships to ensure that the desired amount of nuclear retaliatory capability would survive an attack. The study therefore recalculated the total program costs for the force options under this assumption and examined how changes in both type and severity of the ASW threat would affect the cost rankings of the options.

In general, the analysis tended to confirm the conclusions stated above. At the 4,000-warhead level, a Trident II-equipped force would seem the cheapest hedge against an unknown Soviet threat. Only if one thought that a trailing threat jeopardizing more than seven U.S. submarines were likely to arise might a Trident I-equipped force appear less expensive. At the 2,000-warhead level, a "Long" Poseidon-class force might appear the least costly hedge against an unknown ASW threat. Only if an area-search threat able to locate and destroy more than 25 percent of the force seemed likely might a Trident II-equipped force become less costly.

To help deter a Soviet attack on the United States or its allies, the United States maintains a strategic nuclear "triad," a three-part arsenal that includes nuclear-powered ballistic missile submarines (SSBNs), as well as land-based bomber aircraft and intercontinental ballistic missiles (ICBMs). These forces are designed to ensure that, even after a preemptive strike, the United States would have retaliatory capability sufficient to inflict what is deemed an "unacceptable" level of damage on the Soviet Union. At present and for the next decade or so, SSBNs at sea represent the component of the triad best able to survive a possible attack.

TODAY'S BALLISTIC MISSILE SUBMARINE FORCE

Ten Polaris and 31 Poseidon submarines now constitute the sea-based portion of the strategic nuclear triad. Initially planned for service lives of 20 years, all 41 submarines entered the fleet between 1959 and 1967. If they were retired according to this original schedule--which was based on predicted factors of aging and technological obsolescence--all of these submarines would be phased out of operation by 1987. Although the Navy may retire the ten Polaris submarines in 1980 and 1981 as planned, 1/ it currently projects the useful service lives of the newer Poseidon ships to be about 25 years, 2/ implying a retirement schedule for these 31 submarines spanning from the late 1980s into

1/ Press Release, Office of the Assistant Secretary of Defense (Public Affairs), "FY 1981 Department of Defense Budget" (January 28, 1980), Chart #11. Indeed, not all Polaris submarines go out on patrols now; the Navy has already placed some on standby status. See remarks of Senator Lloyd Bentsen, "Polaris Submarine Life Extension," Congressional Record (July 16, 1979), p. S9539.

2/ Department of Defense Appropriations for 1980, Hearings before the House Committee on Appropriations, 96:1 (March and May 1979), Part 3, p. 443.

the early 1990s. The Navy is currently examining the feasibility of extending the service lives of Poseidon submarines beyond 25 years. Such an extension appears possible; 3/ indeed, options for future strategic forces programs presented by the Administration assume that Poseidon submarines would retire at the end of 30 years' service, in the mid-1990s. 4/

THE TRIDENT SUBMARINE PROGRAM

The Navy does not intend to operate the existing SSBN fleet indefinitely, however. Instead, it plans to replace the Polaris and Poseidon submarines with newly built ships. Legislation already enacted by the Congress has partially determined the composition of the SSBN fleet that will succeed the Polaris/Poseidon force. The Congress authorized construction of seven Trident submarines in fiscal years 1974 through 1978, and appropriated about \$1.5 billion in fiscal year 1980 for construction of an eighth. 5/ The first Trident SSBN, the OHIO, is scheduled to be deployed on patrol in August 1981.

More than twice the size of a Poseidon submarine (8,250 tons displacement when submerged), the Trident (18,700 tons) will carry 24 missiles, eight more than either a Polaris or Poseidon ship. Although designed with the development of a new, large submarine-launched ballistic missile (SLBM) in mind, the Trident submarine will initially be armed with Trident I

3/ Department of Defense Appropriations for 1980, Hearings, Part 3, p. 359.

4/ Department of Defense Authorization for Appropriations for Fiscal Year 1980, Hearings before the Senate Committee on Armed Services, 96:1 (March, April, and May 1979), Part 3, pp. 1432-3.

5/ Unless otherwise indicated, all cost figures cited in this paper are expressed in fiscal year 1980 dollars. Of the \$1.5 billion, only about \$1.1 billion is for procurement of the eighth Trident submarine; the remaining \$400 million includes funds for advanced procurement of material for a ninth Trident ship, for military construction, for research and development, and for cost escalation on the first seven submarines.

missiles, 6/ which are small enough to fit the launch tubes of Poseidon ships as well. The launch tubes on the Trident SSBN could, however, house SLBMs some ten feet longer and 50,000 pounds heavier than the Trident I missile.

Indeed, the Department of Defense may develop a new SLBM--the Trident II--that will take advantage of the full capacity of the Trident submarine's launch tubes. The increased payload of the Trident II SLBM would allow delivery of a greater number of equal-size warheads than the Trident I missile can carry at a given range. Alternatively, the Trident II missile could carry warheads with a greater explosive yield than those on the Trident I. It could also be made more accurate than the Trident I SLBM.

Difficulties have beset the Trident submarine program, however, causing some critics to question the wisdom of procuring this ship to replace the Polaris/Poseidon force. The unit procurement cost of an average Trident SSBN, originally estimated at \$517 million (in fiscal year 1974 dollars), has risen to about \$1.24 billion (in fiscal year 1980 dollars), an increase of about 27 percent after adjustment for inflation. Cost increases were caused in part by long delays in the Trident building schedules at the shipyard: the Navy expects to receive each of the first seven Tridents about a year and a half after the contractual delivery dates.

POSSIBLE ALTERNATIVES TO THE TRIDENT SUBMARINE

The high unit procurement cost of the Trident SSBN has sparked interest in the possibility of building smaller, cheaper missile-carrying submarines rather than continuing to procure Trident ships. In fiscal year 1979, the Congress appropriated \$3 million to study designs for less expensive submarine alter-

6/ The Trident I missile program represents the only active production line for submarine-launched ballistic missiles; to develop, test, and deploy a new missile would require about seven years. Because the first seven or eight Trident submarines will enter the fleet by 1985 or 1986, before any new missile would be available, they will initially be deployed with Trident I missiles. The Congress has already authorized procurement of 312 Trident I missiles, appropriating \$676.5 million for 82 missiles in fiscal year 1980.

natives and in 1980, another \$5 million for the same purpose. Responding to a request from the Senate Armed Services Committee, the Navy has drafted a study focusing on submarine alternatives that would use well demonstrated technology and that could be available in the near term to complement the base force of Tridents already authorized. 7/

An alternative submarine under consideration by the Navy might cost as much as 30 percent less to build than a Trident, implying a potential savings of \$450 million a ship. 8/ With a displacement probably on the order of 15,000 tons (3,700 tons less than a Trident), this ship could carry 24 of the new, large Trident II missiles (if they were developed), the same number as deployed by a Trident SSBN. For reference purposes, this study henceforth calls this ship a "Necked-down" Trident-class SSBN. The term is derived from the shape of the submarine's hull, which would narrow--that is, be "necked-down"--to a 33-foot diameter just aft of the 42-foot-diameter missile compartment.

If a decision were made to cancel development of a new, large Trident II SLBM, however, it might prove desirable to design and build a radically smaller SSBN that could carry only the Trident I missile. Such a submarine could have a uniform 33-foot diameter like the Poseidon ship's, rather than the 42-foot diameter of the Trident SSBN, resulting in a significantly smaller total displacement than that of a Trident. Given that the procurement cost of a nuclear submarine varies closely in proportion with its displacement, 9/ a submarine with a uniform 33-foot diameter might cost

7/ Unclassified summary of a draft of a study on submarine alternatives, provided by the Navy.

8/ George C. Wilson, "Savings Seen in Smaller A-Subs," Washington Post, May 16, 1979, p. A-1. The 30 percent savings probably represents the difference in average procurement cost between the Trident submarine and the new SSBN type. If so, it would not include the cost to design and develop the new submarine, or the cost differential between the lead ship and subsequently procured ships--costs that have already been paid in the case of the Trident submarine and that could prove quite substantial.

9/ Unclassified summary of a draft of a study on submarine alternatives, provided by the Navy.

only 50 to 60 percent as much to produce as a Trident. Such a submarine might be designed to carry either 16 or 24 Trident I missiles. This study refers to the 16-tube version as a new Poseidon-class SSBN, and to an elongated version with 24 missile launch tubes as a "Long" Poseidon-class ship.

A 33-foot-diameter submarine--either a Poseidon-class or a "Long" Poseidon-class ship--might appear practical for reasons other than cost. Some observers have expressed concern that the Trident, owing to its large size, might be more vulnerable to Soviet detection and destruction than a smaller SSBN. If proven true, this concern might suggest terminating construction of 42-foot-diameter submarines and building smaller ships instead. 10/

Most concern about the ability of a Trident submarine force to survive stems, however, from the small number of ships that would probably constitute such a fleet. To attain a given level of military capability, far fewer Trident SSBNs armed with 24 Trident II missiles would be required than Poseidon-class ships carrying 16 Trident I missiles. But worries about "putting too many eggs in too few baskets" have arisen from plans to concentrate the U.S. sea-based nuclear deterrent in this fashion. Since each Trident II missile could theoretically carry up to six more warheads than a Trident I, 11/ each Trident submarine armed with the new Trident II missiles could carry more than two and one-half times the firepower of a new Poseidon-class submarine armed with Trident I missiles. 12/ Were the United States to deploy such a concentrated SSBN fleet, the loss of even a few ships, either through accident or Soviet attack, could seriously weaken U.S. retaliatory capabilities.

10/ The Navy claims that increased vulnerability due to size has yet to be conclusively demonstrated, except perhaps at very short ranges (see Chapter V).

11/ This would total 14 warheads, the maximum allowed under the proposed SALT II agreement. The Trident II missile would not, however, become available until after SALT II had expired. (See Chapter III for a more detailed discussion of the Trident II missile.)

12/ Trident SSBN armed with Trident II missiles: 24 missiles times 14 warheads per missile equals 336 warheads. Poseidon-class SSBN armed with Trident I missiles: 16 missiles times 8 warheads per missile equals 128 warheads.

Development and construction of new Poseidon-class SSBNs would permit retaliatory capability to be dispersed over a larger force of missile-carrying submarines. Because each submarine could carry only 16 Trident I missiles, more ships would be needed to maintain a given force strength. Some advocates of this approach argue that dispersion of warheads among a larger number of ships might better ensure the survival of the sea-based strategic nuclear deterrent. 13/

KEY CHOICES BEFORE THE CONGRESS

In considering what type of sea-based nuclear deterrent force should replace the aging Polaris/Poseidon SSBN fleet, the Congress faces two fundamental decisions:

- o Should development of the Trident II missile proceed?
- o What kind of missile-carrying submarines should be authorized?

These questions are interrelated and must be considered together.

This paper assesses how choosing any one of the submarine/missile combinations described above would affect the costs of developing, building, and maintaining forces of equal effectiveness. As background for the later analysis, Chapter II offers a brief description of the importance of sea-based deterrent forces to the U.S. strategic posture. Chapter III describes in greater detail the various submarine and missile programs that constitute the force options considered in this study. Chapter IV compares the costs of these alternative forces; the analysis is based on the assumption that all submarines at sea would survive an attack to launch their weapons. Chapter V addresses the question of force survivability and analyzes whether the relative cost-effectiveness of the force options would change if the survivability of submarines at sea proved less than perfect. Chapter VI offers some concluding remarks on other considerations that might influence the choice among alternative SSBN forces.

13/ A force of "Long" Poseidon-class submarines that carried 24 Trident I missiles would not be so concentrated as a force of Trident SSBNs armed with Trident II missiles, and hence would retain some of the possible advantage of a dispersed force.

CHAPTER II. THE VALUE OF THE SEA-BASED DETERRENT FORCE

The U.S. fleet of nuclear-powered ballistic missile submarines, a key component of the triad, carries a large fraction of all U.S. strategic nuclear warheads. In addition, SSBNs possess unique features that make them particularly valuable as a deterrent. This chapter briefly describes these aspects of the sea-based deterrent force.

SIZE AND SIGNIFICANCE OF THE SEA-BASED DETERRENT

Each of the 41 SSBNs the United States currently deploys carries 16 ballistic missiles. Operating in the Pacific Ocean out of Guam, the ten older Polaris ships are armed with Polaris A-3 missiles, which were first deployed in 1964. 1/ These missiles carry three warheads that cannot be targeted independently, with an explosive power (yield) reported as about 200 kilotons each. The 31 newer Poseidon submarines, stationed in Charleston, South Carolina, King's Bay, Georgia, and Holy Loch, Scotland, are armed with the more modern Poseidon C-3 missile. Introduced into the fleet in 1971, each of these missiles carries an average of ten independently targetable warheads with a reported yield of about 50 kilotons. 2/

Though the SSBN force now accounts for less than one-third of all U.S. strategic weapons launchers, roughly one-half of the total U.S. warhead inventory is carried on submarines. Indeed, Secretary of Defense Harold Brown has indicated that, by 1986, in the absence of improvements to the strategic bomber and ICBM

1/ Some of these ships are on standby status and no longer go out on operational patrols.

2/ Numbers and yields of warheads taken from International Institute for Strategic Studies, The Military Balance, 1979-1980 (London: IISS, 1979), p. 86. The Navy plans to equip 12 of the Poseidons with new Trident I missiles; one or two of these conversions are already completed.

forces, ballistic missile submarines might be relied upon to provide five out of every six "penetrating" warheads (those that actually arrive on target). 3/

ADVANTAGES OF BALLISTIC MISSILE SUBMARINES

The Navy at present maintains roughly half of the SSBN force at sea at all times. 4/ The remaining ships are in port, either for overhaul or for a brief maintenance and replenishment period at the end of a patrol. 5/ Although a Soviet attack on U.S. strategic nuclear forces would probably destroy all submarines in port, the Navy currently expects that virtually all SSBNs at sea would survive to perform their retaliatory mission. The Soviets' ability to locate and destroy U.S. SSBNs is believed to be extremely limited, and no major advances in this area are foreseen in the near future. 6/ The SSBN force hence ensures the survival of a sufficient number of nuclear warheads at sea to inflict extensive damage on the Soviet Union in a retaliatory strike. It is therefore a significant deterrent against Soviet attack.

3/ H.R. 8390 (Supplemental Authorization for Appropriations for Fiscal Year 1978) and Review of the State of U.S. Strategic Forces, Hearings before the House Committee on Armed Services, 95:1 (July, August, September, and November 1977), p. 160.

4/ Fiscal Year 1978 Authorization for Military Procurement, Research and Development, and Active Duty, Selected Reserve, and Civilian Personnel Strengths, Hearings before the Senate Committee on Armed Services, 95:1 (April 1977), Part 10, p. 6621.

5/ After approximately six years of operation, Polaris and Poseidon submarines enter port for an extensive overhaul, which lasts about two years (including the post-overhaul testing period). When in operation, the submarines deploy on a 100-day cycle: a 68-day patrol period, followed by a 32-day maintenance period.

6/ Chapter V examines submarine survivability and antisubmarine warfare in greater detail.

The relative invulnerability of U.S. submarines at sea gives the sea-based deterrent force a number of desirable features. These assets--such as independence from need for tactical warning, long-term "survivability," and so-called "crisis stability"--enhance the value of missile-carrying submarines. In addition, the SSBN force plays a critical role in ensuring against the potential failure or destruction of either the land-based ICBM or bomber aircraft forces.

Independence from Tactical Warning

To survive, strategic bomber forces rely on warning of an imminent strike. Informed of an impending nuclear attack, "alert" bombers--maintained on runways and ready for prompt take-off--would attempt to escape the area under attack and thereby survive. Ballistic or cruise missiles carried on aircraft would similarly depend upon tactical warning for survival.

Missile-carrying submarines, on the other hand, ensure the survival of considerable retaliatory capability even without warning of an attack, since approximately half of the SSBN fleet is always at sea and hence virtually attack-proof.

Survivability

Ballistic missile submarines at sea could continue to function after an attack much longer than bombers or land-based missiles could. Since submarines are believed to have very good chances for survival once in the open ocean, their indefinite operation would be constrained primarily by crew endurance and limited stocks of food and other supplies.

The extended survivability of the SSBN fleet could allow the United States to delay and time strategically part or all of a retaliatory attack. Since the fleet would not have to "use or lose" its missiles, the United States would probably have days or even weeks in which to plan a response to a Soviet strike. Because a secure reserve of warheads could be withheld after an initial retaliatory strike, the SSBNs' survivability might also enable the United States to engage in an extended conflict, should this prove to be appropriate.

Crisis Stability

The ability of submarines to survive at sea exerts a stabilizing influence on the U.S./Soviet strategic balance. A nation's need to strike first diminishes as the ability of its forces to survive increases. If a country's nuclear forces are vulnerable to preemptive strike, that country might feel compelled in a crisis to attack the enemy's arsenal in an effort to avert potential destruction of its own forces. By ensuring the survival of retaliatory capability, however, missile-carrying submarines help offset a perceived need to launch a first strike on the enemy's strategic forces.

Ironically, a strategic asset can also be seen in an apparent weakness of submarine-launched ballistic missiles. At present, SLBMs lack sufficient explosive power and accuracy to destroy targets hardened against nuclear blast, such as missile silos, nuclear weapons storage sites, or command centers. ^{7/} Because today's SLBMs present very little threat to an enemy's land-based ICBMs, they give the enemy no incentive to launch its ICBMs out of fear of losing them. In short, SLBMs do not provoke enemy ICBM attack.

SSBN Force's Role in the Strategic Nuclear Triad

In an attempt to ensure survival of retaliatory capability sufficient to inflict "unacceptable" damage on the Soviet Union even after a Soviet preemptive attack, the United States operates its triad of strategic nuclear forces: land-based, airborne, and sea-based. Should one component of the triad either fail to function or be destroyed by a Soviet strike, the other two parts of the triad would be looked to to carry out their retaliatory missions.

The SSBN force thus offers insurance against failure of the strategic bomber or land-based ICBM forces. For example, improved Soviet air defenses might render uncertain the penetration to a target of either a bomber or a cruise missile; such an event would not, however, affect the ability of submarine-launched warheads

^{7/} The Trident II missile may, however, possess a significantly increased capability to destroy hardened targets (see Chapter III).

to reach their targets. The Department of Defense expects that increases in both the number and the accuracy of warheads on Soviet ICBMs will present a significant threat to U.S. silo-housed missiles in the early 1980s. 8/ The continuing survivability of U.S. SSBNs, though, prevents such problems from reaching crisis proportions and allows the United States to deal with matters in a measured fashion rather than with hasty programs.

Besides complicating Soviet attack, maintaining three separate nuclear forces might prevent the Soviet Union from concentrating its resources on particular ways to counter the U.S. forces. For example, Soviet spending on antisubmarine warfare (ASW) assets cannot be applied to building up defenses against U.S. strategic nuclear bombers.

LIMITATIONS OF SSBNs

Uncertain Communications

At present, large, fixed, very-low-frequency transmitters provide peacetime communication with SSBNs at sea. The locations of these shore-based transmitters are well known, and the Soviet Union would almost certainly target them in a nuclear attack on the United States. A fleet of TACAMO 9/ aircraft could provide the communications link with submerged submarines if the land-based transmitters were destroyed, but it is uncertain how long these planes could operate effectively. Unless the communications network could be reconstituted after the TACAMO planes were forced to land, the U.S. National Command Authority might experience difficulty in transmitting messages to SSBNs at sea.

Missile Accuracy

Missiles launched from submarines do not possess the accuracy achieved by land-based missiles. The location and attitude of missile silos can be surveyed with great precision; this is

8/ U.S. Department of Defense, Annual Report, Fiscal Year 1980, pp. 116-117.

9/ The acronym for the naval aircraft designated "Take Charge and Move Out."

not true, however, of missile launchers on an SSBN. Errors in determining the exact speed, location, and attitude of a submarine detract greatly from its accuracy in warhead delivery. As observed earlier, submarine-launched missiles at present have very little capability to destroy targets hardened against nuclear blast, largely because of insufficient accuracy.

Limited Nuclear Options

It is possible that the National Command Authority might decide to launch only a few missiles against well-defined targets at a given time. Submarine-launched ballistic missiles would appear ill-suited for this role. For the reasons stated above, communications with submerged SSBNs might not suffice for transmission of a command requiring speedy confirmation and action. The accuracy of submarine-launched missiles might appear inadequate for the purpose of a limited strike. And finally, the launch of one or two missiles might reveal the submarine's location, perhaps making the ship vulnerable to Soviet attack.

CHAPTER III. ALTERNATIVE SEA-BASED STRATEGIC FORCES--SUBMARINES AND MISSILES

Various alternative SSBN forces--comprising different missile-carrying submarines armed with different missiles--might replace the aging Polaris/Poseidon fleet. This chapter briefly identifies the possible options for a new SSBN force; it first describes the alternative programs' components.

SUBMARINE PROGRAMS

The SSBN force alternatives analyzed in this study include four different types of submarine, one already in production (the Trident SSBN), and three others that are, as yet, still purely hypothetical (see page xii).

The Trident SSBN

In the late 1960s and early 1970s, the Navy considered a large number of missile/submarine combinations to constitute an "Underwater Long-Range Missile System." The designs studied varied in at least four important aspects: the number of missiles to be carried, the size of the missiles, the type and power of submarines' propulsion plants, and overall size of the ships.

The ship that evolved from the Navy's development effort--the Trident SSBN--is more than twice the size of its predecessors. Its hull measures 560 feet in length and 42 feet in diameter, and it has a submerged displacement of 18,700 tons. It can carry 24 missiles (eight more than the Poseidon) and can travel both faster and more quietly than any U.S. SSBN now in operation.

Anticipation of eventual deployment of a new, large missile heavily influenced the size of the Trident submarine. Since a U.S. SSBN carries missiles vertically inside the hull, the diameter of the missile compartment must nearly equal the length of the missile (a small portion can protrude slightly beyond the ship's girth).

Survivability. Although some observers fear that the large size of the Trident might render it more susceptible to Soviet detection than a smaller SSBN, the Trident has features intended to enhance its survivability; at least two of these features are inherent to its larger hull. First, the Trident's powerful propulsion plant might well give it a greater maximum speed than a smaller submarine's, and allow it to travel faster at a given level of generated noise. Second, the Trident's design entails extensive sound isolation mountings for equipment aboard the submarine, an asset made possible by some of the extra space available in the ship. Thus, the Trident's speed and quietness might improve its chances to escape Soviet detection or pursuit.

In addition, the Trident's size is expected to increase operating efficiency by allowing for an improved logistics system. Larger passageways and logistics hatches facilitate installation and removal of equipment. Combined with extensive use of self-diagnostic equipment, these features are intended to shorten the duration of overhauls and the replenishment and maintenance period between patrols, enabling the ship to spend more time at sea, where it is safer from attack.

Managerial Considerations. The Trident shipbuilding program suffered long delays in construction and delivery, which in turn helped drive up real construction costs. Severe disruptions in the shipyard labor force accounted for much of the problem. But the employment situation at the shipyard building Trident SSBNs--the Electric Boat Division of General Dynamics--has apparently improved. So from a managerial standpoint, continued production of Trident SSBNs at the same shipyard would present far fewer complications than shifting to construction of a new type of SSBN. After a difficult transition, machine tools at the production facilities, worker and crew training, and the logistics base are now adapted to building the Trident. Although restructuring these assets to the production of a new SSBN could certainly be done, the process would probably involve many complications.

Indeed, even if the Congress decided to authorize a new SSBN type (such as those discussed below), it might wish to procure a few additional Trident ships beyond the eight already authorized. The Navy has indicated that construction of a newly designed SSBN could not begin until 1984. Continued procurement of Trident submarines until that time would help stabilize employment levels in the industrial base needed to produce SSBNs and might thereby help avert the type of industrial dislocations the Trident SSBN program encountered in the mid-1970s.

Choices for a New, Smaller SSBN

In place of an all-Trident force to succeed the current Polaris/Poseidon fleet, the Congress might choose to authorize one of three new SSBN types in the future:

- o A "Necked-down" Trident-class ship, displacing perhaps 15,000 tons when submerged and carrying 24 Trident II missiles. Although the missile compartment on this ship would have to be about 42 feet in diameter to accommodate the large missiles, narrowing the hull down to a 33-foot diameter aft of this compartment might result in a total displacement some 3,700 tons less than that of the existing Trident;
- o A new Poseidon-class ship, 1/ with a 33-foot diameter and carrying 16 Trident I missiles; or
- o A "Long" Poseidon-class ship, also with a 33-foot diameter but carrying 24 Trident I missiles. This SSBN might be about 40 feet longer and 1,000 tons heavier than the ship described above. 2/

1/ It might prove desirable to design such a submarine to be slightly larger than the present Poseidon to accommodate some new equipment. If so, this SSBN might exceed by several hundred tons the 8,250-ton displacement of the Poseidon. "Poseidon-class" is used here primarily to indicate a 33-foot diameter and capacity for 16 Trident I missiles.

2/ The ratio of a submarine's length to its diameter affects the ship's hydrodynamic stability; if the ratio becomes too high, the ship might experience problems in maneuverability. A 33-foot-diameter submarine built to accommodate 24 missile tubes might potentially suffer such problems. It is unclear, however, whether this would render a "Long" Poseidon-class SSBN undesirable: unlike an attack submarine, an SSBN does not normally operate at high speeds but rather cruises slowly on patrol and attempts to avoid contact with enemy units. Indeed, the Trident SSBN was designed with a length-to-diameter ratio greater (and hence less stable) than that of the present Poseidon submarine.

These three alternative submarines are as yet purely conceptual. No detailed designs for them exist, and much engineering analysis would be needed before any of them could be authorized or built. Any of these new SSBNs would, however, rely on existing technology rather than on anticipated developments. Even so, the Navy estimates that an alternative submarine could not be authorized before fiscal year 1984, 3/ resulting in an initial deployment date not much sooner than 1990.

Compared with Trident. A new, smaller missile-carrying submarine might differ from the Trident SSBN in a number of aspects, including speed, quieting, and amount of time it could spend at sea. With a less powerful reactor than that of a Trident, 4/ a new submarine might not be able to attain so high a maximum speed; the difference would probably amount to less than five nautical miles per hour, however, which some advocates of the concept do not regard as critical. 5/

3/ Department of Defense Appropriations for 1980, Hearings before the Subcommittee on Defense, House Committee on Appropriations, 96:1 (March and May 1979), Part 3, p. 343. It might be possible to move forward the authorization date, however, if the United States were to modify existing Los Angeles-class (SSN-688) attack submarine designs to include a missile-tube compartment. (Indeed, the first five Polaris submarines were essentially Skipjack-class attack submarines modified to carry 16 missile tubes.) In this case, the first new SSBN might be authorized in 1982 or 1983. This approach might offer other advantages: the logistics supply base, machine tooling, and crew training for the 688-class attack submarines already exist, perhaps reducing managerial problems in a shift to a new SSBN.

4/ In 1974, the Navy discussed the possibility of placing a Narwahl-type nuclear reactor in a new, small ballistic missile submarine. See Fiscal Year 1975 Authorization for Military Procurement, Research and Development, and Active Duty, Selected Reserve, and Civilian Personnel Strengths, Hearings before the Senate Committee on Armed Services, 93:2 (April and May 1974), Part 7, p. 3755.

5/ George C. Wilson, "Savings Seen in Smaller A-Subs," Washington Post, May 16, 1979, p. A-1.

Some skepticism also arises concerning whether a submarine much smaller than the Trident could accommodate all of the sound isolation mountings made possible by the Trident's large size. Advances have been made in quieting technology since the Trident was designed in the early 1970s, however. A new SSBN with quieting features nearly as successful as those of the Trident could perhaps be designed. 6/

A submarine much smaller than a Trident probably could not, however, accommodate equally large logistics hatches and passageways and increased equipment accessibility. This might well prevent a comparable amount of ongoing repair and maintenance from being accomplished; a new SSBN might therefore have to spend more time in port than a Trident. Although, like the Trident, a new SSBN would probably be designed to operate for nine years between overhauls, 7/ the overhauls themselves might take several months longer, and "extended refit periods" (60-day mini-overhauls) might be required once or twice between normal overhauls. In addition, the replenishment and maintenance period (or "refit") following a patrol might last several days longer for a new SSBN than for a Trident ship.

Termination of Trident SSBN production and a shift to construction of a new SSBN would probably require changes in both production facilities and equipment, as well as retraining for part of the labor force. In addition, the Navy would have to maintain crew-training and logistics-support systems for each type of ship should a mixed Trident/new SSBN force evolve. 8/ Substantial engineering and design costs, perhaps on the order of \$900 million, 9/ might be associated with a move to a new SSBN.

6/ Wilson, "Savings Seen in Smaller A-Subs."

7/ The Navy is currently exploring the possibility of operating Poseidon SSBNs for up to nine years without an overhaul.

8/ As mentioned earlier, the conversion of existing attack submarine designs to create a new SSBN might well minimize some of these problems.

9/ This figure includes the difference in cost between the first new SSBN produced and the average procurement cost of subsequent submarines of that type.

MISSILE PROGRAMS

Trident I SLBM

With the same overall dimensions as the Poseidon C-3 missile (34 feet in length and 74 inches in diameter), the Trident I missile was designed to fit into the missile tubes of the Poseidon SSBN with only minor modifications to the ship. The Department of Defense currently plans to replace the C-3 missiles in 12 Poseidon submarines with the new Trident I missile; if it becomes desirable to do so, the remainder of the Poseidon fleet could be equipped with this missile as well. After a successful flight-test program, the Trident I was first deployed aboard a Poseidon SSBN in late 1979. In addition, Trident submarines will carry Trident I missiles until a new missile--if any is developed--becomes available.

Payload and Hard-Target Kill Capability. Carrying a reported load of eight MK-4 warheads, the Trident I SLBM is expected to have accuracy equal to that of a Poseidon C-3, but at a much greater range. ^{10/} This combination of warhead size and accuracy will not give the Trident I missile significant ability to destroy targets hardened to withstand nuclear blast. The ability of the Trident I SLBM to destroy hard targets would increase greatly if technology from the Navy's ongoing Improved Accuracy Program were applied to the missile, at a development cost of about \$2.5 billion. ^{11/} The accuracy of the missile could probably not be improved sufficiently to attain very high likelihood of hard-target kill, however. (The Trident I missile cannot carry the

^{10/} Clarence A. Robinson, Jr., "New Propellant Evaluated for Trident Second Stage," Aviation Week and Space Technology (October 13, 1975), p. 16. As of June 18, 1979, however, the Navy had tested the Trident I missile with only seven reentry vehicles. (Reported in the First Agreed Statement to paragraph 12 of Article IV of the proposed SALT II agreement.) The MK-4 warhead could also be carried by the Trident II missile, described below.

^{11/} Department of Defense Appropriations for 1980, Hearings, Part 3, p. 394. The development cost was converted to fiscal year 1980 dollars. This does not include the cost to make the required conversions to Trident I missiles or to SSBNs' fire control systems.

higher-yield MK-12A warhead, which would increase the missile's ability to destroy hardened targets.)

A major design objective of the missile program, the increased range of the Trident I SLBM--4,000 nautical miles, as compared with about 2,500 nautical miles for the Poseidon C-3 missile--expanded roughly tenfold the area of open ocean available to the SSBN force for its patrols. ^{12/} By allowing SSBNs to operate farther from Soviet shores, this increased range substantially improves the chances for survival of the U.S. sea-based deterrent because it enlarges the area the Soviets would have to search. The greater range also enhances efficiency in SSBN logistic support, since less time is needed for submarines based in the continental United States to reach their patrol stations. Should improvements in Soviet antisubmarine warfare capability make a further increase in SSBN operating area desirable, the number of warheads on the Trident I SLBM could be lowered, giving the missile a range greater than 4,000 nautical miles.

Cost Considerations. Almost all development costs of the Trident I SLBM have been paid, and procurement funds for the first 312 missiles have been authorized. Since production becomes more efficient as more missiles are produced, and as unit costs descend, procurement of additional Trident I missiles becomes relatively cheap. The estimated marginal procurement cost of a Trident I missile is now approximately \$7.6 million.

Trident II SLBM

Although no detailed designs for a Trident II missile yet exist, several general characteristics of the Trident II are known. The missile, measuring approximately 44 feet in length and 83 inches in diameter, would take full advantage of the Trident SSBN's launcher dimensions.

Payload and Hard-Target Kill Capability. The Trident II could probably carry up to 14 warheads, each with a yield equal to or greater than those carried by the Trident I. ^{13/} Alter-

^{12/} Department of Defense Appropriations for 1980, Hearings, Part 3, p. 359.

^{13/} The proposed SALT II agreement would in any case limit the number of warheads on a submarine-launched ballistic missile to 14, the largest number tested to date.

natively, a smaller number of larger-yield warheads could be deployed on the missile. ^{14/} The Trident II SLBM would probably be designed to achieve significantly better accuracy than the Trident I missile. Finally, like the Trident I, the Trident II's range could be increased by decreasing its payload of warheads.

The Trident II missile would maximize U.S. retaliatory capability for any given number of missile tubes deployed in the SSBN force. It would greatly increase the number of warheads an individual submarine could carry, meaning that fewer SSBNs would be required to arm the fleet with a given number of warheads. If, in a putative SALT III agreement, the United States wished to retain the ability to inflict a certain amount of damage on the Soviet Union with SLBMs and yet negotiate lower limits on strategic nuclear launchers, development of the Trident II missile would help make it possible to do so.

Together with the Trident II's ability to carry the larger-yield MK-12A warhead, its greatly improved accuracy would significantly increase the ability of the SSBN fleet to destroy all types of targets, including hard targets. Some decisionmakers might approve the acquisition of a sea-based "counterforce" capability, especially if the growing vulnerability of land-based missiles in fixed silos caused greater reliance to be placed on SSBNs for a variety of retaliatory missions. Should the MX missile system be either cancelled or substantially delayed, the Trident II missile might achieve central importance in the U.S. nuclear deterrent arsenal.

Critics oppose development of a highly accurate Trident II missile, however, precisely because it would have the potential for a significant hard-target kill capability. They argue that the ability to threaten or destroy missile silos could jeopardize the stability of the U.S./Soviet strategic balance: uncertain that their fixed ICBMs could survive a U.S. attack, the Soviets might feel compelled to strike first in a crisis. Al-

^{14/} See Clarence A. Robinson, Jr., "New Propellant Evaluated for Trident Second Stage" and "Study Finds Joint MX/Trident Impractical," Aviation Week and Space Technology (October 13, 1975), pp. 16-17. The Trident II missile could reportedly carry seven MK-12A warheads, the type of warhead that will be deployed in part of the land-based Minuteman III ICBM force and possibly on the MX missile.

though Secretary of Defense Harold Brown has indicated a possible need for the ability to destroy hardened targets, 15/ acquisition of such a capability remains a contentious issue.

Cost Considerations and Timing. Estimated at between \$7.5 and \$8.5 billion, 16/ the high development cost of the Trident II missile could deter either the Administration or the Congress from embarking on this program soon. Indeed, the Congress deleted funding for conceptual studies of the Trident II missile from the Administration's fiscal year 1976 and 1977 budgetary requests, as well as from the fiscal year 1979 supplemental request. Total funding for the Trident II in fiscal years 1978 and 1979 amounted to \$10 million (in then-year dollars); and in a report on the fiscal year 1980 defense authorization bill, the House Armed Services Committee recommended deletion of the Navy's entire request of \$40.6 million for the Trident II missile. The Congress ultimately appropriated \$25.6 million in fiscal year 1980 for concept design of the Trident II missile and for the improved accuracy program studies. The conferees of the Senate and House Armed Services Committees have requested by March 1, 1980 a report from the Secretary of Defense that would, among other things, make explicit the requirements and a funding schedule for the Trident II missile.

Budgetary constraints may continue to be a factor in the future, especially given the Administration's commitment to the costly development and deployment in the next few years of the MX missile and a multiple protective structure basing system. 17/ The Administration's previously proposed funding schedule, which totaled \$3.4 billion (in fiscal year 1980 dollars) through fiscal year 1984, would have supported initial deployment of the

15/ See U.S. Department of Defense, Annual Report, Fiscal Year 1980, pp. 77-78.

16/ Department of Defense Appropriations for 1980, Hearings, Part 3, p. 394. The cost has been converted to fiscal year 1980 dollars. Should a decision be made to forego improvements in accuracy over the Trident I missile, however, development costs might decline by as much as \$2 billion.

17/ See Congressional Budget Office, The MX Missile and Multiple Protective Structure Basing: Long-Term Budgetary Implications, Budget Issue Paper for Fiscal Year 1980 (June 1979).

Trident II in 1990. 18/ An accelerated funding schedule could result in earlier availability of the missile: the soonest feasible deployment date for the Trident II might be 1987 or 1988. 19/

Delay in the availability of the Trident II missile will increase the cost of any force that deploys this SLBM. Until Trident IIs become available, submarines able to carry Trident II SLBMs will enter the fleet outfitted with Trident I missiles. These ships would actually have to undergo some conversion before they could be equipped with Trident IIs; such an operation could cost on the order of \$100 million per ship. 20/ More important, though, is the fact that Trident I missiles would have to be purchased for submarines entering the force before the Trident II was ready for deployment. Since this might cost approximately \$200 million per ship, and since at least one SSBN would probably enter the fleet each year in the relevant time period, late availability of the Trident II missile could prove costly (assuming, of course, that Trident I missiles would have limited utility once replaced by Trident IIs).

FIVE ALTERNATIVE SEA-BASED DETERRENT FORCES

Should development of the Trident II missile proceed, the Congress might consider two alternative forces to replace the Polaris/Poseidon fleet:

18/ Department of Defense Appropriations for 1980, Hearings, Part 3, p. 344.

19/ The projected availability date for the "common" MX-Trident II missile was 1987. See Department of Defense Authorizations for Appropriations for Fiscal Year 1980, Hearings before the Senate Committee on Armed Services, 96:1 (March, April, and May 1979), Part 3, p. 1433. The Administration has decided against joint development of the MX and Trident II missiles, and it has decided instead to develop a 92-inch-diameter MX, which would be too large to fit into the Trident SSBN's missile tubes.

20/ Department of Defense Appropriations for 1980, Hearings, Part 3, p. 478. Since an SSBN initially outfitted to carry the Trident II missile could cost from \$50 million to \$100 million more to procure than if initially outfitted to carry

- o Option I. Trident submarines--armed with 24 Trident II missiles, each of these SSBNs might carry 336 warheads (24 missiles times 14 warheads per missile); or
- o Option II. New "Necked-down" Trident-class submarines--armed with 24 Trident II missiles, each of these ships could also carry 336 warheads.

On the other hand, should the Congress decide to forego development of the Trident II missile, three different types of forces might potentially succeed the current SSBN fleet:

- o Option III. Trident submarines--armed with 24 Trident I missiles, each of these ships could carry up to 192 warheads (24 missiles times 8 warheads per missile);
- o Option IV. New "Long" Poseidon-class submarines--armed with 24 Trident I missiles, each of these SSBNs could also carry 192 warheads; or
- o Option V. New Poseidon-class submarines--armed with 16 Trident I missiles, each of these SSBNs could carry up to 128 warheads (16 missiles times 8 warheads per missile).

It is assumed throughout the analysis in Chapter IV that a transition force of Poseidon submarines would complement any of the alternatives listed above. Helping maintain a reasonably constant level of retaliatory capability in the sea-based deterrent force, the Poseidon SSBNs would be retired from the fleet as newly built submarines were phased into operation. A Poseidon transition program could entail two elements: the extension of the Poseidons' service lives from 25 to 30 years and the replacement of Poseidon C-3 missiles on some of these ships with newer Trident I C-4 missiles. The Administration has already implemented the latter and is currently considering the former.

Analysis of the options also rests on the assumption that any new SSBN force would include a "base force" of ten Trident ships. Procurement of at least two more than the eight already

Trident I missiles, however, the real cost per submarine would be less than \$100 million.

authorized might appear practical for two reasons. 21/ First, authorization of additional Tridents could help provide insurance against possible risks in the future. Should problems arise in construction of a new type of SSBN, or in the effort to extend the service lives of Poseidon submarines to 30 years, the availability of extra Tridents in the late 1980s and early 1990s might help counter any potential weakening of the U.S. sea-based deterrent force. Second, as stated earlier in this chapter, procurement of additional Trident submarines could help prevent disruptions in the industrial base required to produce ballistic missile submarines.

21/ The base at Bangor, Washington, is largely completed; because this base is sized to deployment of ten Trident SSBNs, authorization of these two ships would incur no extra basing costs.

As a basis for comparing the five SSBN force alternatives outlined at the end of Chapter III, this chapter first establishes a standard for measuring the effectiveness of such a force. The costs of the options are then examined at three levels of capability. The chapter closes with a brief discussion of how these force alternatives might be affected if the United States were to contain its defense arsenal beyond 1985 within the limits set by the proposed SALT II agreement.

The analysis presented in this chapter is based on the assumptions that all SSBNs at sea at the time of an enemy attack would survive to launch their missiles in a retaliatory strike, and that all ships in port would be destroyed. To determine the extent to which imperfect survivability at sea would affect the cost ranking of alternative SSBN forces, the former assumption is varied in Chapter V.

MEASURES OF CAPABILITY AND COST

The measures of capability and cost used in this study go beyond simple comparison of the procurement cost and the capability of individual submarines. Because the CBO measures differ from those used by many analysts, this first section describes them in full.

A measure combining the proportions of various types of targets an SSBN force could destroy--such as military sites, industrial complexes, political centers, or population--would represent the most exact index of the force's retaliatory capability. Percent of destruction in each target category is difficult to estimate, however; such calculations would require extensive information on the number, size, and location of targets in each category, as well as their ability to withstand blast and other nuclear effects. In addition, targeting constraints of both a political nature (the desire to avoid one sort of target while attacking another) and of a technical nature (missile range and so-called "footprint"--the total area over which a missile can deliver warheads) are essential factors.

The number of warheads of a given size that an SSBN force could contribute to a retaliatory strike constitutes a much simpler--though less exact--measure of a force's effectiveness in war. In this study, if two force alternatives comprise comparable numbers of MK-4 or equivalent warheads after a Soviet attack, they are considered to be of equivalent military capability. 1/

This study compares the five force alternatives at three different levels of nuclear retaliatory capability: 2,000, 3,000, and 4,000 surviving MK-4 warheads (see Table 1). 2/ The lowest level, 2,000 warheads, roughly equals the amount of retaliatory capability now maintained at sea (and hence, it is assumed here, survivable) aboard Polaris and Poseidon submarines. 3/ Building up to higher levels of retaliatory capability in the SSBN force might appear appropriate should improvements in Soviet air defenses threaten either U.S. cruise missiles or penetrating bombers, or should problems arise with the deployment of a mobile MX missile in a basing mode capable of surviving an attack.

1/ This measure of capability overlooks missile accuracy, range, and the ability to deliver warheads with a higher explosive yield than the MK-4. See the Appendix for a brief discussion of these points.

2/ The analysis presented in both this chapter and Chapter V assumes no warning of a Soviet attack; the number of submarines at sea in a force represents a routine deployment level, or a day-to-day alert status. If a period of tension signaling that action were warranted preceded an attack, submarines not in overhaul would be put to sea as quickly as possible, increasing the number that might be expected to survive.

3/ Two thousand MK-4 warheads would have approximately the same equivalent megatonnage as the weapons on board the Polaris and Poseidon submarines maintained at sea. Equivalent megatonnage, equal to the yield of the warhead (expressed in megatons) raised to the 0.66 power times the number of warheads, is not an exact measure of damage capability, however. If the target base is composed of a series of point targets, a large number of small warheads is as effective as a smaller number of very large warheads, though the larger warheads would constitute a much higher value for total equivalent megatonnage.

As analyzed for this study, the five force alternatives would build up to the capability levels and retire from operation at different times and rates. To ensure comparable levels of capability for all forces at all times, this study assumes in each case that Poseidon submarines remain to help the new force maintain the stipulated number of warheads at sea as it is phasing into operation. 4/ Each force option is projected to maintain the warhead requirement from fiscal year 1987 through 2011, 5/ a period sufficiently long to permit total costs to reflect operation of the SSBNs for a reasonable number of years. 6/

Measure of Cost

Costs in this study represent the sums of money required beginning in fiscal year 1981 to design, construct, and operate the forces through 2011. All expenditures authorized before 1981 are excluded from the total program amounts shown in Table 2. In this category fall the development and procurement costs for eight Trident submarines and 312 Trident I missiles, and the

4/ Poseidon warheads are converted to MK-4 warheads or equivalents using the formula for equivalent megatonnage (see Footnote 3). In every case, it is assumed that enough Poseidon submarines are retained to achieve the required warhead level but not exceed it, and that all Poseidons would be retired from the fleet by 1997. The number of Poseidon SSBNs equipped with Trident I missiles varies from a minimum of 12 (the current program) to a maximum of 31, depending upon cost factors and warhead requirements.

5/ Since 4,000 surviving warheads constitute approximately double the retaliatory capability currently maintained at sea, it would be very difficult to attain this goal by 1987. The warhead requirement is therefore not imposed until 1992 in the case of 4,000 warheads at sea.

6/ Any Trident SSBNs authorized in fiscal year 1981 would probably enter the fleet in fiscal year 1987, which might also be the earliest possible date for deployment of the Trident II missile. The first Trident submarine, the OHIO, might be retired in 2011, after 30 years of operation.

construction cost of a submarine base at Bangor, Washington, for ten Trident SSBNs. 7/

The cost of each option includes submarine and missile procurement, research and development (where appropriate) for the Trident II missile and new submarine types, operation and maintenance, Poseidon service-life extension, backfitting Trident submarines to accept Trident II missiles and Poseidon submarines to accept Trident I missiles, and base construction. These different costs would not affect all force alternatives equally. For example, Trident II-equipped forces would have much higher development costs than the others; these same forces would cost much less to operate through the year 2011, however.

COMPOSITION OF FORCE ALTERNATIVES

In order to determine the composition and the cost of the five force alternatives at each of the warhead levels considered, CBO developed a force-planning model. To calculate the number of ships and missiles required for each force, the model uses various planning factors for SSBNs such as length of patrols and refit periods, frequency and duration of overhauls, construction times, and number of missiles required for testing and for spares. The model also takes into account the transition force of Poseidon submarines needed to ensure that the warhead requirement is met, both by backfitting Poseidon SSBNs with Trident I missiles and by extending their service lives from 25 to 30 years when necessary.

7/ Since no warhead requirements were imposed beyond the end of the study period, no costs were counted after the year 2011. The forces would retire from operation at different times; the first force in which all ships would reach their 30-year service lives would be the Trident/Trident II force, and the last ships to be withdrawn from operation would be the newest 16-tube Poseidon-size SSBNs. For example, at the 3,000-warhead level, ships in the new Poseidon-class fleet would have an average age of 19.5 years in the year 2011, as compared with 25 years for Trident SSBNs equipped with Trident II missiles. It may not be an advantage to have younger ships in the force in 2011, however: these SSBNs' design would be close to 30 years old.

Table 1 summarizes the forces determined by the CBO model. Exhibited in the table are the number of submarines in each option (excluding the Poseidon transition force, which does not remain in operation beyond 1996) and the approximate number of missiles required. The missile totals include not only deployed missiles but also spares and test missiles required through the year 2011, the end of the study period. 8/

It must be noted that the three force alternatives using new submarine types also include a base force of ten Trident submarines, for reasons explained in Chapter III. The new submarine types, it is assumed here, would not become operational until 1990. In addition, it is assumed that the Trident II missile would become available for deployment beginning in 1990. Until that time, all SSBNs entering the fleet would initially be equipped with Trident I missiles and would later be backfitted with Trident IIs in the course of regularly scheduled overhauls. 9/

New Trident II-Capable SSBN Only at Increased Capability Levels

Table 1 suggests an important conclusion about designing a new submarine capable of carrying Trident II missiles. To maintain 2,000 warheads at sea, only nine Trident submarines armed with Trident II missiles are required. This implies that, if one wishes merely to maintain the retaliatory capability now at sea in the Polaris/Poseidon fleet, only one more Trident

8/ Missile lifetime is assumed to be indefinite; no costs for refurbishment or replacement of aging missiles are included in the total program costs for each option. If missiles could not remain operational for 30 years but instead had shorter service lives, the number of missiles required for each force would rise, as would their costs. Since Trident II missiles would be newer than Trident I's in most cases, limited missile life expectancy might have less of an effect on forces equipped with Trident IIs; this would depend, however, on the actual functional lifetime of the missiles.

9/ Should it prove desirable to increase sea-based retaliatory capability as quickly as possible, planned overhauls might be moved forward to accommodate accelerated deployment of Trident II missiles in the fleet.

TABLE 1. DESCRIPTION OF ALTERNATIVE SSBN FORCE COMPOSITIONS AT THREE CAPABILITY LEVELS

Force Options	Force Levels Expressed in Numbers of Warheads Maintained at Sea		
	2,000	3,000	4,000
Option I:			
Trident SSBNs Carrying	9 Trident SSBNs	14 Trident SSBNs	18 Trident SSBNs
24 Trident II Missiles	600 Trident I missiles	680 Trident I missiles	780 Trident I missiles
	600 Trident II missiles	720 Trident II missiles	820 Trident II missiles
Option II:			
New "Necked-Down" Trident-Class SSBNs Carrying	a/	4 new SSBNs	9 new SSBNs
24 Trident II Missiles		10 Trident SSBNs	10 Trident SSBNs
		730 Trident I missiles	800 Trident I missiles
		720 Trident II missiles	850 Trident II missiles
Option III:			
Trident SSBNs Carrying	16 Trident SSBNs	24 Trident SSBNs	32 Trident SSBNs
24 Trident I Missiles	950 Trident I missiles	1,190 Trident I missiles	1,490 Trident I missiles
Option IV:			
New "Long" Poseidon-Class SSBNs Carrying	7 new SSBNs	15 new SSBNs	24 new SSBNs
24 Trident I Missiles	10 Trident SSBNs	10 Trident SSBNs	10 Trident SSBNs
	960 Trident I missiles	1,220 Trident I missiles	1,500 Trident I missiles
Option V:			
New Poseidon-Class SSBNs Carrying	10 new SSBNs	23 new SSBNs	36 new SSBNs
16 Trident I Missiles	10 Trident SSBNs	10 Trident SSBNs	10 Trident SSBNs
	990 Trident I missiles	1,290 Trident I missiles	1,550 Trident I missiles

SOURCE: Congressional Budget Office.

NOTES: The table reflects force compositions after 1996, after which year all Polaris and Poseidon SSBNs are presumed to be retired from service. Initial operational capability in 1990 is assumed for both the Trident II missile and all new types of SSBNs.

a/ No "Necked-down" Trident-class SSBNs would be procured at the 2,000-warhead level.

submarine need be procured if the Trident II missile is eventually developed and deployed. Thus the hypothetical "Necked-down" Trident-class submarine, which could carry 24 Trident II missiles, should be considered only if it appears appropriate to increase the fleet's retaliatory capability markedly. 10/

Lower At-Sea Rates For New, Smaller SSBNs

Table 1 also reflects one perceived disadvantage of a submarine smaller than a Trident. Although the new "Long" Poseidon-class SSBNs could carry the same number and type of missiles as Trident submarines armed with Trident I missiles, the "Long" Poseidon-class force would require one or two more submarines to achieve a given level of retaliatory capability. This results from the assumption that the new submarines would spend slightly less time at sea than Trident SSBNs, owing to the lack of space that would facilitate ongoing maintenance; not only would these smaller submarines spend more time in port for refitting, but they might also have to undergo one or two special extended refit periods of about two months each between overhauls. (The same phenomenon is apparent in the case of the new "Necked-down" Trident-class SSBN with Trident II missiles, when compared to the Trident SSBN/Trident II SLBM force at the 4,000-warhead level.)

10/ Even at the 3,000-warhead level, only four new "Necked-down" Trident-class SSBNs would be required. This is based on the assumption that two more Trident SSBNs would be built, for a total of ten in the fleet. Of course, if no more Trident SSBNs were authorized, six or seven of the new submarines would have to be built. As explained in Chapter III, however, this could result in a three-year period (1981 through 1983) during which no SSBNs would be authorized, causing dislocations in the industrial base required to build nuclear submarines. It would also result in a three-year hiatus in the deployment of new SSBNs in the late 1980s, setting back the date the new force would be fully phased in (and hence delaying the retirement of the Poseidon force). Indeed, there are indications that the Administration would favor authorization of an eleventh Trident SSBN before moving to a new submarine type--meaning that only three of the "Necked-down" Trident-class SSBNs would be needed to maintain 3,000 warheads at sea.

TABLE 2. COSTS OF SSBN FORCE ALTERNATIVES AT THREE CAPABILITY LEVELS: IN BILLIONS OF DOLLARS

Force Options	Force Levels Expressed in Numbers of Warheads Maintained at Sea		
	2,000	3,000	4,000
Option I: Trident SSBNs Carrying 24 Trident II Missiles	36	53	66
Option II: New "Necked-Down" Trident- Class SSBNs Carrying 24 Trident II Missiles	<u>a/</u>	53	65
Option III: Trident SSBNs Carrying 24 Trident I Missiles	35	58	80
Option IV: New "Long" Poseidon-Class SSBNs Carrying 24 Trident I Missiles	34	53	70
Option V: New Poseidon-Class SSBNs Carrying 16 Trident I Missiles	38	63	85

SOURCE: Congressional Budget Office.

a/ No "Necked-down" Trident-class SSBNs would be procured at the 2,000-warhead level.

COSTS OF FORCE ALTERNATIVES

The approximate costs of the force options shown in Table 1 are displayed in Table 2. To illustrate the composition of these costs, Table 3 shows program costs broken down into development,

TABLE 3. BREAKDOWN OF COSTS FOR THE FIVE SSBN FORCE OPTIONS AT THE 4,000-WARHEAD LEVEL: IN BILLIONS OF DOLLARS

Force Options	Research and Development <u>a/</u>	Procurement	Operation and Maintenance	Total
Option I: Trident SSBNs Carrying 24 Trident II Missiles				
	7.5	28.1	30.3	65.9
Option II: New "Necked-Down" Trident-Class SSBNs Carrying 24 Trident II Missiles				
	8.4	26.2	30.8	65.4
Option III: Trident SSBNs Carrying 24 Trident I Missiles				
	0	40.8	38.8	79.6
Option IV: New "Long" Poseidon- Class SSBNs Carrying 24 Trident I Missiles				
	1.1	30.2	39.0	70.3
Option V: New Poseidon-Class SSBNs Carrying 16 Trident I Missiles				
	1.1	39.0	45.0	85.1

SOURCE: Congressional Budget Office.

a/ Includes the difference between the cost to procure the first SSBN of a new type and the average later procurement costs.

procurement, and operating costs for the five force options at the 4,000-warhead level. (Because the 4,000-warhead requirement results in the largest number of submarines in a force, it demonstrates most clearly the extent to which a specific cost category determines the total program cost of a force alternative.)

A wide margin of uncertainty surrounds certain aspects of calculating total program costs. The development and procurement costs for both any new submarine type and the Trident II missile are necessarily only rough approximations, since neither of these systems has yet been developed. Although estimates of the cost to produce the first Trident submarine, the OHIO, are reasonably well established, the average procurement cost of forthcoming Trident SSBNs is somewhat less clear. The cost to extend the service lives of Poseidon submarines beyond 25 years is not fully defined either, nor is the cost for building new submarine bases. The estimates presented in Tables 2 and 3 must therefore be taken as approximate.

Trident II Forces Cheapest at the 4,000-Warhead Level

Development of the Trident II missile appears to offer the least costly way to maintain a very high level of retaliatory capability--4,000 warheads--at sea. At this level, the lower operating costs incurred by the numerically smaller Trident II-equipped forces would more than offset the expense for development of the Trident II missile; these forces would have somewhat lower total procurement costs than the Trident I alternatives as well. There is no apparent cost advantage to be gained with Trident II SLBMs at the lower capability levels.

If Trident II SLBM Is Deployed, Smaller SSBNs Yield No Cost Savings

If the Trident II missile were deployed, a force of the new "Necked-down" Trident-class SSBNs would appear to cost roughly the same as a force of Trident SSBNs. A number of factors combine to produce this result. Only a few of the smaller SSBNs would be produced: in combination with the base force of ten Trident submarines, nine of these ships would allow the United States to maintain at sea roughly twice the retaliatory capability that the Polaris/Poseidon fleet now maintains. At the 4,000-warhead level, an at-sea rate lower than that of a Trident submarine would require procuring and operating an additional ship, offsetting the lower unit procurement cost. In addition, development costs for this new ship (including the difference in cost between the first ship and the average procurement cost of ships built later) might reach \$900 million. Given that this option would result in only minor cost savings, if any, other considerations (such as a potential loss of speed, the need to maintain two training and

logistics bases, or the potential managerial and industrial problems) might militate against this force alternative.

If Trident II SLBM Is Not Deployed, Smaller SSBNs May Be Cheaper

Should development of the Trident II missile be cancelled, it might appear wise to construct new, "Long" Poseidon-class submarines with 24 launch tubes. Since this option would present little cost savings over a Trident SSBN force at the 2,000-warhead level, continued procurement of Trident ships might be preferred for managerial reasons if capability in the SSBN force is not to be increased. Savings could prove significant, however--from \$5 to \$10 billion--if higher levels of retaliatory capability were maintained in the sea-based deterrent. As indicated in Table 3, these savings would stem from a much lower total submarine procurement cost than would be the case with a Trident SSBN force. Cancellation of the Trident II missile would obviate the need to construct submarines with a 42-foot diameter; since SSBN procurement costs appear to rise in proportion with displacement, a 33-foot-diameter SSBN with 24 missile tubes might be produced at roughly two-thirds of the cost of a Trident. Although continued construction of Trident SSBNs would constitute a kind of insurance policy, keeping open the option of developing the Trident II missile at some undetermined time, this insurance could cost a few billion dollars if the Trident II missile were never deployed.

Sixteen-Tube Poseidon-Class Ships More Expensive

Finally, a force of new Poseidon-class ships with only 16 missile tubes would clearly prove more expensive to procure and operate than any of the other alternatives examined. While this type of SSBN would cost less to produce than the others, the need for more of them to maintain a comparable number of warheads at sea would negate the value of their lower unit cost. In turn, a force comprising more ships would cost significantly more to operate over a 30-year period.

Effect of Increased Procurement Costs for New SSBN Types

As mentioned above, some of the costs used in calculating the total program spending of the options are uncertain. Estimated procurement costs of new submarine types appear to be the most uncertain. Indeed, the average procurement cost of the

Trident SSBN has proven more than 25 percent greater than early estimates, after adjustment for inflation. ^{11/} Although some of this real cost growth can be traced to serious delays in Trident building schedules owing to labor force dislocations--problems that would not necessarily arise in a new SSBN program--the cost estimates for the new SSBN types may have been understated in Tables 2 and 3.

Table 4 indicates how the costs of Options II, IV, and V would change if the estimated procurement costs of new submarine types were increased by 25 percent. Such cost growth would strengthen two of the conclusions stated above: that development of the Trident II missile might be the least expensive way to maintain 4,000 warheads at sea; and that constructing a new "Necked-down" Trident-class SSBN force would save no money over a force of Trident SSBNs armed with Trident II missiles. Cost growth would, however, tend to weaken the conclusion that "Long" Poseidon-class SSBNs could maintain 3,000 or 4,000 warheads at sea more cheaply than Trident SSBNs if the Trident II missile is not developed.

An "Inaccurate" Trident II Missile

The preceding analysis rests on an assumption that the Trident II missile would cost approximately \$7.5 billion to develop. This sum refers to an SLBM that could deliver warheads with much greater accuracy than can the Trident I missile. It would be possible, however, to develop the Trident II missile without stressing accuracy improvements. Developing an "inaccurate" Trident II would allow the United States to take full advantage of the missile's greater payload without posing a threat to hardened targets. The advantages of this approach, as perceived by some advocates, are outlined in Chapter II.

If improving the accuracy of the Trident II missile were foregone, savings in development costs could approach \$2 billion. Smaller savings might also be realized in production costs. Although savings of this magnitude would not suffice to give the Trident II force a clear cost advantage at the lower levels of

^{11/} In contrast, the development cost of the Trident I missile came within 6 percent of Navy estimates, and the cost to procure it was overestimated by roughly 7 percent.

retaliatory capability examined, they would further increase the practicality of this option at the 4,000-warhead level.

TABLE 4. COSTS OF SSBN FORCE ALTERNATIVES SHOWING 25 PERCENT INCREASE IN UNIT COSTS FOR NEW SHIP TYPES: IN BILLIONS OF DOLLARS

Force Options	Force Levels Expressed in Numbers of Warheads Maintained at Sea		
	2,000	3,000	4,000
Option I: Trident SSBNs Carrying 24 Trident II Missiles	36	53	66
Option II: New "Necked-Down" Trident- Class SSBNs Carrying 24 Trident II Missiles	a/	54	67
Option III: Trident SSBNs Carrying 24 Trident I Missiles	35	58	80
Option IV: New "Long" Poseidon-Class SSBNs Carrying 24 Trident I Missiles	35	55	74
Option V: New Poseidon-Class SSBNs Carrying 16 Trident I Missiles	40	67	91

SOURCE: Congressional Budget Office.

a/ No "Necked-down" Trident-class SSBNs would be procured at the 2,000-warhead level.

Accelerating Trident II Development

Accelerating the Trident II development program might result in lower total program costs, though the savings would be less than those from pursuing an "inaccurate" Trident II. Fewer Trident I missiles would have to be procured, for example. The exact number would depend upon several factors, but it might prove possible to avoid procurement of three shiploads of Trident I's, each costing roughly \$200 million. ^{12/} In addition, earlier deployment of the Trident II missile would raise the number of warheads carried by Trident submarines, allowing earlier retirement of some Poseidon submarines and hence leading to lower operating and service-life-extension costs for Poseidon SSBNs.

Funding levels as of March 15, 1979, would have supported operational availability of the Trident II missile in 1990. In general, though, it takes about six years to develop and deploy a missile after the decision is made to embark on full-scale engineering development. Stretching out the development process can introduce inefficiencies (the need to keep design organizations and production lines open for a longer period) that lead to increased program cost. Accelerating the Trident II development program to make the missile available by 1987 would compress the development program, resulting in potential savings on the order of \$150 million.

Budgetary Considerations and Trident II Missile Development

Near-term budgetary constraints, however, could present a major obstacle to acceleration of the Trident II development program. If the projected deployment date of the Trident II were moved forward to 1987, development funding through fiscal year 1985 might be approximately \$3.3 billion higher than it would be for 1990 availability, although the total development cost might prove slightly lower (as mentioned above). The Navy apparently finds this increase in near-term costs unacceptable, since its primary opposition to development of a common MX-Trident II

^{12/} The number of Trident I missiles that would not be procured would depend upon the date of availability of the Trident II missile and the rate at which Trident SSBNs (both new ships entering the fleet and older ones previously outfitted with Trident I SLBMs) would be equipped with the new missile.

missile--which would have become available in 1987--was the required acceleration of the funding schedule. 13/

Indeed, even deployment of the Trident II missile in 1990 would require a high level of funding over the next ten years. If near-term budgetary considerations continue to pose problems for Trident II development, an SSBN force carrying Trident II missiles might appear less advantageous than a Trident I-equipped force, even though the total program costs used in this study suggest the opposite conclusion at the highest level of capability examined. 14/

IMPLICATIONS FOR STRATEGIC ARMS LIMITATION

The SALT II agreement (as it is framed at the time of preparation of this study) would allow the United States to deploy no more than 1,200 launchers of multiple-warhead (MIRVed) ballistic missiles through 1985, when the treaty would expire. If it is assumed that this total would be divided more or less evenly between the land- and sea-based deterrent forces, the

13/ See Department of Defense Appropriations for 1980, Hearings before the House Committee on Appropriations, 96:1 (March and May 1979), Part 3, p. 433.

14/ Analytically, this same point can be made by using "discounted" total program cost. Discounting is an accounting procedure that emphasizes near-term costs. At the 4,000-warhead level, for example, a Trident SSBN/Trident II SLBM force might cost \$66 billion in the undiscounted total program costs used in this study; a "Long" Poseidon-class SSBN force carrying Trident I missiles might cost \$70 billion in undiscounted total program costs. If a real discount rate of 10 percent a year were applied, however, the Trident/Trident II force would cost \$30 billion while the "Long" Poseidon-class force would cost only \$27 billion. Thus the cost conclusions would be reversed. There is much argument about the appropriate discount rate for use in these calculations, however. Although a real discount rate of 10 percent is sometimes used in Department of Defense studies, a rate of 2 percent or 3 percent would appear more reasonable. In this case, both programs would have roughly the same discounted cost.

TABLE 5. NUMBER OF MIRV-EQUIPPED LAUNCHERS IN SSBN FORCE ALTERNATIVES AT THREE CAPABILITY LEVELS a/

Force Options	Force Levels Expressed in Numbers of Warheads Maintained at Sea		
	2,000	3,000	4,000
Option I: Trident SSBNs Carrying 24 Trident II Missiles	216	336	432
Option II: New "Necked-Down" Trident- Class SSBNs Carrying 24 Trident II Missiles	<u>b/</u>	336	456
Option III: Trident SSBNs Carrying 24 Trident I Missiles	384	576	768
Option IV: New "Long" Poseidon-Class SSBNs Carrying 24 Trident I Missiles	408	600	816
Option V: New Poseidon-Class SSBNs Carrying 16 Trident I Missiles	400	608	816

SOURCE: Congressional Budget Office.

a/ Totals do not include Poseidon SSBN launchers. All Poseidon submarines are assumed to be retired from the fleet by the end of 1996.

b/ No "Necked-down" Trident-class SSBNs would be procured at the 2,000-warhead level.

United States would be limited to roughly 600 MIRVed launchers in the SSBN force. 15/ This limitation could potentially affect some of the options described in the preceding pages should it be extended beyond 1985, or should a lower MIRV limit be negotiated.

Table 5 indicates the number of MIRVed launchers present in the final force for each of the five SSBN/SLBM options considered. 16/ Only at the highest level of retaliatory capability examined would the number of launchers in some of the final forces greatly exceed the SALT limit of 600. Since the United States would probably wish to attain this capability in the SSBN force only if the MX missile were not deployed, some MIRVed ICBMs would probably be retired to make room for more than 600 launchers in the sea-based portion of the strategic nuclear triad.

Forces equipped with Trident II missiles would maintain the greatest amount of nuclear retaliatory capability at sea for a given number of missile tubes in the fleet. If the United States wished to negotiate lower MIRVed launcher limits in a SALT III agreement, while at the same time retaining a very substantial amount of firepower in the SSBN force, development of the Trident II missile might appear desirable.

15/ Indeed, 600 MIRVed launchers in the SSBN force appears reasonable in light of current programs. The Air Force deploys 550 MIRVed ICBMs; in addition, all 173 B-52G aircraft will be equipped to launch cruise missiles. Of these 173 aircraft, 120 make up the difference between the 1,200 MIRVed ICBM/SLBM sublimit and the overall 1,320 MIRV limit; so 53 will be counted under the 1,200 sublimit. Air Force programs might hence account for a total of 603 (550 plus 53) delivery vehicles that would be counted under the 1,200 sublimit--or approximately one-half.

16/ These numbers do not include Poseidon launchers, which would gradually be phased out of the fleet as the replacement forces came into operation. The maximum number of MIRVed launchers in the force alternatives (including Poseidon launchers) would greatly exceed 600 only at the 4,000-warhead level, though.



CHAPTER V. POSSIBLE SOVIET ANTISUBMARINE THREATS AND
SURVIVABILITY OF ALTERNATIVE SSBN FORCES

The assumption underlying the analysis in Chapter IV--that all U.S. SSBNs at sea at the time of a possible Soviet attack would survive to launch their missiles in a retaliatory strike--seems reasonable at present and for the next decade or so. The rise of a Soviet antisubmarine warfare (ASW) threat to the SSBN force cannot be dismissed, however. Were Soviet ASW capability to improve markedly, the threat perceived might influence the choice of one type of SSBN force over another.

There is some concern that a force of large submarines armed with Trident II missiles might be more vulnerable to an ASW threat than a numerically larger fleet of smaller SSBNs carrying Trident I missiles. This concern has two sources: the relatively small number of ships that would constitute a Trident II force, and the relatively large size of ships capable of carrying Trident II missiles. Some observers fear that a smaller number of SSBNs might be easier to locate and destroy than a more numerous force; they believe that spreading the strategic deterrent over a larger number of hulls would be the wiser course. Compounding this fear is the suspicion that large submarines might be more easily detected by the Soviet Union than smaller ones.

Because both the nature and the magnitude of the Soviet ASW threat in coming decades is extremely speculative, it is impossible either to justify or discount these concerns. No definitive answers exist.

The following sections present three different characterizations of the Soviet ASW threat and indicate the circumstances under which the number of ships in an SSBN force might affect the overall survivability of the U.S. sea-based deterrent. How the physical traits of an SSBN could affect its susceptibility to detection is then briefly discussed.

The final section explores the question of how imperfect survivability of U.S. SSBNs at sea could change the conclusions of Chapter IV. In the analysis, the number of warheads to be maintained at sea after an attack is held constant, and the survivability level of each force is varied, resulting in a different

force size and cost at each level of survivability. 1/ This allows comparison of total program costs for the force alternatives under a number of assumptions about the magnitude of the Soviet ASW threat. (Because the analysis rests upon a comparison of force costs, the results of this section are sensitive to changes in cost estimates for the alternatives.)

FUTURE U.S. SSBN VULNERABILITY

The discussion that follows should be read with several points in mind. First, detecting and destroying SSBNs at sea remains most difficult. Indeed, as indicated above, the Department of Defense projects no significant threat to the safety of U.S. SSBNs at sea for the next decade or so. 2/ Discussion of the Soviet ASW threat is not meant as a prediction of whether or not such a threat will arise.

Second, it is assumed that an attack on U.S. SSBNs would be intense and short. Once aware of Soviet actions against U.S. SSBNs, the United States would probably move to protect its sea-based deterrent forces from further assault. The following

1/ For example, assuming no ASW threat, only nine Trident SSBNs armed with Trident II missiles are needed to achieve the 2,000-warhead requirement; of these nine submarines, six would be at sea at all times. If it were assumed that Soviet forces could destroy one-half of all SSBNs at sea, however, 12 SSBNs would have to be kept at sea to ensure the survival of 2,000 warheads. This would require a total force of about 18 Trident ships armed with Trident II missiles.

2/ William J. Perry, Undersecretary of Defense for Research and Engineering, has indicated his belief that Poseidon and Trident submarines on patrol in broad ocean areas would be invulnerable to detection and attack and would survive any attack on the United States. The Soviet antisubmarine warfare threat is not expected to become significant until the 1990s or later. See Department of Defense Authorization for Appropriations for Fiscal Year 1980, Hearings before the Senate Committee on Armed Services, 96:1 (March, April, and May 1979), Part 3, p. 1327; and Department of Defense Appropriations for 1980, Hearings before the House Committee on Appropriations, 96:1 (March and May 1979), Part 3, p. 72.

brief characterizations of the Soviet ASW threat do not take into account the possibility of U.S. submarine losses in a conflict lasting several days or weeks. This assumption does not, however, affect the quantitative analysis at the end of the chapter.

Last, detection of an SSBN would not necessarily result in the ship's destruction. The first detection of the submarine might have determined its position very roughly--that is, within an area measured in thousands of square nautical miles. Then the attacker would have to pinpoint the location of the ship, a process called "localization." Not every detection would lead to a localization, especially if the SSBN were aware of the danger and made evasive maneuvers. Finally, the enemy would have to deliver a weapon successfully on target, which is also not a certainty. Some fraction of submarine detections would result in the destruction of SSBNs, though. For the sake of simplicity, the descriptions of the ASW threat that follow are based on the assumption that destruction would be proportional to detection.

Types of ASW Threat Influencing Vulnerability

This section briefly describes two very different possible Soviet ASW approaches. The first type, an area search, could theoretically result in the destruction of a given portion of a U.S. SSBN force. Contrasted with this is what the Navy calls a "trailing threat," which might make a given number of ships, rather than a fixed fraction of the fleet, vulnerable to destruction. Both of these strategies stem from the apparent Soviet lack of an "open-ocean" sensor system, ^{3/} the means to detect a submarine's presence at long ranges (at hundreds of nautical miles). (The next section discusses how Soviet development of an open-ocean sensor system might affect the ASW equation.)

One should bear in mind that these characterizations of the Soviet ASW threat represent two theoretical extremes; the actual threat would probably lie somewhere in between. They do, however, serve as a useful tool for assessing the importance of force size as a factor in overall U.S. fleet survivability.

3/ Department of Defense Authorization for Appropriations for Fiscal Year 1979, Hearings before the Senate Committee on Armed Services, 95:2 (April and May 1978), Part 9, p. 6667.

The Area Search Threat. Using an area-search strategy, the Soviets might attempt to identify which ocean areas U.S. SSBNs would most probably patrol. 4/ The Soviets could then use their air, surface, and submarine ASW units to make a coordinated sweep of these regions to search for U.S. submarines.

The total amount of ocean area swept would depend in part on the number and location of Soviet ASW vessels and aircraft, together with their search rates and the duration of a search. The area the Soviets could search might well constitute no more than a fraction of the total operating area open to U.S. submarines. If U.S. submarines were distributed more or less evenly over the total operating area available, only a fraction of the U.S. force would be located and destroyed. The anticipated losses would be in proportion to the fraction of the total operating area searched by the Soviets.

Given a threat of this nature, spreading a constant number of warheads over a greater number of ships might not necessarily ensure survival of a greater number of warheads. One would expect a constant share of any force of any size to be destroyed. 5/ Since the size of the total operating area would not be changed by the number of ships in a force--patrol area depends largely on missile range, which is assumed here to be equal for all force options--a larger fleet would simply have more ships distributed

4/ Along with other factors in their analysis, the Soviets could combine knowledge about the length of submarine patrol cycles, submarine operating speed on patrol, the range of U.S. SLBMs, and the areas of the ocean least favorable for antisubmarine warfare.

5/ For example, a force of eight Trident SSBNs at sea carrying Trident II missiles would have the same capability (2,688 warheads) as 14 Tridents at sea armed with Trident I missiles. If the ships were evenly distributed over the total operating area, and if the Soviets searched half of this area, locating and destroying all U.S. SSBNs present in this sector, the first force would lose four ships and the second force would lose seven. Each force would lose exactly the same number of warheads (1,344), however, leaving equal surviving capability.

in the operating area than a smaller fleet. 6/ In theory, for the larger fleet, more ships would be present within the area searched by Soviet forces, resulting in a greater number of submarines located and destroyed.

Therefore, if forces of different sizes possessed the same initial number of warheads at sea, it might be expected that the capability surviving an area-search attack would be equal for all forces. Since the Navy regards an area search as probably the more likely Soviet strategy in an attack on U.S. SSBNs, 7/ it could be argued that the smaller number of ships in a Trident II-equipped force would not adversely affect the overall survivability of the U.S. deterrent. 8/

The Trailing Threat. Rather than searching operating areas, the Soviet Union might try to establish the position of U.S. SSBNs by tracking them as they leave port. Using this strategy, Soviet ASW units would endeavor to maintain a fix on a given U.S. ship's position throughout its entire patrol. Once the Soviet Union had

6/ Submarines armed with the 2,500-nautical-mile Poseidon C-3 missile can patrol in an area of approximately 3 million square miles. SSBNs carrying Trident I missiles command an operating area roughly ten times this size. See Department of Defense Appropriations for 1980, Hearings, Part 3, p. 359; and Department of Defense Authorization for Appropriations for Fiscal Year 1980 and Department of Defense Supplemental Authorization for Appropriations for Fiscal Year 1979, Hearings before the House Committee on Armed Services, 96:1 (March and April 1979), Part 4, p. 595.

7/ See Fiscal Year 1975 Authorization for Military Procurement, Research and Development, and Active Duty, Selected Reserve, and Civilian Personnel Strengths, Hearings before the Senate Committee on Armed Services, 93:2 (April and May 1974), Part 7, p. 3862.

8/ All force alternatives might not have access to equal operating areas, however, owing to differences both in quiet speed between submarine types and in the range/payload trade-off between Trident I and Trident II missiles. In addition, the Soviets might be able to search slightly less area in the case of a numerically larger force, since the number of time-consuming localizations and attacks would be greater than in the case of a numerically smaller fleet.

located a significant portion of the U.S. SSBN force, it could attack those segments of the U.S. fleet at will.

A strong Soviet trailing capability could make the number of U.S. SSBNs a significant factor in the survivability of the sea-based deterrent. To establish and maintain contact with U.S. SSBNs, the Soviet Union would have to earmark a certain number of ASW units for pursuit of each U.S. submarine. 9/ With a fixed total level of ASW assets, the Soviet forces might be able to threaten a fixed number of SSBNs. Thus, with a U.S. fleet that is numerically larger, the percentage that could potentially be trailed and destroyed would drop and the overall survivability of the force would rise. Spreading the same number of warheads over a larger number of ships might therefore increase the number of warheads able to survive an attack. 10/

A serious Soviet trailing threat seems unlikely, however. Because the patrol cycles of U.S. submarines are staggered, the Soviet Union would have to track a number of submarines for a period of several weeks to stay in contact with a significant portion of the U.S. SSBN force. Should this operation be detected (a likely eventuality, since Soviet ASW assets would be stationed outside of U.S. submarine bases), the United States would probably be in a position to take self-protective action. 11/

9/ This number would be a function of several different factors, including the location of U.S. and Soviet bases (which would determine Soviet transit time to U.S. ports), the length of time an ASW vessel could remain on station, and the probability that a single unit could detect and maintain contact with a submarine for an extended period of time.

10/ For example, eight Trident SSBNs carrying Trident II missiles and 14 Trident SSBNs armed with Trident I missiles both could carry the same number of warheads (2,688). If the Soviet Union had the capability to track and destroy five U.S. submarines, the first force would lose 1,680 warheads, while the second would lose only 960.

11/ For example, noisemakers programmed to simulate submarine sounds could be dropped in the ocean to confuse Soviet sound sensors. U.S. attack submarines could be used as decoys to draw away Soviet forces. If necessary, U.S. vessels could actively harass any Soviet units that tried to initiate a trail.

A Soviet Long-Range Sensor System

Future advances in the Soviets' submarine detection technology might enable them to acquire a long-range, or open-ocean, sensor system. 12/ Such a system could change the nature of Soviet ASW strategy--and at the same time, the importance of force size to the survival of U.S. nuclear retaliatory capability at sea.

Soviet development of a long-range detection mechanism might greatly increase the likelihood of a successful area-search threat. If such a system could indeed ascertain from long range the general location of U.S. SSBNs, it would allow the Soviets to concentrate their search in specific areas. Even if the system could only determine the position of a U.S. submarine within a sizable radius--an area measuring perhaps tens of thousands of square miles of open ocean--it could still greatly reduce the total area to be searched.

If technological and geographical constraints prevented the Soviet Union from developing a fixed sensor system that provided an open-ocean surveillance capability, the Soviets might eventually deploy sensors on mobile platforms; these might make possible detection of submarines a few hundred miles away. Should this advance occur, the trailing threat could become more plausible, since Soviet vessels might be able both to start and to continue trailing U.S. submarines at relatively long distances. 13/

12/ The United States reportedly possesses such a capability in its Sound Surveillance System (SOSUS). See "Arms Control Implications of Anti-Submarine Warfare Programs," in Evaluation of Fiscal Year 1979 Arms Control Impact Statements: Toward More Informed Congressional Participation in National Security Policymaking, prepared by the Congressional Research Service for the Subcommittee on International Security and Scientific Affairs, House Committee on International Relations, 95:2 (January 1979), pp. 110-112.

13/ This ability could complicate any U.S. response. Although maintaining a close trail on U.S. SSBNs could be widely recognized as a highly provocative act, such might not be the case if Soviet tracking vessels remained distant from their quarry. Indeed, if the Soviet units were extremely far away, the United States might not even be aware that a portion of its sea-based deterrent was under trail.

With either a stationary or a mobile Soviet open-ocean detection system, a numerically larger SSBN force might improve the overall survivability of the sea-based deterrent. In the first case (with a fixed system), the total area that the Soviets would have to sweep could potentially increase with the number of SSBNs in the U.S. force, since each submarine might account for a given region to be searched. The second case (with mobile platforms) presents a modified trailing threat; once again, a larger number of ships could conceivably ensure the survival of more warheads than a smaller force.

DETECTABILITY OF DIFFERENT SUBMARINE TYPES

The varying features of the four SSBN types discussed in this study--including submerged displacement, maximum speed and maximum quiet speed on patrol, and noisiness of operation--could potentially render one type of ship more susceptible to Soviet detection than others. The type of SSBN used in the sea-based deterrent might result in different survivabilities for the force alternatives. 14/

At present, detection of submarine-generated noise is the easiest way to determine a submarine's presence at any but very short distances. Although a new, smaller SSBN would be designed to generate less noise than the Poseidons now in the fleet, it might not attain as much noise reduction as is now projected for a Trident, because of lack of space for as much sound isolation equipment. Without other means of noise reduction, a new type of submarine might be slightly more detectable by acoustic sensors than a Trident. 15/ Assistant Secretary of the Navy for Research

14/ It must be remembered that the three force alternatives that include a new submarine type would also have a base force of ten Trident SSBNs. This would complicate any attempt to ascribe an overall survivability level to any of these forces, if it were believed that the different submarine types differed significantly in degree of detectability.

15/ Many noise-reduction techniques do not require significant volume, and further improvements in noise-reduction technology will undoubtedly occur in the future. Of course, it might be possible to apply these techniques to Trident ships as well, further reducing their acoustic emissions.

and Engineering David E. Mann has indicated, though, that smaller submarines would be just as quiet as a Trident. 16/

To carry a 44-foot missile internally, submarines armed with the Trident II SLBM would have a greater submerged displacement than SSBNs designed to carry the 34-foot Trident I missile. Trident II-equipped ships would displace from 5,000 to 9,000 tons more than submarines with 33-foot diameters. This greater size could prove a drawback if the Soviet Union relied upon nonacoustic methods of detecting SSBNs. Indeed, the Soviet Union is apparently engaged in extensive research in the area of nonacoustic submarine detection. 17/ Although nonacoustic detection is effective only at short ranges at present, future advances in technology could theoretically change this situation.

For example, techniques used by Soviet surface vessels, aircraft, or satellites to detect the wake of a submarine might be slightly more effective against a large submarine than against a smaller one that created less disturbance at the same speed. Such wakes could potentially be detected either optically, thermally, chemically, or by radar. Alternatively, if future Soviet sensors could detect magnetic anomalies at very long ranges, large submarines, with greater quantities of steel in their hulls, might be somewhat more easily detected than smaller ships. 18/

If a new type of submarine were equipped with a lower-power propulsion plant than the Trident has, the new SSBN could possibly have a lower quiet speed for patrol and a lower maximum speed overall than a Trident. 19/ A higher quiet speed might appear

16/ See George C. Wilson, "Savings Seen in Smaller A-Subs," Washington Post, May 16, 1979, p. A-1.

17/ Department of Defense Authorization for Appropriations for Fiscal Year 1979, Hearings, Part 9, p. 6667.

18/ Existing magnetic anomaly detectors are effective at only very short ranges, on the order of 1,000 yards. See Stockholm International Peace Research Institute, Tactical and Strategic Antisubmarine Warfare (Stockholm: SIPRI, 1974), p. 21.

19/ This would depend on the size of the submarine as well as the power output of its reactor. Decreases in ship size would partially compensate for a move to a smaller reactor.

useful: in the time following detection of an SSBN's approximate location, the area in which the ship might hide would increase with its speed. The usefulness of a higher maximum speed is not quite so clear, however. Operation at maximum speed would generate more noise, perhaps increasing the Soviet Union's ability to detect the ship's position acoustically. Nor is a U.S. SSBN likely to be able to outrun an enemy vessel in many cases once Soviet ASW forces had firmly established contact with the submarine.

No firm conclusions about whether one type of submarine would be more prone than another to Soviet detection and destruction are clear. In the first place, as mentioned earlier, no detailed designs exist for any new SSBNs, and the first Trident SSBN, the OHIO, is not yet in service. It is therefore difficult in some cases to measure the degree to which the observable physical characteristics (called "signatures") would differ among the alternatives. Further, accurate predictions cannot be made about the nature and quality of Soviet ASW sensors in the distant future. Even if slight differences in observable signatures did exist between submarine types, it would be very difficult to determine whether these differences would prove significant and result in a measurably different survivability level for one type of ship relative to another. This problem would be complicated by the fact that one submarine design might be more detectable than another by one type of sensor but less detectable by a second.

COMPARATIVE SSBN FORCE COSTS AT DIFFERENT LEVELS OF SURVIVABILITY

Despite the many uncertainties concerning Soviet ASW capabilities, it is possible and pertinent to compare the costs of the force alternatives at different levels of survivability. By this means, one can determine how ASW considerations might affect the major conclusions in Chapter IV, which rest on an assumption of no Soviet antisubmarine warfare threat. In brief, these conclusions were:

- o Development of the Trident II missile would lead to the lowest force costs if 4,000 warheads were required at sea;
- o If the Trident II missile is developed, only very small cost savings, if any, would arise from building a new submarine type capable of carrying 24 Trident II missiles;
- o If development of the Trident II missile were canceled, Trident submarines armed with Trident I missiles might

be the preferable option at the 2,000-warhead level. At higher levels of capability, though, construction of "Long" Poseidon-class SSBNs might save from \$5 billion to \$10 billion; and

- o Construction of new Poseidon-class ships with only 16 missile tubes would not appear desirable on cost grounds.

Figures 1 through 4 depict the relationship of cost to survivability for each SSBN force alternative, given the number of warheads desired to survive an attack. The curves were derived by calculating the number of ships needed in a force to yield the required number of warheads given a particular survivability level, and then computing the total program costs of that force. As the expected survivability of a force falls, the number of ships required rises, resulting in higher total program costs. On the vertical axes appear the total program costs of the forces from fiscal year 1981 through fiscal year 2011. The survivability levels of the forces are shown on the horizontal axes.

Two graphs are shown for both the 2,000- and 4,000-warhead levels. In Figures 1 and 3, the level of submarine survivability is expressed as the percent of the SSBN force that would survive a Soviet attack (known as "pre-launch survivability"), corresponding to an area-search threat. Figures 2 and 4 express the survivability of a force in terms of the number of ships destroyed at sea, which could correspond to a trailing threat. 20/

20/ It should be noted here that the survivability levels of the force alternatives were varied only in the ten-year period fiscal years 2002-2011. Perfect survivability of all submarines at sea is assumed in previous years for two reasons. First, the forces require a long time to build up to their ultimate strengths. If submarine survivability were varied in earlier years, many of the forces could provide the desired number of surviving warheads only if very high submarine building rates were achieved, especially at the 3,000- and 4,000-warhead levels. Second, all Poseidon submarines would be retired from the fleet by the year 2002. Varying submarine survivability beginning in that year allows a more pure comparison of the different force types, since the Poseidons would not be in the force when submarines at sea came in danger of destruction.

PROGRAM COSTS FOR ALTERNATIVE SSBN FORCES AS A FUNCTION OF SURVIVABILITY AT SEA^a

FIGURE 1. FOR 2000 WARHEADS TO SURVIVE ATTACK

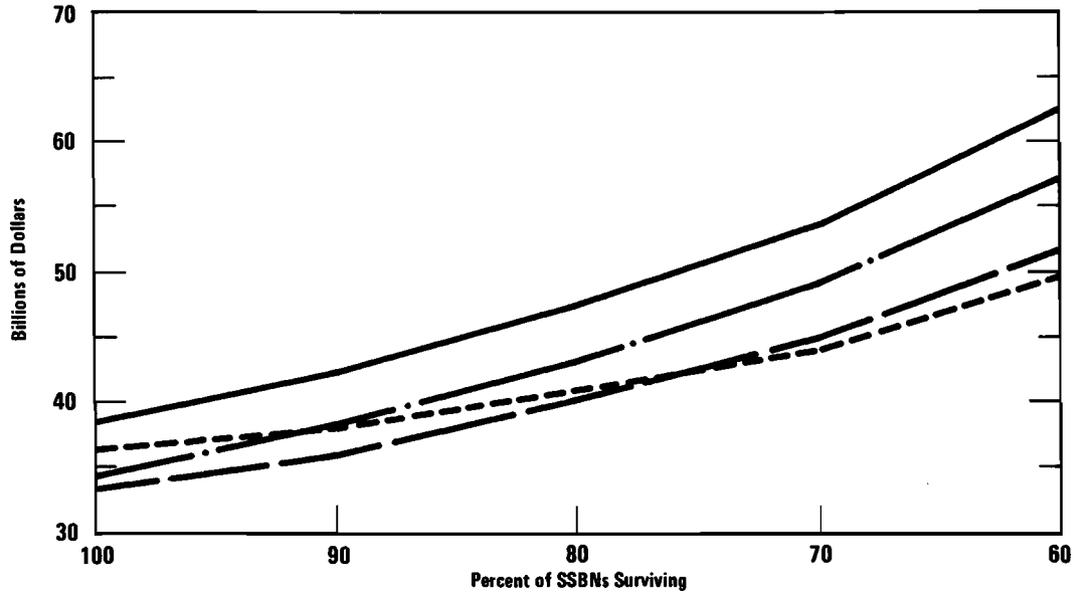
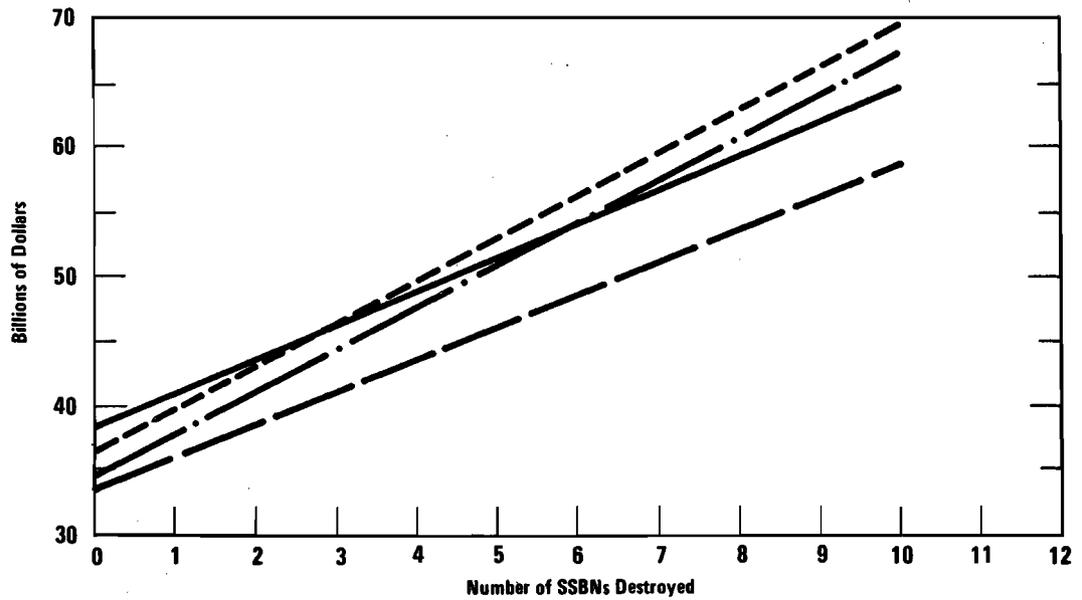


FIGURE 2. FOR 2000 WARHEADS TO SURVIVE ATTACK



^a For Figures 1 and 2, it is assumed that no "Necked-down" Trident-class SSBNs would be procured at the 2,000-warhead level.

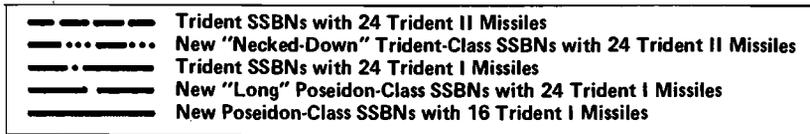


FIGURE 3. FOR 4000 WARHEADS TO SURVIVE ATTACK

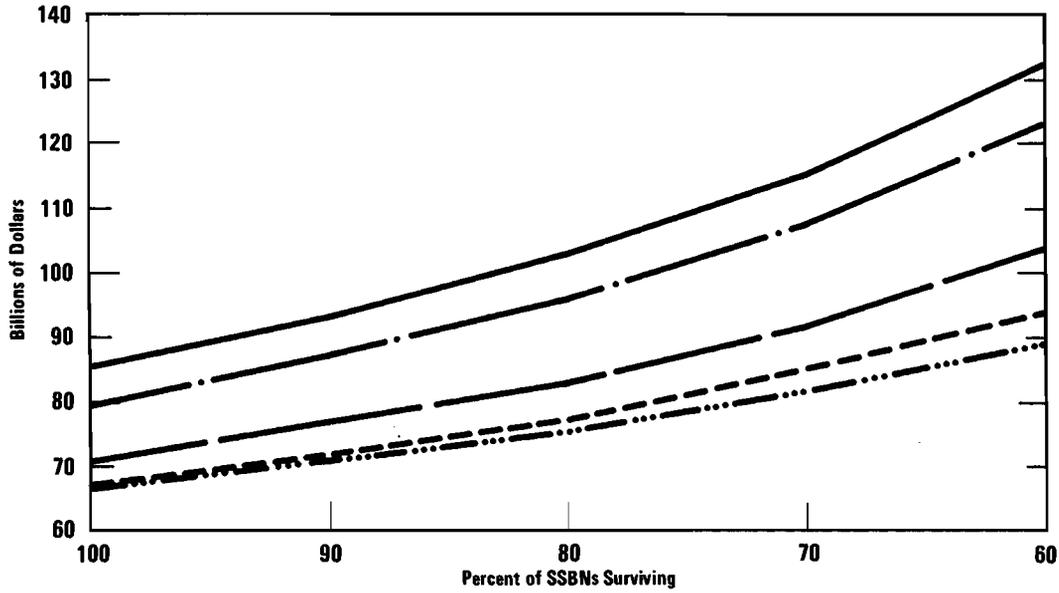
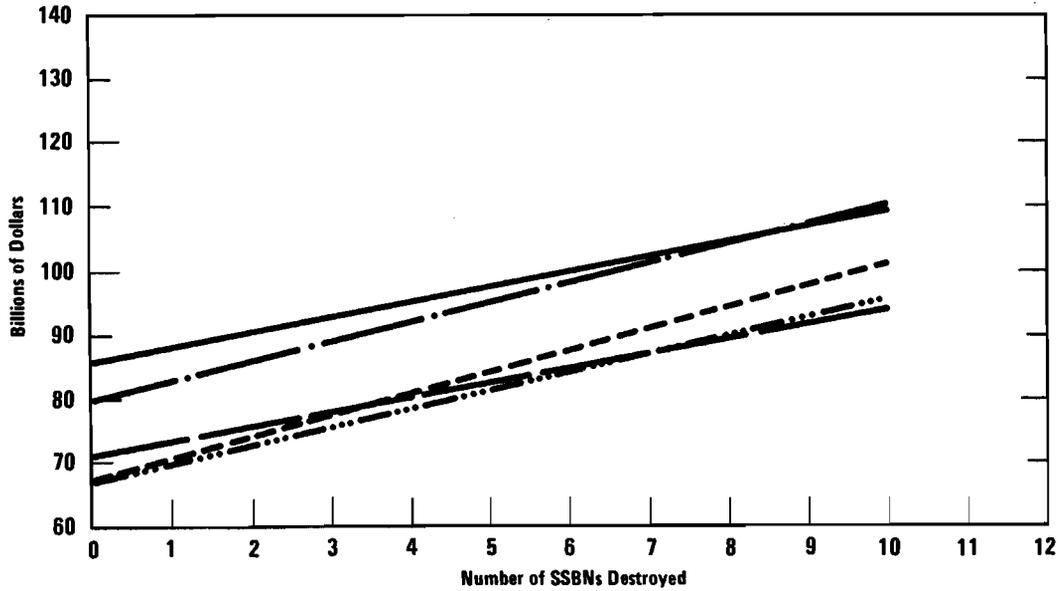


FIGURE 4. FOR 4000 WARHEADS TO SURVIVE ATTACK



The first conclusion--that deployment of the Trident II missile might result in lowest total program costs at the 4,000-warhead level--would not change in most cases if SSBNs at sea were expected to become vulnerable in the future. If an area-search attack were to destroy the same percent of any SSBN force (Figure 3), a force of SSBNs armed with Trident II SLBMs might prove cheaper by \$4 to \$14 billion than the least expensive Trident I-equipped force, depending upon the severity of the ASW threat. In the case of a trailing threat (Figure 4), a Trident II force would appear reasonably close in cost to the cheapest Trident I alternative even at high threat levels, and it might cost the same or less if faced with a less severe threat. Since the nature and severity of an ASW threat 20 years hence cannot be predicted with confidence, deployment of the Trident II missile would seem the best hedge against a Soviet ASW threat if 4,000 warheads were desired for retaliatory purposes.

The second conclusion--that construction of a new SSBN type would not yield great savings if the Trident II missile were deployed--would similarly remain unchanged in most cases by Soviet ASW considerations. At the 4,000-warhead level, the costs of the two Trident II-equipped forces would probably fall quite close together most of the time. ^{21/} Only when large numbers of ships are required in a force, ^{22/} corresponding to high threat levels in the 4,000-warhead case (Figures 3 and 4), might a force of "Necked-down" Trident-class SSBNs appear \$4 to \$5 billion cheaper than a force of Trident submarines; this difference would represent about 5 or 6 percent of total program costs for the two SSBN force options.

Concern about survivability of SSBNs at sea would reverse part of the third conclusion. Previously, it appeared that a

^{21/} This outcome is partly determined by the assumption that a new SSBN type smaller than the Trident would spend less of its lifetime at sea than a Trident. If this proved untrue, the difference in cost between the two forces would rise and perhaps render more practical the possibility of producing a new SSBN smaller than the Trident.

^{22/} In these cases, a total of 30 to 40 SSBNs armed with Trident II missiles would be needed; to date, only eight Trident SSBNs have been funded. A "Necked-down" Trident-class ship might thus yield appreciable savings if another 22 Trident SSBNs were to be built.

force of Trident submarines carrying Trident I missiles might represent the preferred alternative at the 2,000-warhead level if the Trident II missile were not developed, and also that construction of a new "Long" Poseidon-class ship would result in much lower force costs only at higher capability levels. If extra ships were procured to meet a possible future Soviet ASW threat, however, building "Long" Poseidon-class SSBNs might prove desirable at all levels of retaliatory capability examined. In both the area-search threat and the trailing-threat cases, the "Long" Poseidon-class option appears appreciably less expensive than a force of Trident SSBNs armed with Trident I missiles, particularly if the severity of the ASW threat were to become high.

Indeed, given a desire to hedge against Soviet ASW capabilities, the "Long" Poseidon-class force may seem the preferred option among all alternatives at the 2,000-warhead level. In the case of an area-search threat (Figure 1), this force would be comparable in cost to a Trident II-equipped force except at a very high threat level. In a trailing-threat situation (Figure 2), a "Long" Poseidon-class force would seem to be clearly less expensive than all other alternatives, except perhaps at a very low level of threat (in which case, it would represent an equal-cost option).

ASW considerations would leave unchanged the fourth conclusion--that on cost grounds, construction of new Poseidon-class ships armed with only 16 Trident I missiles would not appear desirable. In fact this option never represents the cheapest alternative; on the contrary, it appears the most costly force in many cases.

These conclusions rest on the assumption that all submarine forces would be equally vulnerable at sea, suffering the same losses in either percentage terms (in the case of an area search) or numerical terms (given a trailing threat). If it were possible to determine with confidence that a new, smaller SSBN would be significantly less vulnerable to detection and destruction than a Trident SSBN, or significantly more so, the above conclusions might change.

If one force type were believed to be especially susceptible to detection and destruction, Figures 1 through 4 would give a basis for determining how great the difference in survivability between two forces would have to be to reverse their cost ranking.

This difference is represented on the graphs by the horizontal distance between the two cost curves. 23/

It might appear wise in any event to take into account any expected Soviet ASW threat when determining the final size of the U.S. SSBN force. If the Soviet forces appear to be developing the capability to locate and destroy U.S. ballistic missile submarines at sea at some point in the future, extra ships could be added to the U.S. force to ensure a retaliatory capability that could survive an attack.

23/ For example, a force of "Long" Poseidon-class SSBNs that cost approximately \$103 billion could provide 4,000 warheads after losing about 40 percent of its ships at sea (see Figure 3). An equal-cost force of Trident SSBNs armed with Trident I missiles, however, could not provide 4,000 warheads if it lost more than 25 percent of its submarines at sea. In this instance, a force of Trident SSBNs carrying Trident I missiles would appear preferable to a "Long" Poseidon-class force only if it were to prove greater than 15 percent more survivable at sea than the latter force. It must be remembered, though, that all forces consisting of newly designed submarines would also contain a "base force" of ten Trident SSBNs, which would presumably have the same survivability factor as ships in an all-Trident force.

Considerations other than program costs--the focus of Chapters IV and V--would influence any choice among SSBN force options. Principal among these would be a decision to deploy the Trident II missile or to cancel its development.

Several arguments have been raised against development of the Trident II missile. First, the missile would increase the SSBN force's ability to destroy hard targets, 1/ which, as discussed in Chapter III, would be an ability of debated merit in the context of the U.S./Soviet military balance. Second, if the MX missile is indeed successfully deployed in a survivable basing mode, the perceived need for the Trident II missile might diminish. The MX would probably have greater hard-target kill capability than the Trident II SLBM; and survivable retaliatory capability embodied in the MX could decrease the amount required at sea. Finally, near-term budgetary constraints could render large development expenditures for the Trident II missile impractical over the next decade or so.

Factors not related to cost can also be cited in favor of developing the Trident II missile, however. For example, the Secretary of Defense has indicated the possible need for survivable forces that could attack all classes of targets, including hardened ones. 2/ In this light, the Trident II SLBM might appear desirable. Development of the Trident II would also ensure against complications or delays in the deployment of the MX missile; indeed, should the MX missile program be terminated, the Trident II SLBM could become important for its potential hard-target kill capability and also to maintain a commensurately greater retaliatory capability at sea. In addition, a Trident II-equipped force would maximize U.S. wartime capability for any

1/ In theory, though, acquisition of this capability could be largely avoided by developing the "inaccurate" Trident II SLBM discussed in Chapter IV.

2/ See U.S. Department of Defense, Annual Report, Fiscal Year 1980, pp. 77-79.

given number of MIRVed launchers in the sea-based deterrent. Should a SALT III agreement curtail the number of MIRVed launchers allowed each country, development of the Trident II missile might appear appropriate.

Factors other than total program cost could affect a decision to deploy a new SSBN type as well. As discussed in Chapter III, construction of an alternative submarine and termination of Trident SSBN construction would probably entail changes and possible disruptions in the industrial base producing SSBNs. Further, should a new SSBN type be introduced into the fleet alongside the Trident, the Navy might have to maintain two separate SSBN crew-training and logistics-support systems over the next three decades or more. 3/

Finally, it should be recognized that a decision to construct a smaller-diameter submarine not capable of carrying a Trident II-sized missile might preclude development of such a missile at any time during the next 20 to 30 years. Although a large missile could always be deployed on the base force of Trident SSBNs already authorized, paying high development costs for a missile that not all ships in the fleet could carry might seem uneconomical. 4/ If a pressing military requirement for a large missile over the next few decades should seem likely, it would make sense to continue authorization of ships with large launch tubes. In such a case, however, it would prove most economical to undertake early development of the Trident II missile, and thereby decrease the number of ships needed to meet military requirements.

3/ Indeed, three different support systems would be required until the Navy phased all Poseidon submarines out of operation in the mid-1990s.

4/ It should be noted, however, that the Poseidon C-3 missile was developed even though it was never deployed in one-fourth of the SSBN force.

APPENDIX. THE MK-4 WARHEAD AS A MEASURE OF
NUCLEAR RETALIATORY CAPABILITY

This study used the number of MK-4 warheads (or equivalents) that would survive an attack as the unit of measure of an SSBN force's military capability. This measure overlooks a number of important factors, however: a missile's accuracy, its ability to carry warheads with an explosive yield higher than the MK-4, and its range.

Warhead size and accuracy constitute two of the major factors that determine a weapon's ability to destroy targets hardened to withstand nuclear blast. If ability to destroy hard targets were the standard by which force capability were measured, SSBN forces armed with Trident II missiles would offer a marked advantage over forces armed with Trident I missiles, since the Trident II would probably be designed both to achieve much greater accuracy than the Trident I and to carry the higher-yield MK-12A warhead. The Trident I missile currently has only very limited effectiveness against hard targets. If the accuracy of the Trident I SLBM were upgraded either to equal or to approach that expected for the Trident II, the Trident I's effectiveness against hard targets would increase greatly. Even with accuracy equal to the Trident II goal, though, the Trident I missile would possess markedly less hard-target kill capability than the Trident II because of its smaller warhead.

Similarly, use of surviving MK-4 warheads as a unit of measurement fails to take into consideration the range from which the warheads would be delivered. It is assumed here that missiles would be launched approximately 4,000 nautical miles or less from their targets, a range at which Trident I and Trident II missiles could carry their full payloads. It is possible, however, that developments in Soviet antisubmarine warfare capabilities might make desirable operation at an even greater range, thereby increasing the total SSBN operating area the Soviets would have to search in an attempt to destroy U.S. SSBNs at sea (see Chapter V). Increasing the missiles' range could require equipping them with fewer warheads to lighten their payloads, however. This range/payload trade-off might possibly favor the selection of one missile over the other.

Nevertheless, the number of surviving MK-4 warheads provides a good measure of overall military capability that can be applied to all five force alternatives under consideration. This measure constitutes the product of factors that differ across the various forces; as such, it takes account of these factors and yields a standard unit of measurement. The number of surviving warheads in a force is computed as follows:

$$\begin{aligned} &(\text{Number of ships in force}) \times (\text{At-sea deployment rate}) \times \\ &(\text{Pre-launch survivability}) \times (\text{Number of launchers per} \\ &\text{ship}) \times (\text{Number of warheads per missile}) = \text{Number of} \\ &\text{surviving warheads at sea.} \end{aligned}$$



