REPORT BY THE

Comptroller General

OF THE UNITED STATES

The Navy's TRIDENT Fleet--Some Success But Several Major Problems

The TRIDENT submarine and missile fleet will replace the POLARIS/POSEIDON ballistic missile fleet. GAO's cost estimate for 21 and 29 TRIDENT submarines exceed the Navy's $30 and $40 billion estimates by $7 and $10 billion, respectively.

The ship contractor--Electric Boat--is experiencing a continuing cash drain problem. Claims against the Navy for $544 million are still in the settlement process. Productivity, manpower, and material problems at the contractor's facility continue. Delivery of the first submarine continues to slip.

The Congress should require detailed cost estimates for each alternative TRIDENT force size the Navy is considering. The Secretary of Defense should report the situation at Electric Boat to the Congress.

PSAD-78-31

APRIL 7, 1978

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

B-163058

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

This report presents our views on the major issues of the TRIDENT submarine and missile programs. A draft of this report was reviewed by agency officials associated with the program. Their comments are incorporated as appropriate.

For the past several years we have annually reported to the Congress on the status of selected major weapons systems. This report is one of a series of reports that we are furnishing this year to the Congress for its use in reviewing fiscal year 1979 requests for funds.

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

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

Comptroller General
of the United States

COMPTROLLER GENERAL'S REPORT TO THE CONGRESS

THE NAVY'S TRIDENT FLEET--SOME SUCCESS BUT SEVERAL MAJOR PROBLEMS

D I G E S T

The TRIDENT submarine and missile fleet is a sea-based weapons system designed to deter nuclear attack. It will replace the POLARIS/POSEIDON ballistic missile fleet. Each submarine will be able to carry 24 missiles.

The program continues to face serious schedule delays because of low productivity, a shortage of skilled workers, and late receipt of materials. In addition, the continuing cash drain at Electric Boat (the contractor) may become the more serious overriding problem--General Dynamics could halt its support of the Electric Boat Division if this situation continued.

At the time of GAO's review, the Navy was reporting a cost estimate of $22.2 billion for a 13-ship program. As of December 31, 1977, the Navy reported a 14-ship program at a cost of $25.1 billion. (See pp. 31 and 32.)

The Congress and GAO asked the Departments of Defense and the Navy to estimate the total number of submarines and missiles in the program and its total cost. During 1977 congressional appropriation hearings, the Navy illustrated a few force sizes, including one for 21 ships and another for 29 ships. Its cost estimates for these force sizes were $30 billion and $40 billion, respectively. They were provided to the Congress as rough-order-of-magnitude estimates. The Navy's estimates do not include all relevant cost--GAO's rough-order-of-magnitude estimates for these same forces are $37 billion and $50 billion. (See p. 3.)

SUBMARINE

Delivery of the first TRIDENT submarine continues to slip. The Navy now estimates that the first submarine delivery date may not be until April 1980--a year behind the contract delivery date. (See p. 6.)

Key factors that will affect Electric Boat's profitability are the shipyard's productivity and the extent of settlement of the $544 million in claims against the Navy. It is too soon to determine whether the October 1977 reorganization at Electric Boat will overcome its production problems and have a favorable effect on its financial position. Also, since Electric Boat's claims against the Navy are still being settled there is no way of telling what effect the final settlement will have on Electric Boat's financial position. (See p. 6.)

Since the uncertainties at Electric Boat could have an adverse effect on the U.S. defense posture and the future funding of the TRIDENT program, GAO recommends that the Secretary of Defense periodically provide a special report to the principal congressional committees on the situation at Electric Boat. The frequency of reporting should be determined in consultation with the committees. The report should specifically address changes in shipyard productivity and the status of settlement of outstanding claims. (See p. 11.)

The planned TRIDENT communications includes an extremely low frequency system called SEAFARER advocated by the Navy as a way to limit submarine vulnerability to possible Soviet antisubmarine warfare. However, the system remains controversial and a decision on what communications technology will be used has not been made. (See pp. 15 and 19.)

MISSILE

The Navy has classified the first 10 developmental test flights of the TRIDENT I missile as successful. The 11th developmental flight test experienced problems near the end of second stage flight and an explosion occurred. The exact cause of the failure is under examination. (See p. 20.)

The contractor (Lockheed Missiles and Space Company) has indicated that unplanned costs for the design, development, and production of 52 TRIDENT I missiles could reach $50 million. Lockheed said that the extra cost will be offset by reducing labor costs but a Navy official stated that they do not know whether Lockheed can recover this overrun. (See p. 21.)

On October 10, 1977, Lockheed employees went on strike. Initial assessment indicates little likelihood of any delay, but the strike's effect on missile costs and production schedules is being assessed. (See p. 21.)

The Secretary of Defense should provide the Congress with a detailed cost estimate for the force alternatives described by the Navy in 1977 testimony and for the force levels currently being considered by the Navy. While these estimates will contain a degree of uncertainty, the information should help the Congress in its deliberations on future TRIDENTs required for deterrence. (See p. 5.)

On March 13, 1978, General Dynamics notified the Navy that it intends to stop work on April 12, 1978, on the SSN-688 submarines being built at Electric Boat unless settlement is made on its outstanding claims with the Navy. The manner in which this dispute will be settled and the possible effects, if any, on the TRIDENT program is unknown at this time. Subsequently, the

Navy agreed to provide General Dynamics with a provisional payment on its claim and General Dynamics extended its date for stopping work on the SSN-688 program for 2 months.

This report was reviewed by agency officials associated with management of the program. Their comments have been incorporated as appropriate.

Contents

ABBREVIATIONS

DOD	Department of Defense
EBDIV	Electric Boat Division
EHF	extremely high frequency
ELF	extremely low frequency
GAO	General Accounting Office
HF	high frequency
LF	low frequency
MIRV	Multiple Independent Reentry Vehicle
MF	middle frequency
SALT	Strategic Arms Limitation Talks
SAR	Selected Acquisition Report
UHF	ultra high frequency
VLF	very low frequency

CHAPTER 1

INTRODUCTION

U.S. strategic nuclear weapons can be launched from bombers, fixed silos, or submarines--together, the three are commonly referred to as the TRIAD. The Department of Defense (DOD) views submarines at sea as the least vulnerable of the three, and TRIDENT will replace the present POLARIS/POSEIDON systems.

The principal objectives of the TRIDENT program are to

--deploy a faster, quieter, and more capable ballistic missile submarine that can carry 24 missiles;

--deploy a ballistic missile (TRIDENT I) that has a full payload range of 4,000 nautical miles and is capable of being launched from TRIDENT and some modified POSEIDON submarines;

--construct a personnel training and support facility for the TRIDENT system at Bangor, Washington (called SUBASE Bangor); and

--conduct advanced development of the Mark 500 Evader maneuvering reentry vehicle that is compatible with the TRIDENT I missile.

The Navy also plans to develop a TRIDENT II missile that will be larger and more capable than TRIDENT I, but this is not included in the current program.

The Electric Boat Division of the General Dynamics Corporation was awarded the construction contract for the first submarine in July 1974. The Navy exercised its option for three more submarines; a contract for the fifth submarine, with options for up to two more, was awarded to Electric Boat in June 1977.

The Lockheed Missiles and Space Company was awarded the prime contract for full-scale development and production of the first 52 TRIDENT I missiles in August 1974. On January 17, 1977, the missile was approved for production through May 1977. Since initial flight tests were successful, further production was authorized.

SCOPE OF REVIEW

The major objectives of our review were to examine the system's technical performance, cost, and schedule, and to determine if the submarine and missile will be operational as planned. In addition, we examined the communication subsystem planned for TRIDENT.

The information presented in this report is based on interviews with Navy and contractor officials and reviews of records provided by those officials. This report was reviewed by agency officials associated with management of the program. Their comments have been incorporated as appropriate.

CHAPTER 2

POTENTIAL TRIDENT FORCE COSTS

For the past several years, the Congress and this office have urged DOD and the Navy to estimate the TRIDENT fleet's ultimate size and cost. During the 1977 hearings before the Defense Subcommittee of the House Appropriations Committee, the Navy, for illustration, identified a few force sizes, including one for 21 ships and another for 29 ships, and estimated that the costs, of a rough order of magnitude, would be $30 billion or $40 billion, respectively. Our rough-order-of-magnitude cost estimates for the same number of submarines exceed the Navy's estimate by $7 billion and $10 billion, respectively.

PROJECTED SIZE

The submarine force level is limited by the number of submarine missile launchers permitted under Strategic Arms Limitations Talks (SALT) I agreements. Assuming retirement of all POSEIDON submarines, a 21-ship TRIDENT force built at the rate of 3 submarines every 2 years would have, by 1992, 504 multiple independent reentry vehicle (MIRV) missile launchers. This level slightly exceeds the 496 MIRV launchers the Navy has now. A 29-ship force would have 696 MIRV missile launchers, which is below the level of 710 launchers permitted in the interim agreement of SALT I.

DOD plans to procure three submarines every 2 years, but has not determined actual future size of the TRIDENT force because of several unresolved issues, including:

--The outcome of SALT II.

--The TRIDENT system's role in national strategic policy.

--The retirement dates of the POLARIS and POSEIDON submarines.

--The evolution of national strategic objectives.

NAVY COSTS ESTIMATES

The Navy emphasized that the $30 billion and $40 billion costs were rough-order-of-magnitude estimates and should not

be construed as budget-quality estimates. It did not calculate detailed estimates of TRIDENT system acquisition costs beyond the 5-year defense plan; both amounts were stated in fiscal year 1978 dollars.

We believe that the total cost of either a 21- or a 29-ship TRIDENT fleet could be much greater than the Navy's estimates. Our rough-order-of-magnitude estimates indicate that the total cost of

--a 21-ship program could exceed $37 billion and

--a 29-ship program could exceed $50 billion.

Our estimates include research and development for the TRIDENT submarine and TRIDENT I missile, submarine and missile procurement, and support facilities. Calculations are based on estimates in the June 1977 Selected Acquisition Report (SAR), except for submarine procurement costs that are based on estimates in the December 1976 report. We assumed that all submarines would be armed with TRIDENT I missiles.

Since the Navy did not make detailed calculations of its estimates, nor did it formalize its estimates, we were unable to make a comparison to explain the differences. However, while these figures exceed the Navy's by $7 billion and $10 billion respectively, we believe that they are conservative estimates. Additional cost estimates associated with the current or future TRIDENT program that were not included in our estimates are:

--Economic escalation costs beyond fiscal year 1978. (Of the total $3.3 billion fiscal year 1977 TRIDENT program cost increase nearly 50 percent was attributed to economic escalation.)

--Development costs for the proposed TRIDENT II missile. (In September 1977 the Navy estimated that TRIDENT II development would cost $2.8 billion during the current 5-year defense plan.)

--Costs associated with the recent TRIDENT submarine delivery delays. (The September 1977 Navy estimate is $391.5 million.)

--Costs associated with the TRIDENT backfit program. (The September 1977 Navy estimate is $3.09 billion.)

OTHER POSSIBLE TRIDENT FORCE LEVELS

As a result of current SALT negotiations, the ceiling on MIRV submarine missile launchers could be lower than either the 710 permitted under SALT I or the existing level of 496. We developed the following rough-order-of-magnitude estimates of the cost (stated in fiscal year 1978 dollars) of TRIDENT force levels ranging from 14 ships with 336 missile launchers to 21 ships with 504 missile launchers:

No. of submarines	No. of missile launchers	Total cost (note a)
		(billions)
14	336	$26
15	360	27
16	384	29
17	408	31
18	432	33
19	456	34
20	480	36
21	504	37

a/Estimates include research and development for the TRIDENT submarine, TRIDENT I missile procurement, and support facilities.

CONCLUSION AND RECOMMENDATION

Our rough-order-of-magnitude cost estimates for 21-ship and 29-ship TRIDENT force levels exceed the Navy's by $7 billion and $10 billion, respectively.

We recommend that the Secretary of Defense provide the Congress with detailed cost estimates of the alternative force levels being considered by the Navy. This information, while containing a degree of uncertainty, would be useful to the Congress in its deliberations over the number of submarines required for deterrence.

CHAPTER 3

DELIVERY OF FIRST TRIDENT STILL BEHIND SCHEDULE

The TRIDENT submarine construction contract established an April 1979 delivery date for the first submarine; however, the contractor promised to use its best efforts to deliver the submarine as early as December 1977. Except for improvements in the design effort, problems with productivity, manpower, and material continue to delay TRIDENT production. In addition, a longstanding cash flow problem on the SSN-688 program is becoming serious at Electric Boat. This problem may dominate all other shipyard problems and could affect the TRIDENT program.

Since the construction contract was awarded in July 1974, Electric Boat has revised the delivery date of the first TRIDENT three times:

Date of revision	Revised delivery date
2/75	8/31/78
4/76	12/31/78
7/77	10/27/79

Our March 1977 report, "Status of the TRIDENT Submarine and Missile Programs" (PSAD-77-34), concluded that, if improvements were not made in the design effort, the shipyard's productivity, the availability of skilled labor, and the receipt of material furnished by subcontractors, the first submarine would be delivered later than December 1978.

In July 1977 Electric Boat notified the Navy that it would not meet the December 1978 delivery date and estimated that the delivery date would be October 1979. The Navy believes that the October date is optimistic, and that the first TRIDENT will not be delivered until April 1980, a year later than the contract delivery date. Based on our analysis, we also question whether Electric Boat can meet its October 1979 delivery date.

EMERGING FINANCIAL PROBLEMS AT ELECTRIC BOAT

Electric Boat and its parent (General Dynamics Corporation) are continuing to incur significant cost overruns on

the SSN-688 attack submarine program and have filed very substantial claims with the Navy. This problem seriously affects

--the Navy's current ability to influence lagging TRIDENT productivity at Electric Boat; and

--Electric Boat's future financial ability to build TRIDENT and SSN-688 submarines particularly if (1) productivity on these projects does not increase, and (2) a substantial settlement of the SSN-688 shipbuilding claims currently pending against the Navy is not made.

Electric Boat's and General Dynamics' financial problems with the SSN-688 program are a matter of public record. In the March 1977 hearings before the Defense Subcommittee of the House Appropriations Committee, a high-ranking General Dynamics official stated that the corporation had involuntarily invested approximately $200 million of working capital in the SSN-688 program. He noted that if Electric Boat were a separate corporation (that is, not receiving help from its parent, General Dynamics) it would have gone bankrupt. General Dynamics' 1975 and 1976 consolidated financial statements also note the corporation's problems with the SSN-688 program.

The SSN-688 program's financial problems currently inhibit the Navy's ability to influence lagging TRIDENT production at Electric Boat. The Navy is reluctant to take any action that could be perceived by the contractor as a direction to reallocate manpower resources from the SSN-688 program to TRIDENT. The Acting Secretary of the Navy noted in a September 1977 memorandum to the Secretary of Defense:

> "Our main concern on the currently planned SSN (688) building program and delivery schedules involves those SSN's previously awarded at EBDIV [Electric Boat Division]. This concern is based on the same factors regarding EBDIV's management actions to improve productivity linked with the substantial financial losses which EBDIV has incurred and continues to incur in the SSN program. While transfer of manpower resources from the SSN's to the TRIDENT at EBDIV is theoretically possible, sizeable cost increases in the SSN (688)

program would inevitably occur, with resulting massive claims against the Navy if it were responsible for the transfer. These claims would come on top of the already critical claims situation with EBDIV. It is clear that any action involving or implying a direction by Navy to transfer manpower resources from the SSNs to the TRIDENTs at EBDIV should be avoided."

Key factors that will affect the profitability of Electric Boat's operations include the yard's productivity and the extent of settlement of the $544 million in claims against the Navy. A $20 million provisional payment offer was made to General Dynamics in September 1977, which was turned down, according to General Dynamics, for unstated legal reasons. Electric Boat is not currently being reimbursed for the excess costs for which claims have been filed. General Dynamics has advised the Navy that the total unreimbursed expenditures on the SSN-688 program would total approximately $350 million by the end of 1977.

In 1977 hearings before the Defense Subcommittee of the House Appropriations Committee, a high-ranking General Dynamics official stated that Electric Boat's operations would be halted before its financial problems would be allowed to threaten the entire corporation. Such a halt would adversely affect the TRIDENT and SSN-688 programs.

In an attempt to overcome production problems, Electric Boat was reorganized on October 24, 1977. A new general manager was appointed; 11 individuals were to report directly to him. Eight of the 11 were transferred from General Dynamics' Quincy Shipbuilding Division, while the other 3 were from Electric Boat.

On October 25, 1977, the new general manager announced that many major organizational changes and personnel reductions would be made soon. He believes that he can streamline the organization and reduce personnel, primarily in the overhead and support functions, while at the same time increase productivity. The present plans call for a reduction of about 3,000 people.

As of November 1977 no sign of dramatic changes in the deteriorating financial condition of Electric Boat has occurred. The Navy has not identified any major improvements in productivity.

General Dynamics officials can best assess the magnitude of the current SSN-688 program problems and the financial impact of these problems. However, the Navy, which has been closely monitoring the situation, projected the following on Electric Boat's SSN-688 program problems:

--Electric Boat is currently recovering between 55 to 70 cents for each dollar spent.

--Electric Boat cash shortfalls may run as high as $3.5 million per week in 1978.

Consequently, unless Electric Boat recovers a substantial portion of the claims against the Navy on the SSN-688 program, a yard shutdown, which would also adversely affect the TRIDENT program and the U.S. defense posture, is possible.

LOW PRODUCTIVITY AND SHORTAGE OF SKILLED WORKERS

Electric Boat and Navy officials agreed that worker productivity must improve. Electric Boat's labor performance report showed that work on the first TRIDENT was estimated to take 7.5 million hours for the period ended June 30, 1977. Although employees worked about 7 million hours, only 55 percent of the planned work was accomplished. As of August 1977 Electric Boat increased the estimate to construct the first TRIDENT from 16.3 million to 18.5 million hours.

According to an Electric Boat official, physical progress on the ship should be currently averaging about 3.5 percent a month in order to meet the October 1979 delivery date. He stated that since it is averaging only 2.5 percent, Electric Boat's progress must be greater than the 3.5-percent rate over the remainder of the construction period. And, if the work continues to fall behind schedule, the needed percent will increase, making any catching up very difficult.

Low productivity seems to be in part related to the number of skilled people employed. As of October 2, 1977, Electric Boat had 28,709 employees, an increase of about 5,100 over the 23,600 cited in our March 1977 report. 1/

1/"Status of the TRIDENT Submarine and Missile Programs," PSAD-77-34, Mar. 8, 1977.

The increase, however, was 439 less than planned. More importantly, shortages exist within certain trades:

Trade	Planned	Actual	Shortage	
			Number	Percent
Shipfitters	1,030	945	85	8.3
Shielders	200	157	43	21.5
Structural welders	2,220	2,003	217	9.8
Riggers and erectors	485	439	46	9.5
Burners	215	183	32	14.9
Pipefitters	1,220	1,187	33	2.7
Sheetmetal mechanics	310	287	23	7.4
Electronics specialists	230	142	88	38.3

When Electric Boat increased its work force, the skill mix of the new hires was less than that of the existing force. Additionally, skilled mechanics who had little supervisory training were promoted to supervisors. Both of these actions resulted in dilution of the shipyard skill mix.

Electric Boat officials stated that, to deliver the first TRIDENT by October 1979 it must not only find enough skilled workers, but also allocate them according to work plans. Electric Boat records show that it is not allocating employees as planned. For example, in September 1977 the actual hours allocated to the first TRIDENT was only 80 percent of that planned, whereas the actual hours allocated on the first SSN-688 contract was 129 percent of the plan.

LATE RECEIPT OF MATERIAL FURNISHED BY SUBCONTRACTORS

Material furnished to Electric Boat by subcontractors continues to be a problem. An Electric Boat official said that, to deliver the first TRIDENT by October 1979, the situation involving late receipt of vendor-procured items must not get worse. About 3 months after Electric Boat announced its revised TRIDENT delivery date, planned receipt of six items changed from 1 to 7 months. An Electric Boat official said that the cumulative effect of late deliveries has been a major disruption to orderly construction, with attendant increases in hours worked and in cost of construction.

CONCLUSIONS AND RECOMMENDATION

The TRIDENT program continues to face serious schedule delays because of low productivity, a shortage of skilled workers, and late receipt of materials. In addition, the continuing cash drain at Electric Boat may become the more serious overriding problem, particularly in view of the statement by a General Dynamics official that General Dynamics would halt its support of the Electric Boat Division if this situation continued.

Key factors that will affect Electric Boat's profitability are the shipyard's productivity and the extent of settlement of the $544 million in claims against the Navy. It is too soon to determine whether the October 1977 reorganization at Electric Boat will overcome its production problems and have a favorable effect on its financial position. Also, since Electric Boat's claims against the Navy are still being settled there is no way of telling what effect the final settlement will have on Electric Boat's financial position.

In view of the above uncertainties and the congressional interest in the situation at Electric Boat, we recommend that the Secretary of Defense periodically provide a special report to the principal congressional committees on the situation at Electric Boat. The results of these uncertainties could have an adverse effect on the U.S. defense posture and TRIDENT's future funding. The frequency of reporting should be determined in consultation with the committees. The report should specifically address changes in shipyard productivity and the status of settlement of outstanding claims.

CHAPTER 4

TRIDENT COMMUNICATION SYSTEMS

To enhance strategic deterrence, U.S. fleet ballistic missile submarines must remain undetected while maintaining continuous communications with command authorities. Current communications systems require all submarines to operate at reduced speed and maintain an antenna at or near the ocean's surface to communicate. Unless better communications systems are developed, all future submarines, including the TRIDENT, will face speed and depth restrictions.

The potential vulnerability of future submarines to detection caused by near-surface, day-to-day operations concerns the Navy. They believe that the Soviets are placing great emphasis on countering U.S. strategic submarine effectiveness. While frequent submarine detection by an enemy is not considered currently probable, evolving technology may make detection of future submarines operating near the water's surface a reality, reducing their effectiveness as a deterrent.

Various configurations of communication systems have been developed or proposed for submarines. One of these proposed systems, the extremely low frequency (ELF) system, has been advocated by the Navy as a system that would reduce peacetime detectability of submarines by allowing them to operate at relatively deep depths without using near-surface antennas while maintaining communication. Specific Navy ELF proposals, however, each contain advantages and disadvantages and remain controversial. Consequently, while submarine and missile development continue to advance, the development of an operational ELF communication system that would allow future submarines to operate at deep depths without maintaining an antenna at or near the ocean's surface has not been decided. Thus, unless a communications system is decided upon, the first several TRIDENT communications systems will face the same speed and depth constraints that current U.S. submarine forces face.

THE TRIDENT INTEGRATED SUBMARINE COMMUNICATION SYSTEM

The TRIDENT submarines' communications equipment consists of an integrated radio room and an integrated submarine communications antenna system designed to bolster the ship's external communications in the face of a sophisticated enemy threat, including signal jamming or ionospheric disturbance

by nuclear blasts. In addition to the submarine equipment, various types of transmission relay facilities (land based) or equipment (aircraft or satellite based) are needed to maintain communications. Within this total system, four distinct types of communication systems are planned for TRIDENT. These are:

--Middle frequency/high frequency/ultra high frequency (MF/HF/UHF) system.

--Very low frequency low/frequency (VLF/LF) system.

--Extremely high frequency (EHF) subsystem.

--ELF subsystem.

Current submarines use MF/HF/UHF and VLF/LF systems. ELF and EHF systems are being developed. The Navy believes that all of these systems operating redundantly will enhance future TRIDENT security and communications capability.

MF/HF/UHF system

MF/HF/UHF communication systems currently provide U.S. submarines with two-way communications to shore stations, the fleet, aircraft, and, to an increasing extent, satellites. The MF/HF/UHF system on TRIDENT will also be designed for similar two-way communication. Antennas planned to support TRIDENT MF/HF/UHF message reception and transmission include:

Antenna	Capabilities		
	Transmit	Receive	System
Buoyant cable		X	MF/HF
Combined mast	X	X	MF/HF/UHF
Emergency whip	X	X	HF
Towed buoy		X	MF/HF

The MF/HF/UHF systems and its antennas will allow TRIDENT to receive and transmit normal voice, secure voice (HF and UHF only), and clear or encrypted teletype data messages. The advantages of the MF/HF/UHF system include its ability to receive and transmit data at a very high rate and its relatively low cost transmission sites. Disadvantages of MF/HF/UHF follow:

--Current systems are relatively easy to jam.

--The system does not penetrate seawater well, thus requiring the submarine to expose an antenna above

the water's surface and to reduce speed to either transmit or receive MF/HF/UHF messages.

--Transmission relay sites that are land based are more vulnerable.

--Current systems have a limited range.

--These systems are susceptible to atmospheric static during thunderstorms, and antenna wave washovers during high seas.

VLF/LF system

VLF/LF communication systems currently provide day-to-day submarine broadcast capabilities. An airborne communication system--TACAMO (consisting of EC-130Q "HERCULES" aircraft with VLF relay capability)--provides the survivable communication link for the retransmission of very critical messages to submarines. Consequently, the TRIDENT VLF/LF system will be the primary means of receiving shore-to-ship communications or communications from an airborne command post before and during an attack. Antennas to be used on TRIDENT to receive VLF/LF communications include towed buoys, buoyant cables, and a combined mast.

Advantages of the VLF/LF systems include (1) a relatively large coverage area, (2) a relatively high resistance to jamming, and (3) a relatively high degree of survivability (airborne VLF only). Its primary disadvantage is the inability to penetrate seawater to great depths.

EHF system

The EHF system will use satellites as the communication link between the submarine and shore facilities or other ships/aircraft. These satellites would receive and transmit messages using a mast antenna. EHF's primary advantages will be its ability to receive and transmit large volumes of information quickly and its relatively high resistance to jamming. Its main disadvantage will be the inability to penetrate seawater well, making the submarine expose an antenna on the surface and operate within certain speed and maneuverability limits.

EHF's primary role will be ship-to-shore communication. It is not considered to be a primary means of receiving messages. Because EHF is in the validation phase of development,

it is unlikely that it will be available for installation in the first TRIDENT submarines. Consequently, space and weight have been set aside for the future installation of the system.

ELF system

TRIDENT's integrated submarine communications system includes a system that was specifically designed to provide shore-to-ship reception of continuous ELF transmissions. ELF communication systems have been advocated by the Navy for its future strategic submarines since the mid-1960s. The Navy has been concerned that evolving Soviet antisubmarine warfare technology will make submarine operation near the surface increasingly vulnerable to detection in the 1980s. MF/HF/UHF and VLF/LF systems require that either the submarine or an antenna be near the surface. In addition, these systems also limit submarine speed and maneuverability. The Navy has advocated ELF as the technology to relieve TRIDENT and other submarines from these problems. Despite its benefits, the ELF system proposed by the Navy has met considerable opposition where ELF transmission facilities have been proposed.

Background of ELF

The first ELF system the Navy advocated was the Sanguine Baseline System. Sanguine was to provide a shore-to-ship command and control communication system for Navy submarines--one that could survive enemy attack.

The follow-on to the Sanguine system was the Seafarer. The Seafarer was to be able to deliver high-priority messages to submarines operating deep and fast, without requiring them to expose their antennas. Potential advantages of the Seafarer system include:

--Almost worldwide communication would be possible from a U.S.-based transmitter that would deny a jammer the range advantage it would have at higher frequencies.

--Nuclear detonations along the dissemination path would not severely alter the ELF signal.

--The system would cost less than Sanguine.

The Seafarer system also contained some disadvantages. Congressional critics have pointed out that:

--The system would be vulnerable to attack.

--The biomedical/environmental impact of the transmitter site is difficult to define (a final environmental impact statement has been filed by the Navy.)

--The Seafarer's low data transmission rate makes it an impractical system to use.

--A large amount of land within the United States would be needed.

--The estimated cost of the system is high (the Navy estimates approximately $600 million).

In approving the fiscal year 1978 funding, the Congress urged DOD to "* * * determine whether an ELF communication system can be defined which will meet the essential requirements of a more survivable submarine force and which would use less land."

Current status of Navy ELF site proposals

Because of congressional interest in an ELF system that would require less land and be less costly, the Navy is considering combining the existing Wisconsin transmission facility with a smaller new facility in Michigan. Previously the Navy was pursuing a large facility in Michigan.

The combined-site proposal for Seafarer contains advantages and disadvantages when compared to the previously proposed Seafarer system. As advantages, the combined-site Seafarer could:

--Provide a communication system capable of permitting submarines to operate in both oceans with less vulnerability to attack.

--Reduce by 95 percent the length of antenna cable of the Seafarer system originally planned for Michigan.

--Provide for antenna installation primarily in already approved right-of-ways. (Only 5 miles would require new right-of-ways.)

--Reduce public objections to a large system. (Original proposal was 2,400 miles of antenna located in a 68-by-68 square mile area in Michigan.)

As disadvantages, the combined-site Seafarer, when compared to the previously proposed system;

--has less coverage and

--transmits data slower.

In summary, the following chart compares the estimated strengths and weaknesses of the communication systems that have been proposed for TRIDENT.

COMPARISON OF ESTIMATED CAPABILITIES

System	Relative penetration of seawater	Relative rate of data reception	Relative resistance to jamming	Relative survivability	Relative coverage area
MF/HF/UHF	None	High	Low	a/Low	One ocean; UHF line of sight only
UHF (satellite)	None	Very high	Low	Low	One ocean
VLF/LF	Shallow (20 to 30 ft.)	b/Low/ moderate	High/ moderate	Very low	Two oceans
VLF TACAMO	Shallow (20 to 30 ft.)	c/Low	Very high	High	Two oceans
ELF (Sanguine)	Deep (100s of ft.)	Low	Extremely high	Moderate	Near worldwide
ELF (Seafarer)	Deep (100s of ft.)	Low	Extremely high	Low	Near worldwide
ELF (combined site)	Deep (100s of ft.)	Very low	Extremely high	Very low	Two oceans

a/Survivability increases if transmitters are on mobile platforms or if network is constructed of a large number of transmitters.

b/One VLF/LF system is multichannel mode. Moderate on normal channels and low on low data rate channel.

c/Normal TACAMO rate of data reception is low. Rate of reception can be increased with a corresponding decrease in jam resistance to moderate.

Alternatives to ELF

The Navy has studied other potential communication systems that could allow submarines to maintain communications without their antennas being near the surface. Alternative means of communicating over long distances to submerged submarines were examined by the Pacific-Sierra Research Corporation during 1976 under contract with the Office of Naval Research. The following chart shows the systems examined and the problems found:

System	Problem
Pisces (ELF)	Moderate technological risk
Shelf (ELF)	High cost and technological risk
Airborne (ELF) systems	High cost and technological risk
ELF Satellite systems	High technological risk
Ultra low frequency systems	High technological risk
Lithospheric waveguide systems	Considerable research still needed
Rotating superconducting transmitters	Limited coverage
Blue-green optical laser	Limited coverage; limited penetration of seawater
Acoustic reception systems	Subject to jamming and moderate technological problems

Status of ELF on TRIDENT

The interface of the TRIDENT and ELF systems is being delayed by the controversy surrounding Navy ELF proposals. Navy officials indicate that even if full funding is given for the combined site in 1979, this system would not be ready until mid-1983. Consequently, the first several TRIDENTs may have the same speed, depth, and maneuverability problems while maintaining continuous communication that current submarines have.

Anticipating this situation, the Navy is planning to backfit ELF onto the first TRIDENT. Specific actions to accommodate ELF on TRIDENT include:

--Funding and developing an antenna control unit for a multiple-system buoyant cable antenna for TRIDENT.

--Setting aside space and weight in TRIDENT's integrated radio room for ELF reception equipment.

--Requiring the submarine contractor to meet the Navy's requirements for ELF quieting.

--Placing a conduit on the hull for the ELF buoyant cable.

--Testing the TRIDENT towed buoy antenna system for ELF reception capability.

--Reserving space and weight for an ELF antenna on the hull.

CONCLUSION

Various configurations of communication systems have been developed or proposed for TRIDENT to meet its strategic communication needs. One proposed system, the ELF system, remains controversial. While specific ELF and alternative proposals each contain advantages and disadvantages, the Navy continues to believe that future TRIDENT invulnerability to Soviet antisubmarine warfare threats will be more likely insured by developing a communication system that will allow TRIDENT and other submarines to communicate while operating at maximum patrol speeds and depths without antennas on or near the surface. A decision on which communication system to use to meet this threat has not been made.

CHAPTER 5

OTHER TRIDENT-RELATED MATTERS

Several other issues are affecting the TRIDENT program--the TRIDENT I missile program, the submarine base Bangor construction program, and the possible east coast basing of TRIDENT submarines. Because of submarine problems, however, the effect of any problems in these areas on the overall TRIDENT program is uncertain.

PROGRESS OF THE TRIDENT I MISSILE PROGRAM

The TRIDENT I missile being developed for the new TRIDENT submarine is to be backfitted into some POSEIDON SSBNs currently configured with POSEIDON equipment.

As of February 14, 1978, 11 TRIDENT I developmental flight tests had been made. Navy officials said the first 10 flights met their test objectives, and were classified as successful.

Problems did occur during the 2d, 4th, 7th, and 11th tests. The second and fourth tests experienced an apparent activation of the destruct flight termination system on the forward dome of the first stage rocket motor shortly after first stage separation.

After separation, the first stage is directly in the flame path of the second stage. Lockheed officials said the explosions probably occurred because of excessive heat or an electronic malfunction in the first-stage flight termination system, which caused "inadvertent initiation" of the system on the expended motor's forward dome. Lockheed officials said that although the destruct action did not affect the flight tests, a piece of the expelled material could hit the second-stage rocket motor and damage the missile. Lockheed officials said that the electronics and heat shielding have been changed to reduce the chances of this type of problem.

In the seventh flight test, the guidance system malfunctioned after two reentry bodies were released, thereby preventing the release of the other reentry bodies. A Navy official said the malfunction was due to a deficiency in the software which showed up in this test because of the peculiarity of the missile flight path flown. This was the first flight test of a low trajectory short-range profile.

The speeds and angles of the flight prevented the guidance computer from absorbing all the flight data and thus the control of the reentry body platform was lost. The Navy advised us on February 22, 1978, that the Charles Stark Draper Laboratories, which is the guidance system contractor, has corrected the problem. A similar trajectory has since been successfully flown. The Navy also advised us that analysis, verification, and validation of software has solved this problem for all missile trajectories.

The Navy reported that the 11th flight test proceeded normally until the end of the second stage flight when an explosion occurred. Preliminary analyses suggest that the malfunction was a burn-through in the forward end of the second stage motor. The exact cause is under investigation.

Based on the qualified success of the flight tests, Lockheed plans to recommend a reduction in the number of flight tests from 30 to 25. A Navy official said that the decision on whether to proceed with the 25-missile flight test program will not be made until the summer of 1978. Lockheed estimates savings of $16 million for conducting only 25 flight tests.

Assuming this savings is realized, Lockheed estimates that there will be a $50 million overrun on its $2.4 billion contract for the design, development, and initial production of 52 TRIDENT I missiles. Lockheed said the extra cost is due to higher suppliers' costs than anticipated and to difficulties in solving advanced missile equipment and component designs. According to Lockheed, the extra cost will be largely offset by the end of October 1979 by reducing labor costs. A Navy official said that they do not know whether Lockheed can recover this overrun.

In addition, on October 10, 1977, 4,500 Lockheed employees (about 1,000 assigned to TRIDENT missile production) went on strike. The strike ended on November 28, 1977. Initial assessment indicates little likelihood of any delay in initial availability. The strike's effect on the missile's cost and the production schedule is being assessed.

The TRIDENT I missile launch tubes, missile eject system, and related systems are being produced by Westinghouse Electric Corporation. The contractor is having problems with the launch tube seals because of an additional Navy requirement that the gas generator supply more power to eject the missile from the launch tubes. A greater velocity will

then be imparted to the missile, allowing the first stage to ignite after the missile leaves the water.

Westinghouse has received an additional $6 million to develop the larger gas generator and to make the other related changes. It is forecasting an additional $18 million cost to complete the development and testing programs. The Navy advised us on February 22, 1978, that the first 20 of the planned 92 tests of the more powerful generator have been completed and classified as successful.

STATUS OF MILITARY CONSTRUCTION AT SUBMARINE BASE BANGOR

The submarine base under construction at Bangor, Washington, includes facilities for submarine maintenance, missile assembly and checkout, and personnel training and housing. The base is scheduled to be fully operational in the third quarter of fiscal year 1980. Through fiscal year 1977 $483.6 million has been appropriated for site construction; approximately $224.0 million has been expended. The fiscal year 1979 budget contains a request for $21.1 million for military construction. This includes $10.3 million for community assistance, $4.8 million for public works and site improvements, $3.5 million for planning and design, $1.0 million for defense access roads, and $1.0 million for two other small projects.

EAST COAST BASING OF TRIDENT SUBMARINES

The Navy plans to base the first 10 TRIDENTs at the U.S. Naval Submarine Base, Bangor, Washington. TRIDENT support beyond the 10th submarine could be developed at that site, since the base can expand to accomodate up to 20 submarines. However, according to the Navy, these additional submarines could be based on the Atlantic coast. While no decision has been made on where additional TRIDENT submarines will be based, the Navy has studied alternative east coast locations for a ballistic missile submarine refit site and possible TRIDENT basing.

Each site considered by the Navy study was evaluated for its ability to support (1) the POSEIDON squadron, to be relocated from Rota, Spain, (2) the TRIDENT-I-backfit POSEIDON submarines, and (3) TRIDENT submarines at some future time. The study was completed in September 1976 and the Secretary of the Navy announced on November 30, 1976, that Kings Bay, Georgia, was the preferred alternative location.

A draft environmental impact statement was issued on June 21, 1977. Hearings were held in Kingsland, Georgia; Jacksonville, Florida; and Atlanta, Georgia; in August 1977, and the final statement was released on December 7, 1977. On January 26, 1978, the Secretary of the Navy announced the selection of King's Bay, Georgia, as the site of a submarine support base to accommodate the withdrawal of the fleet ballistic missile squadron from Rota, Spain, and to provide a facility for refit of fleet ballistic missile submarines with the TRIDENT I missile.

CHAPTER 6

TRIDENT PROGRAM STATUS

This chapter highlights the cost, schedule, and performance of the TRIDENT program through September 30, 1977, as shown in the SAR and related documents. 1/

TRIDENT PROGRAM ACQUISITION COSTS

The September 30, 1977, SAR estimated that the cost for the TRIDENT program would be $22.2 billion for 13 submarines; 418 TRIDENT I missiles (including 30 developmental ones); and the submarine base in Bangor, Washington, the west coast support facility. Since September 30, 1976, the estimated cost has increased $3.3 billion:

	9/30/76	9/30/77	Net change
		(millions)	
Submarine:			
Development	$ 719.4	$ 818.0	$ 98.6
Procurement	9,845.0	12,876.7	3,031.7
Missile:			
Development	3,578.7	3,595.0	16.3
Procurement	4,007.5	4,162.6	155.1
TRIDENT support construction (note a)	727.0	746.0	19.0
Total	$18,877.6	$22,198.3	$3,320.7
Number of submarines	11	13	2

a/For support of a 10-ship force.

The Navy attributed the cost increase to the following changes:

1/The appendix in this report shows major changes that are in the December 31, 1977, SAR which we received on February 16, 1978, and did not review.

TRIDENT Program Status

Change	Amount (millions)	
Submarine:		
Development		
Addition of 12th and 13th submarines	$ 27.1	
Delay in delivery dates of the first five submarines	43.3	
Other changes	28.1	$ 98.6
Procurement		
Addition of 12th and 13th submarines	2,582.8	
Delay in delivery dates of the first five submarines	79.2	
Contract cost overrun due to delay in delivery dates and contractor's progress	265.0	
Other changes	104.7	3,031.7
Net increase--submarine acquisition		3,130.3
TRIDENT I missile:		
Development		
Delay in delivery dates of the first five submarines	3.0	
Contract cost overrun	15.0	
Other changes (-)	-1.7	16.3
Procurement		
Delay in delivery dates of the first five submarines (includes net increase of 12 missiles)	0.9	
Revised pricing of missile program	229.9	
Restructuring of missile production in line with FY 78 program budget decision (-)	-53.2	
Reduction (-) in fiscal year 1977 missile buy	-22.5	155.1
Net increase--TRIDENT I missile acquisition		171.4
TRIDENT support construction:		
Refinement of estimate for community impact assistance	16.7	
Other changes	2.3	
Net increase--TRIDENT support construction		19.0
Net increase--TRIDENT program		$3,320.7

Items excluded from TRIDENT acquisition costs

The procurement estimate reported in the September 30, 1977, SAR was based on acquiring 13 submarines as shown in the schedule below.

Fiscal year	Number of submarines	Fiscal year	Number of submarines
1974	1	1979	1
1975	2	1980	2
1976	1	1981	1
1977	1	1982	2
1978	2		

Advance procurement costs for three more submarines estimated to be $626.3 million in fiscal years 1981 and 1982 are noted in the SAR but are not included in the 1977 estimate. The Navy has not developed complete estimates for these submarines, which are to be fully funded after 1982.

The Navy plans to arm the submarines with TRIDENT II missiles as soon as they become available. The cost of these missiles has not been estimated; however, the SAR shows, for informational purposes, that the Navy has estimated that developing them will cost $2.8 billion during the January 1977 5-year defense plan. No TRIDENT II missile costs were included in the TRIDENT program acquisition costs reported for September 30, 1977.

The TRIDENT support facilities estimate--$746 million--was based on a 10-ship force. No cost estimate for supporting a force larger than 10 submarines has been developed, even though the Navy now plans on procuring at least 16 submarines. Thus, six additional submarines must either be based on the west coast or at a new site on the east coast.

Status of funds

Total appropriations for the TRIDENT program through fiscal year 1978 were $11.9 billion. As of September 30, 1977, $7.7 billion had been obligated--$3.6 billion for development, $3.7 billion for procurement, and $411.7 million for military construction.

REPORTED INCREASES IN PROGRAM COSTS

As reported in the SAR, the TRIDENT's total cost has increased $9.8 billion from the development estimate of $12.4 billion to the September 30, 1977, estimate of $22.2 billion. The major component of this estimated increase has been a $6.8 billion increase caused by escalation due to economic and program related changes.

One component of the total program cost increase is the estimated cost associated with the procurement of individual submarines. The Navy has prepared detailed cost analyses for the first seven submarines. These analyses show the original estimate approved by the Congress, the Navy's most recent estimate, and the changes to date. Each estimate is broken down into specific categories and adjusted as needed based on actual cost information supplied by the contractors.

At a recent press conference, the Navy noted that the cost estimate for the first submarine (SSBN 726) has increased approximately $400 million--from $800 million to $1.2 billion. The Navy classifies this $400 million increase into four major categories:

Navy ship construction contract estimated cost increases	$114.4
Design contract cost increases	80.0
Escalation	133.2
Government-furnished material	73.2
Total	$400.8

As reported, the Navy's estimates for SSBNs 727, 728, 729, and 730 have also increased. The total of these increases as of September 1977 equals that for the first submarine--approximately $400 million.

SCHEDULED COMPLETION DATES DELAYED

The dates when different phases of the submarine and missile programs were to be completed changed between September 30, 1976, and September 30, 1977:

	As of 9/30/76	As of 9/30/77	Change (months)
TRIDENT submarine:			
Construction started on last ship	a/11/81	b/3/83	16
Launch			
First ship	11/77	c/3/79	16
Last ship	a/3/85	b/7/86	16
Acceptance trials			
First ship	11/78	c/3/80	16
Last ship	a/3/86	b/7/87	16
Delivery			
First ship	12/78	c/4/80	16
Last ship	a/4/86	b/8/87	16
System initial operating capability	9/79	c/1/81	16
TRIDENT missile			
First performance evaluation missile flight test (from submarine)	11/78	3/79	4
First demonstration and shakedown operation (TRIDENT SSBN)	6/79	d/6/80	12
Operational availability date with ballistic reentry vehicle	9/79	e/10/79	1

a/Based on an 11-ship program built at a rate of one, two, one, one, two, one, two, one.

b/Based on a 13-ship program built at a rate of one, two, one, one, two, one, two, one, two.

c/Based on Navy's assessment of contractor performance.

d/1-month delay attributed to resolution of range safety and other issues; 11-month delay attributed to delay in lead ship delivery date.

e/Reflects use of a backfitted POSEIDON submarine rather than a TRIDENT submarine, as previously planned, to have the missile ready and working on time. Results from ship construction being behind schedule.

The revised dates for the lead TRIDENT submarine were determined by the Navy, based on its assessment of the contractor's revised TRIDENT program schedule issued on July 29, 1977, and the contractor's productivity. The delayed delivery of the first TRIDENT submarine caused two completion dates for the TRIDENT I missile to be pushed back:

--The first demonstration and shakedown operation from a TRIDENT submarine was delayed 11 months.

--The availability date with a ballistic reentry vehicle was delayed 1 month.

The Navy also attributed a 10-month delay in the operational date for the submarine base at Bangor, Washington, from the fourth quarter of fiscal year 1979 to the third quarter of fiscal year 1980 to the delay in the submarine's delivery date.

POSEIDON BACKFIT PROGRAM

The Navy has 31 submarines armed with POSEIDON missiles. The submarines' missile tubes can accommodate the TRIDENT I missile. The Navy plans to rearm (backfit) some of these ships with TRIDENT I missiles, which have a greater range than the POSEIDON missiles. The TRIDENT I's superior range increases its patrol area and reduces transit from bases in the continental United States to assigned stations for the backfitted ships.

The POSEIDON backfit costs are not included in the TRIDENT program's acquisition cost--they are reported in TRIDENT SARs only for information purposes. As reported in September 1977 estimated backfit costs were:

	(millions)
Missile cost	$2,936.0
Construction (note a)	158.5
Total	$3,094.5
Number of missiles	288

a/Submarine Support Base, Kings Bay, Georgia; and POLARIS Missile Facility, Charleston, S.C.; costs.

The estimated missile cost was based on a deployed force of 10 ships. According to Navy officials, however, 12 POSEIDON submarines will be backfitted. The first ship is scheduled to become operational in October 1979.

TRIDENT PROGRAM STATUS

SHOWN IN DECEMBER 31, 1977, SAR

At the time of our review, we analyzed the data in the latest available SAR--September 30, 1977. On February 16, 1978, we received a copy of the December 31, 1977, SAR. The major changes in that SAR are shown in this appendix but have not been reviewed by us.

Cost	9/30/77	12/31/77	Net change
		(millions)	
Submarine:			
Development	$ 818.0	$ 844.2	$ 26.2
Procurement	12,876.7	15,396.9	2,520.2
Missile:			
Development	3,595.0	3,591.6	(3.4)
Procurement	4,162.6	4,517.3	354.7
TRIDENT support:			
Construction (note a)	746.0	745.8	(.2)
	$22,198.3	$25,095.8	$2,897.5
Number of submarines	13	14	1

a/For support of a 10-day ship force.

The reasons for the cost changes shown in the SAR are:

QUANTITY CHANGES

	(Millions)
Addition of the 14th ship (FY 1983) to the 5-year defense program	
Ship	1,590.2
Missiles (26 TRIDENT I)	156.0
ESTIMATING CHANGE	
Increased cost estimates for fiscal year 1979 and later ships (8th thru 13th ships) based on current estimates for first seven ships, plus other minor changes	963.5
ECONOMIC CHANGE	
Revision in the strategic weapons' systems costs, missiles cost, and military construction cost caused by use of latest escalation rates	187.8
Total	$2,897.5

Items excluded from TRIDENT acquisition costs

The procurement estimate is based on acquiring 14 ships. Advance procurement costs for three more submarines estimated to be $722.5 million are noted in the SAR but not included in the December estimate. The cost for TRIDENT II missile development also is not included in the costs but the SAR notes, for information purposes, that the estimates for the January 1978 5-year defense plan is $3.2 billion.

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