General Accounting Office

GAO

Report to the Congress of the United States

November 1985

NAVY ACQUISITION

SUBACS Problems May Adversely Affect Navy Attack Submarine Programs

GAO/NSIAD-86-12

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United States
General Accounting Office
Washington, D.C. 20548

Comptroller General of the United States

B-220298

November 4, 1985

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

We recently reviewed the Navy's three-phased Submarine Advanced Combat System (SUBACS) program. SUBACS was designed to provide Los Angeles class nuclear attack submarines (SSN 688 class) authorized for fiscal year 1983 and beyond with new and upgraded sonar and combat control systems and advanced data processing capabilities. A modification of SUBACS was also planned as the combat system design for the proposed new attack submarine class, SSN 21, scheduled for authorization in fiscal year 1989. We performed this review to determine the cost, schedule, and performance risks associated with implementing the SUBACS program and its impact on attack submarine programs. (See app. I.)

We found that since the Secretary of Defense approved the program in October 1983, SUBACS has experienced significant cost, schedule, and performance problems. To address these problems, the Navy has made several programmatic decisions, resulting in a restructure of the program. As a result, the program is no longer being implemented as approved. Because of the risks and uncertainties identified with implementing the latest program plan, we believe that the restructured program needs to be evaluated and implemented only with the approval of the Secretary of Defense.

On October 25, 1985, the Department of Defense provided comments on a draft of this report which have been incorporated in this final report.

The Defense-Approved SUBACS Program

The Navy initiated SUBACS in 1980 to meet expanded SSN 688 class missions and to counter the Soviet antisubmarine warfare threat through the 1990s. SUBACS was originally planned as a single-phase program for SSN 688 class submarines authorized in fiscal year 1989. However, in October 1983, the Secretary of Defense approved the Navy's plan to introduce SUBACS as a Pre-Planned Product Improvement[1] program in three phases. (See app. II.)

[1]Pre-Planned Product Improvement is an acquisition strategy that incorporates advanced technology through planned upgrades. It is adopted early in a system's development and is used to (1) reduce acquisition time and development risk and cost and (2) enhance fielded performance.

The three phases were SUBACS Basic, SUBACS A, and SUBACS B. The objectives of the three-phased approach were to allow the Navy to introduce additional capabilities earlier than planned and to spread program risks and costs over time. More significantly, the approved program introduced SUBACS on the SSN 751, an SSN 688 class submarine authorized in fiscal year 1983 and already under construction, rather than on a submarine scheduled for authorization in fiscal year 1989.

SUBACS Basic, the first phase, was to upgrade existing sonars, add new sonar subsystems, and provide for processing of acoustic information by a distributed system data bus.[2] It was scheduled to be installed on the SSN 688 class submarines authorized in fiscal years 1983, 1984, and 1985. The nine SUBACS-equipped submarines authorized in those fiscal years are currently under construction by two shipbuilders. Five are under construction at the Electric Boat Division of General Dynamics Corporation and four are under construction at Newport News Shipbuilding Company.

SUBACS A, the second phase, was to integrate acoustic and combat control processing by using new and upgraded software. SUBACS A was for SSN 688 class submarines scheduled to be authorized in fiscal years 1986 through 1988.

SUBACS B, the third phase, was to introduce sonar improvements into the integrated combat system. This phase was for SSN 688 class submarines scheduled to be authorized in fiscal year 1989 and beyond. A modification of SUBACS was also the combat system design for the proposed new attack submarine class, SSN 21.

In December 1983, the Navy awarded the International Business Machines Corporation (IBM) a $772 million contract for concurrent full-scale development and production of five SUBACS Basic systems and for an engineering development model.[3] The first SUBACS Basic system must be delivered to the shipbuilder by May 1987 to meet the November 1987 delivery of the first SUBACS-equipped submarine to the Navy.

[2]The distributed system data bus (described in app. III and, hereafter, referred to as data bus) uses fiber optic technology to distribute and communicate data and to link acoustic and combat control subsystems into one major combat system.

[3]An engineering development model is used in the factory to support the completion of hardware and software development prior to the availability of a production system.

Problems Affecting Program Implementation

SUBACS has experienced significant cost, schedule, and technical performance problems that have adversely affected program implementation. We believe several factors have contributed to SUBACS problems. These included Navy decisions to (1) introduce innovative technology into new construction attack submarines through a concurrent development and production program, (2) install the initial SUBACS on a fiscal year 1983 submarine rather than on one scheduled for authorization in fiscal year 1989, as originally planned, and (3) approve the shipbuilder's accelerated delivery schedules for initial SUBACS-equipped submarines. As a result of these decisions, program success became highly dependent upon receiving sufficient funding, maintaining tight cost control, and meeting crucial schedule dates in each of the phases. In addition, according to a high-level Navy committee, some management weaknesses further contributed to the cost, schedule, and performance risks in the SUBACS program.

Cost

Cost control has been a continuing problem in the SUBACS program. As a result, SUBACS has experienced significant cost increases in the estimates to complete the program.

In 1983, the Navy estimated total SUBACS acquisition costs to be $3.8 billion. Life-cycle costs[4] were estimated at $14.5 billion in fiscal year 1983 dollars and over $29 billion in escalated dollars.

As early as April 1983, a Naval Material Command audit indicated the SUBACS Basic phase would cost $762 million, $105 million more than the Navy's initial estimate. When the SUBACS Basic contract was negotiated with IBM in December 1983, however, the cost of the phase increased by $10 million over the audit's estimate. Moreover, IBM estimated a $3.8 million contract increase in its first SUBACS Basic Cost Performance Report in March 1984. To absorb these increased costs, the Navy, in June 1984, decided to delay several portions of the overall SUBACS development program.

An additional cost problem was identified in November 1984, when the Navy, based on the results of an internal audit by the Program Office for SUBACS, determined the total SUBACS program in the fiscal year 1985 Five Year Defense Program would require $853 million more in

[4]Life-cycle cost is the total cost to the government of acquisition and ownership of a system over a defined life span. It includes the cost of development, investment (production and construction), and operation and support.

Research, Development, Test and Evaluation funding. According to the Program Office, the increase was due to new and unfunded requirements, program stretch-outs resulting from budget cuts, future funding needs, and cost overruns in the SUBACS Basic contract. To address this cost problem, the Navy restructured the SUBACS development program in an effort to contain potential cost increases.

In regard to the SUBACS Basic contract, IBM, in its June 1985 Cost Performance Report, estimated a $146.2 million overrun in its contract to complete SUBACS Basic full-scale development. While about $68.2 million of this increase was identified in the 1984 internal audit, $78 million was not. This overrun was primarily due to increased software and system development, additional test and integration requirements, and subcontractor and vendor production problems.

In commenting on the draft report, Defense said that the Navy was aware of the cost overrun before the June 1985 Cost Performance Report was issued and that the estimate formed part of the basis for the Navy initiating contract scope reduction efforts. Additionally, since our review was completed, Defense said the Secretary of the Navy has approved the contract scope reductions.

As of May 1985, the Navy estimated life-cycle costs to be $15 billion in 1983 dollars, about $500 million more than originally estimated. The Navy does not have an official revised estimate of the program's acquisition costs.

Schedule

We believe the selection of the SSN 751 (authorized in fiscal year 1983 and scheduled for delivery in November 1987) as the first SUBACS-equipped SSN 688 class submarine rather than one scheduled for authorization 6 years later (fiscal year 1989) made it difficult to achieve program schedules. For example, as early as June 1983, a Naval Underwater Systems Center (NUSC)[5] risk assessment predicted that the development of the distributed system data bus was a high risk and would be completed 9 to 12 months later than scheduled to meet the delivery of the SSN 751. The schedules provided little flexibility to deal with problems normally encountered when introducing new and unproven technology through a concurrent development and production program.

[5]NUSC is the lead laboratory and the Navy's Technical Direction Agent for the SUBACS program. It provides technical guidance to SUBACS contractors and assists the Navy's Project Office in technical and design reviews.

In commenting on our draft report, Defense officials stated that assessments other than those prepared by NUSC were considered. Defense stated that while none of these assessments claimed the development was risk-free, the aggregate showed the risk was acceptable, particularly when additional modeling and testing was incorporated into the program. While we recognize other assessments were considered, we emphasized the NUSC assessment because NUSC, as the Navy's Technical Direction Agent for the SUBACS program, is responsible for evaluating development risks and providing overall technical advice.

A February 1985 NUSC technical risk assessment identified eight major hardware subsystems, such as the weapons launch system, as medium to high risk for delayed deliveries to the shipbuilder. The potential delays were related to ceramic and other module design, development, and production problems due to vendor difficulties in meeting Navy testing requirements and low production yields. According to the assessment, software development was also a high schedule risk. In addition, in February 1985, IBM estimated that six software deliveries would be delayed from 2 months to more than 2 years because of insufficient time to test, integrate, and modify system software.

In commenting on our draft report, Defense also stated that the February 1985 NUSC hardware risk assessment, commissioned by the Project Office, was used to restructure the program. Defense noted that problems with ceramic modules have been solved and that sufficient modules for the first ship set are on hand. However, the modules were delivered late and Defense did not comment on the impact continued delays in module deliveries might have on future ships.

Technical Performance

In our opinion, the most serious problem affecting SUBACS implementation relates to the development of the data bus and the software necessary to process and distribute acoustic information. Preliminary critical item tests made by IBM in December 1984 showed that the data bus' software system distributed data at a rate about one-sixth of the original program requirements. According to NUSC, this reduction in speed would prevent combat system operators from receiving, interacting, and responding to acoustic information fast enough to solve combat problems on a real-time basis (i.e., as they occur). In addition, NUSC's February 1985 assessment stated that data bus-related problems severely constrained system test and integration schedules, "leaving virtually no margin for error."

For more information on SUBACS cost, schedule, and performance problems, see appendix III.

Other Factors Contributing to Program Problems

Two additional factors contributed to the cost, schedule, and performance problems. First is the Navy's decision to accelerate ship delivery schedules for the first two SUBACS-equipped submarines. The accelerated schedules allow shipbuilders to claim award fees for increasing productivity and reducing construction schedules. For example, Electric Boat (the shipbuilder) is planning to deliver the SSN 751 in November 1987, about 8 months earlier than the contract delivery date of June 1988. The earlier delivery of the SSN 751 would reduce the time available to install the SUBACS Basic system from 12 months to 5 months. Under the terms of its contract with Electric Boat, the Navy must deliver SUBACS Basic equipment for the SSN 751 to Electric Boat no later than May 1987.

The second factor relates to the Navy's management of the program. During April and May 1985, a committee of high-level Navy military and civilian personnel reviewed the feasibility of the data bus and other alternative systems for SUBACS. Its report stated that the Navy's management structure provided neither the necessary focus nor the effective use of program management control procedures, such as cost, schedule, and technical reports. Also, the report indicated that NUSC, as the lead Navy laboratory, had not provided a strong technical input to the development program. The committee recommended several changes to strengthen program management and concluded that the SUBACS program would not be under control until these weaknesses are resolved. (See app. IV.)

In commenting on our draft report, Defense stated that the Naval Sea Systems Command (NAVSEA) and NUSC are restructuring their respective organizations for the SUBACS program. Both NAVSEA and NUSC are defining, in concert, responsibilities, lines of communications, and accountability to ensure proper roles are established and performed. Defense stated that this effort would be completed and in place by November 1, 1985.

Navy Actions to Address Program Problems

In attempting to address the cost, schedule, and performance problems experienced in SUBACS Basic, the Navy and IBM revised the SUBACS program plan several times between October 1984 and May 1985. The latest plan adopted by the Navy calls for the redesigned SUBACS Basic system to be installed on the SSN 688 class submarines authorized in fiscal years 1983 through 1988, rather than on just those authorized in fiscal years 1983 through 1985. This system will have less combat system performance than the system originally planned. Also, we believe significant program risks and uncertainties exist with implementing the restructured program plan.

Replanning Efforts

The first replanning effort, Replan I, was initiated in August 1984 and approved in October 1984. It addressed SUBACS Basic ceramic module design, development, and production problems which had caused hardware delivery delays by an IBM subcontractor to IBM's test and integration facilities.

Replan II was initiated in December 1984 in response to continued slips in ceramic module production and supply. In addition, in January 1985, performance and escalating cost problems with the data bus were addressed. Major actions taken by the Navy under this replan were to remove the combat control subsystem from the data bus, defer some SUBACS Basic functions from May 1987 to September 1988, and delay implementing the SUBACS A phase from fiscal year 1986 to fiscal year 1989.

In March 1985, the Secretary of the Navy instructed that funding requirements for Navy acquisition programs remain within fiscal year 1985 Five Year Defense Program levels. The Navy determined that Replan II could not be entirely implemented within available program funding and additional replanning actions were necessary.

Replan III, initiated in March 1985, had the most significant impact on the SUBACS design. It deleted the data bus entirely from the program and proposed replacing the data bus with a standard computer-based processing system. This system's software will be designed and tested at the same time the new hardware is integrated into SUBACS.

Because of the problems encountered during SUBACS Basic, the SUBACS A and B phases have been deferred until 1989 or later. Originally, SUBACS A was to be installed on SSN 688 class submarines authorized in fiscal years 1986 through 1988, and SUBACS B was to be installed on SSN 688s

authorized in 1989 and beyond. However, as a result of system design changes and reduced performance under Replan III, the Replan III proposals would convert the three-phased SUBACS program to a one-phase effort— SUBACS Basic minus the data bus—for SSN 688 class submarines authorized from fiscal years 1983 through 1988. The SUBACS A and B phases have been combined in the new FY 89 Combat System program for attack submarines authorized beginning in fiscal year 1989, including the SSN 21. In effect, there are two separate programs—SUBACS (Replan III) and the FY 89 Combat System. Under the FY 89 Combat System program, new sonars, signal processors, and software will be developed.

In commenting on the draft report, Defense maintained that SUBACS is now a two-phased program—Replan III as phase one and the FY 89 Combat System as phase two. Defense stated that the FY 89 Combat System is an evolutionary improvement to Replan III. According to Defense, each phase will be managed as a separate project.

Navy's Review of Replan III

Because Replan III was a major design change to SUBACS, on April 24, 1985, the Assistant Secretary of the Navy for Research, Engineering and Systems appointed a committee to review the program. The committee directed its review primarily toward combat system alternatives that would address the immediate cost and schedule problems and that would assure confidence in delivering the SSN 751 on time. In its May 28, 1985, report to the assistant secretary, the committee agreed with the Replan III proposal to delete the data bus, but recommended an alternative combat system, the "BQQ-5[6] Like," which would use some portions of systems currently installed on SSN 688 class submarines. The committee believed that Replan III was overly optimistic, had a low chance of meeting delivery schedules, and had unpredictable cost and schedule risks.

On May 31, 1985, the assistant secretary requested more detailed information on the cost and schedule impacts of the two alternatives—Replan III and "BQQ-5 Like." NAVSEA established a second committee to develop this information. In its July 1, 1985, report, the second committee concluded that neither alternative would meet the original SUBACS performance requirements, even though the Navy had made several changes to Replan III. Changes included freezing the design of critical

[6]BQQ-5 refers to the AN/BQQ-5 active/passive sonar system which is the acoustic portion of the combat system currently used on SSN 688 class submarines.

equipment, delaying tests, and adding an essential capability earlier than planned. The committee also concluded that the cost increase of implementing the "BQQ-5 Like" alternative was six times greater than the cost increase under Replan III. In addition, the "BQQ-5 Like" system would have a greater adverse impact on ship delivery schedules. On August 9, 1985, the assistant secretary approved Replan III. (See app. IV.)

In commenting on our draft report, Defense stated that the "BQQ-5 Like" system is essentially the same system being developed under SUBACS Replan III, with certain high-risk hardware replaced with proven, less-capable components from the AN/BQQ-5 sonar system. Defense also stated that the remaining hardware, developed under the SUBACS program, is still required because the system currently installed on SSN 688 class submarines is too large to fit in the space allocated for the combat system in the fiscal years 1983 through 1988 SSN 688 class submarines.

Replan III Implementation Risks

Although the Navy chose Replan III as the preferred alternative for addressing SUBACS Basic problems, we believe that significant risks and uncertainties still exist that could adversely affect program implementation. At the time of the proposal and the Navy's evaluation of Replan III, key documentation was not complete. According to the SUBACS Project Manager, detailed program plans, work breakdown structures, critical path analyses, and work packages for Replan III were scheduled to be completed in October 1985. Further, contract modifications required to implement Replan III must then be negotiated and approved.

In addition, the second committee identified major technical risks and uncertainties with implementing Replan III. These included problems with developing, integrating, and producing system software, particularly for one critical hardware item, a common beamformer. According to the committee, these problems could cause the software for the first two systems to be immature (not fully tested, integrated, and modified) when delivered to the shipbuilder. Consequently, this could result in late delivery of the first two SUBACS-equipped submarines and may subject the Navy to costly shipbuilder claims associated with the delays.

Moreover, the second committee stated that these submarines at delivery will have a combat system with less performance than required under Replan III. For instance, software for the SSN 751 combat system will be upgraded twice—once, 2-3 months after submarine delivery and

again, 9 months after submarine delivery. With respect to the later upgrade, the committee also reported that test and integration planning for the system's software was incomplete and, therefore, prevented a meaningful assessment of schedule risk.

Conclusions

SUBACS was initiated to provide a combat system capable of carrying out the expanded missions of U.S. attack submarines and to counter an improving Soviet submarine threat. Serious development problems, however, have resulted in the Navy revamping the program strategy. As a result, the program is no longer being implemented as presented to the Defense Systems Acquisition Review Council (DSARC) and approved by the Secretary of Defense in 1983. The revised strategy should be evaluated by the Secretary of Defense and implemented only with his approval.

Under the latest Navy plan, Replan III, SUBACS will provide less performance than originally intended, require additional funds, and may delay the delivery of the first two SUBACS-equipped SSN 688 submarines. Further, should Replan III be unsuccessful, SSN 688 class submarines scheduled for authorization in fiscal years 1986 through 1992, as well as the nine currently under construction, could incur increased costs and potential delivery delays.

A DSARC is scheduled to review the SUBACS program in November 1985. Because of the potential impacts on the SSN 688 class submarine program and the risks and uncertainties identified with Replan III, we strongly support the scheduled DSARC review. We believe this review is needed to assure that all alternatives, near and long term, are fully considered to minimize SUBACS cost, schedule, and technical performance problems and to lessen the potential adverse impacts on the Navy's attack submarine programs. We also believe that because the reviews by the Navy's committees primarily focused on near-term solutions to the problem of providing a combat system for the first nine SUBACS-equipped submarines, all viable long-term alternative acquisition strategies were not fully considered for the remaining attack submarines that will have SUBACS. These strategies could possibly include delaying the deliveries of the SSNs 751 and 752, terminating the SUBACS program and returning to the current BQQ-5 system for SSN 688 submarines authorized beginning in fiscal year 1985, or developing a new distributed system data bus. In regard to the SSN 21 class attack submarine program, we believe that the lessons learned from SUBACS problems should be applied in developing the new combat system for the SSN 21.

Recommendations to the Secretary of Defense

Since the SUBACS program is no longer being implemented as approved by the Secretary of Defense and because of the risks and uncertainties identified with implementing Replan III and its potential impact on the Navy's attack submarine programs, we recommend that the Secretary of Defense take the following actions through the DSARC program review process:

- Evaluate the Navy's justification for adopting Replan III from among alternative acquisition strategies to ensure the best course of action is taken for providing SSN 688 class submarines, near and long term, with the needed combat system performance while minimizing the adverse effects on SUBACS and submarine construction costs, schedules, and contracts.
- Condition his approval of the program on the Navy's establishment of a plan for management control, including specific criteria, reporting requirements, and periodic reviews of the program adopted to assess the progress in reaching SUBACS program objectives.
- Before releasing fiscal year 1986 program funds, require the Navy to provide key program documentation and budget quality cost estimates, and base the future release of funds on demonstrated program progress.

Agency Comments and Our Evaluation

Defense provided comments on a draft of this report on October 25, 1985. (See app. V.) Defense concurred with our findings, subject to minor clarifications.

Defense essentially agreed with our conclusions. The one exception was its disagreement that all available alternative acquisition strategies, such as delaying the SSNs 751 and 752, terminating the SUBACS program and returning to the current BQQ-5 system, or developing a new distributed system data bus, were not fully considered during reviews by the two Navy SUBACS committees. Defense stated that these alternatives were considered but were not seriously considered or mentioned in the committees' reports because the prohibitive cost and serious operational impact of the alternatives were unacceptable. It stated that in retrospect the alternatives should have been included in the committees' reports. We believe the committees' focus on a near-term solution is a step in the right direction for addressing the problem. When considered in the long term for all submarines to be equipped with SUBACS, the alternative strategies we identified or others may be viable options for ensuring that the best course of action is taken for providing the needed submarine combat system performance.

Defense agreed with our first two recommendations, but was concerned that our third recommendation was calling for withholding release of fiscal year 1986 funds before the November 1985 DSARC. It said that such an action would result in stop work orders, costly termination and restart proceedings, and would guarantee further costly delays in the program. The thrust of our recommendation is to withhold funds subsequent to DSARC if the Navy does not provide budget quality estimates and key documentation, including a sound plan for management control that accounts for the risks and uncertainties facing development and production of the system. Defense said that the Navy would be required at the DSARC to provide such cost estimates and documentation.

We also want to reemphasize that in the November 1985 DSARC process the Office of the Secretary of Defense should review and evaluate the Navy's key program documentation and the budget estimates and that a Secretary of Defense Decision Memorandum be issued.

Contractor Comments and Our Evaluation

Copies of our draft report were provided to the three major SUBACS contractors—IBM Corporation, Hughes Aircraft Company, and Raytheon Company. Hughes and Raytheon did not provide any comments. IBM provided comments and stated that the report was generally factually accurate for the time period it covered. It expressed the view, however, that many of the issues highlighted as problems are no longer applicable as risk factors to the program. While IBM believes its current program plan supports submarine delivery schedules, the detailed plans for implementing Replan III need to be reviewed and approved by the Navy. IBM's complete comments, as well as our evaluation, are contained in appendix VI.

We are sending copies of this report to the Secretaries of Defense and the Navy; Director, Office of Management and Budget; and Chairmen, House Committee on Government Operations, Senate Committee on Governmental Affairs, and House and Senate Committees on Appropriations and on Armed Services.

Charles A. Bowsher

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Comptroller General
of the United States

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Abbreviations

DNSARC	Department of the Navy Systems Acquisition Review Council
DSARC	Defense Systems Acquisition Review Council
GAO	General Accounting Office
IBM	International Business Machines Corporation
NAVSEA	Naval Sea Systems Command
NUSC	Naval Underwater Systems Center
SUBACS	Submarine Advanced Combat System

Objectives, Scope, and Methodology

The attack submarine is one of the nation's most important antisubmarine warfare assets. The Los Angeles class nuclear attack submarine (SSN 688 class) was originally designed for antisubmarine and antisurface ship warfare missions. The Navy, however, expanded the role of this class by adding surveillance, strike warfare, and mine warfare missions. In addition, new sonar and combat control subsystems were needed to counter an increasing Soviet threat. Thus, SUBACS was initiated to meet these needs by integrating new and improved sonar, combat control, and fire control subsystems into one major system and to provide a logical "building block" approach for future combat system improvements.

We reviewed SUBACS because it is an important and costly attack submarine improvement program. Our review objectives were to identify the cost, schedule, and performance risks associated with the SUBACS program and using fiber optics and ceramic module technology in submarines. We evaluated the program in terms of its impact on the first SUBACS submarines' delivery schedule and performance capability. The frequent changes to the program during our review limited our ability to effectively evaluate SUBACS program costs. Also, the technical complexity of the changes to system design affected our ability to evaluate the specific performance requirements of individual subsystems comprising the SUBACS Basic combat system. Our review, therefore, was limited to the overall cost, schedule, performance, and program status of the SUBACS Basic system.

Our review, in accordance with generally accepted government auditing standards, was performed from October 1984 through July 1985. Our audit work was conducted at the Naval Sea Systems Command and Program Director of Attack Submarine Acquisition Programs offices, Arlington, Virginia; Offices of the Secretaries of Defense and Navy, Washington, D.C.; the Naval Underwater Systems Center, Newport, Rhode Island; IBM Corporation, Federal Systems Division, Manassas, Virginia; Hughes Aircraft Company, Ground Systems Group, Fullerton, California; Raytheon Company, Submarine Signal Division, Portsmouth, Rhode Island; and General Dynamics Corporation, Electric Boat Division, Groton, Connecticut. The work performed at each of these organizations follows.

- The Program Director of Attack Submarine Acquisition Programs (designated PDS 350) is responsible for overall management of attack submarine programs. The Submarine Combat Systems Project Office (PMS 409) reports to PDS 350 and is responsible for management and funding

accountability, development, acquisition, and life-cycle support for the SUBACS system. We examined Navy records, including documents on the decision to use a three-phased program approach, program requirements, funding statements, and program progress reports. We interviewed Navy officials regarding the cost, schedule, and performance status of the program, including replanning activities. We also discussed SUBACS matters with the Project Office's engineering and support contractor (EG&G Analytical Services Center, Inc., Arlington, Virginia).

- The Naval Underwater Systems Center (NUSC), the Technical Direction Agent for SUBACS, provides technical direction and guidance to SUBACS contractors and assists the Project Office in technical and design reviews. To identify program risks, we examined NUSC briefing material, documents, reports, and SUBACS technical risk assessments. We interviewed NUSC officials regarding the assessments, evaluations of SUBACS technical risks, and program alternatives.
- IBM, the SUBACS prime contractor, is responsible for designing, developing, and producing some SUBACS equipment and testing and integrating all SUBACS equipment and software. IBM also designed some ceramic modules for data bus-related equipment. We analyzed cost performance reports, progress reports, briefing materials, contract records, and related documentation used for tracking system progress. We interviewed IBM officials responsible for SUBACS development and obtained forecasts of the test and integration schedules for system hardware and software.
- Hughes Aircraft Corporation, a major subcontractor, is responsible for developing and producing the SUBACS weapons launch system and analog modules for the Submarine Active Detection Sonar receive group. Raytheon is the Navy prime contractor for the Submarine Active Detection Sonar transmit equipment and an IBM subcontractor for combat control software and computer console equipment. Raytheon also designed and produces ceramic modules for SUBACS equipment. At each location, we examined and analyzed cost performance and progress reports, contracts, and other related documentation on the contractor's progress in achieving cost, schedule, and technical milestones. We interviewed contractor managers on these matters.
- Electric Boat Division of General Dynamics Corporation is the shipbuilder for the first two SSN 688 SUBACS-equipped submarines. We discussed the impact of Replan III on those submarines under construction with Electric Boat's SSN 688 Program Manager.

We also discussed the cost, schedule, and performance problems with Navy officials of two committees, appointed by an assistant secretary of

the Navy during spring 1985, who conducted studies of the SUBACS program. These committees evaluated the Navy's solutions to the SUBACS problems. They also identified alternative ways for minimizing the risks in meeting the delivery schedule for the first SUBACS-equipped submarine, SSN 751.

Chronology of Events Relating to SUBACS Development

Date	Event
1976-1977	The Navy began to study ways to improve SSN 688 class combat control systems.
1978	The Navy reviewed three combat system designs: (1) the Federated Combat System, a top-down analysis of combat control operational needs and functional requirements, (2) an ongoing improvement program for the sonar (AN/BQQ-5) and fire control systems that were in the fleet, and (3) the Re-Engineered Combat System, a bottom-up application of new technology for existing sonar and fire control systems.
September 1979	The Assistant Secretary of the Navy for Research, Engineering and Systems directed that funding for the Federated and Re-Engineered Combat Systems programs be deferred and that the Naval Sea Systems Command develop a single program to meet both future SSN 688 and Trident classes applications.
April 1980	The Navy issued the Operational Requirement document for SUBACS.
November 1980	The Navy approved the Mission Element Needs Statement for SUBACS. This document addressed the need for an advanced combat system that could meet the changing threat and mission requirements and still have a low life-cycle cost.
September 1981	An initial SUBACS Combat System Top-Level Requirements document was issued.
March 1982	The Navy awarded a concept development contract to the IBM Corporation, Federal Systems Division, Manassas, Virginia, as the SUBACS prime contractor, following an evaluation of two competitive proposals, the other by Rockwell International Corporation.
June 1982	The Vice Chief of Naval Operations approved the three-phased Pre-Planned Product Improvement program for SUBACS, with planned initial installation on a fiscal year 1983 authorized submarine, SSN 751.
January 1983	The Secretary of the Navy approved the three-phased SUBACS program through the first Department of the Navy Systems Acquisition Review Council (DNSARC).
March 1983	Approval was received from the Under Secretary of Defense for Research and Engineering to expend long lead funds for the SUBACS Basic engineering development model and the fiscal year 1983 ship sets.

April 1983	A Naval Material Command audit of the SUBACS Basic program estimated a $105 million increase over the Navy's initial estimate of $657 million.
July 1983	The second SUBACS DNSARC approved the SUBACS program plan and authorized proceeding to a Defense Systems Acquisition Review Council (DSARC) I/IIA. The first Decision Coordinating Paper was issued for SUBACS.
September 1983	A DSARC was held on SUBACS program milestones I/IIA. It recommended approval of SUBACS Basic full-scale development, SUBACS A concept definition, and SUBACS B concept development.
October 1983	The Secretary of Defense approved the SUBACS three-phased program with procurement concurrent with development of the Basic phase for attack submarines authorized in fiscal years 1983 through 1985.
December 1983	The Navy awarded IBM a $772 million cost-plus-award fee contract modification to the 1982 contract for full-scale development of SUBACS Basic and production of five ship systems, and an engineering development model. The first SUBACS Selected Acquisition Report was issued.
January 1984	The Navy established the Office of the Program Director of Attack Submarine Acquisition Programs (PDS 350) to manage the SSN 688 class and SSN 21 class attack submarines and SUBACS programs.
April 1984	A third DNSARC convened to review SUBACS Basic status and funding. It approved SUBACS A design definition and SUBACS B concept definition. Because of SUBACS Basic cost problems it also approved changes to the overall Pre-Planned Product Improvement program, including delays in the delivery of SUBACS A software and deferral of the land-based test facility to the SUBACS B time frame.
June 1984	IBM established a "Red Team" to review SUBACS Basic progress and recommend improvements to the IBM development program.
August 1984	The Navy Program Director of Attack Submarine Acquisition Programs began an internal review, "Zero Base Audit," of the SUBACS program. The audit was completed in September 1984.

October 1984	Based on the results of the Zero Base Audit, the Navy determined that an $853 million increase was required in Research, Development, Test and Engineering funding for the SUBACS program in the fiscal year 1985 Five Year Defense Program. The Navy began its SUBACS Basic replanning effort (Replan I) as a result of ceramic modules production problems.
December 1984	The distributed system data bus experienced problems in meeting initial critical item tests.
December 1984-February 1985	The Navy initiated Replan II because of data bus critical item test results, further problems with ceramic modules production, and system cost.
March 1985	Replan III, which deleted the distributed system data bus from the program and replaced it with a AN/UYK-7 (later AN/UYK-43) standard computer-based processing system, was developed. Replan III was initiated to stay within the overall fiscal year 1985 Five Year Defense Program funding levels and maintain schedule.
April-May 1985	The Assistant Secretary of the Navy for Research, Engineering and Systems established the first committee to review SUBACS. The committee recommended a "BQQ-5 Like" combat system for SUBACS.
May-June 1985	The Assistant Secretary of the Navy for Research, Engineering and Systems requested on May 31, 1985, additional information on the cost and schedule impacts of "BQQ-5 Like" and Replan III systems. A second committee, established by the NAVSEA Command to develop this data, reported that the Replan III system was the preferred alternative because it would have less of an impact on program implementation than the "BQQ-5 Like" system. The committee indicated that the "BQQ-5 Like" system would impose significant submarine delivery delays and increased costs for the SUBACS program.
August 1985	The Assistant Secretary of Navy for Research, Engineering and Systems approved Replan III for SUBACS Basic. SSN 21 Attack Submarine DNSARC confirms restructure of the SUBACS program into SUBACS Basic and FY 89 Combat System programs.

Factors Affecting Program Implementation

SUBACS is a highly complex system, consisting of various sonar, signal processing, and computer systems; supporting equipment; and software. Software alone consists of over 4 million lines of code written in 11 different computer languages and runs on distributed computer systems with more than 200 processors. The processors were to be connected by a new, untried distributed system data bus, which would have used fiber optic technology. Because of the complexity of introducing this new technology in submarines, the SUBACS program has incurred significant cost, schedule, and performance problems.

Cost

SUBACS has experienced significant increases in total program cost. Even before the October 1983 Secretary of Defense program approval, an April 1983 Naval Material Command audit found the SUBACS Basic phase would cost an additional $105 million more than the Navy's $657 million estimate. In November 1984, about 14 months after program approval, the Navy estimated that an $853 million increase was required in the fiscal year 1985 Five Year Defense Program for Research, Development, Test and Evaluation funding for the total SUBACS program. The increase relates to 11 program requirements, such as about $211 million for SUBACS Basic, A, and B; $118 million for replacing the wide aperture array with the large wide aperture array; and $135 million for the land-based test facility.

The prime contractor, IBM, estimated cost overruns at completion in the full-scale development contract for SUBACS Basic. For example, IBM, in its June 1984 Cost Performance Report, estimated a cost overrun of $6 million. In March 1985, the cost overrun had increased to about $144.6 million. Of this amount, about $78 million was not included in the $853 million increase discussed above. The major areas where cost overruns occurred were

- $62.4 million for developing software, redeveloping a network operating system, increasing test and integration requirements, and providing systems engineering and program support;
- $55.0 million for major subcontractor efforts to work around problems caused by ceramic module production;
- $11.4 million for reworking hardware and for providing additional assembly, test, and quality control equipment; and
- $15.8 million for general and administration overhead and other related costs.

The cost overrun reported by IBM in its June 1985 Cost Performance Report increased by an additional $1.6 million, or a total of $146.2 million.

As a result of cost overruns identified in March 1985, IBM is evaluating $46.9 million in contract scope reductions that, if implemented, will partially offset contract cost overruns. One possible scope reduction is the deletion of an engineering development model, which the Navy has indicated would make it difficult to effectively test and integrate SUBACS prior to delivery to the submarine. The second SUBACS committee considered it necessary to have a full-time model at the factory as a risk reduction measure.

Schedule

On February 15, 1985, NUSC completed an assessment of the hardware, software, and technical risks of delivering the first SUBACS to the shipbuilder by May 1987. According to the NUSC assessment, late deliveries of ceramic modules are a major cause of many hardware schedule delays. These electronic circuits are used in SUBACS equipment to assist in processing data. This type of ceramic module is new technology for submarines and provides greater resistance to heat, more electronics per square inch, and processes data faster than conventional modules.

The NUSC assessment identified eight major subsystems as having a medium to high delivery risk because of development and production problems with ceramic modules. For example, two high-risk hardware items—the weapons launch system and multipurpose consoles—are scheduled to be delivered 5 months and 3 months late. The major reasons for late deliveries were vendor difficulties in meeting Navy testing requirements and low production yields of usable modules. Because of problems with ceramic modules, IBM had to revise test and integration schedules. According to EG&G, the average cost (including nonrecurring costs) of all ceramic modules, produced by all vendors, has almost doubled. In commenting on our report, IBM stated the cost of its ceramic modules increased by 35 percent.

The NUSC assessment also stated that software development and delivery was a high risk. The assessment pointed out that software development required for SUBACS is an "extremely ambitious undertaking," consisting of over 4 million lines of code written in 11 different computer languages. The software runs on distributed computer systems containing more than 200 processors linked together by a new, untried, complex distributed system data bus. After the software is developed, it

will be tested with hardware at the prime contractor's facilities for compatibility and integration with other systems. The assessment stated that the software schedule would be delayed significantly because of insufficient time to test, integrate, and revise software for a very large system. Further, the assessment concluded that software development was a high schedule risk because there was no additional time for code growth or software rework or for correcting anything that may go wrong at the prime contractor's test facilities.

On March 26, 1985, IBM advised the SUBACS Project Office that it had underestimated software schedule deliveries by 15 percent. As a result, IBM estimated that test and integration for six software deliveries would be delayed from 2 months to more than 2 years. According to IBM, these functions, delayed more than 2 years, comprise 2.3 percent of the total software.

Performance

The distributed system data bus was a major technological innovation in the SUBACS program. The data bus was being developed to integrate acoustic and combat control subsystems into one major system, provide error-free communications, and allow the system to process more data at higher speeds than previous systems. The system would have included other innovations such as displaying real-time data on common display consoles.

NUSC's assessment assigned a high technical risk to developing the data bus because during preliminary critical item tests it operated at one-sixth the speed originally planned. In addition, units that interfaced with the data bus had to be redesigned due to ceramic module delays. The delays were due to vendor difficulties in meeting Navy testing requirements and low production yields. According to the assessment, these technical problems resulted in an extremely tight development schedule, with "virtually no margin for error."

An IBM official advised us that most of the problems with the data bus were due to poor implementation of the network operating system design. The original system was too complex, and the data bus was eventually taken out of SUBACS primarily because of performance and funding considerations.

One IBM subcontractor, Hughes Aircraft, has encountered problems designing another type of module, analog function modules, for the Submarine Active Detection Sonar system receive group. During a recent

design review, the subcontractor identified five performance related problems. One of these problems may adversely affect the ability of the first SUBACS submarines to effectively perform their missions. Because of these performance problems, the subcontractor has not met required production schedules and deliveries to the prime contractor. In addition, the estimated cost to complete the Hughes Aircraft subcontract has increased by $7.2 million.

In commenting on our draft report, Defense advised us that problems with analog function modules have been solved and that sufficient modules are on hand for the first ship set. However, we noted that, according to the NUSC July 13, 1985, progress report, the Navy approved major deviations from specifications for these modules.

Navy Actions to Address Program Problems

The Navy's decision under Replan III to delete the distributed system data bus from SUBACS constituted a major deviation in the design as it was originally planned. This decision created the need to implement an alternative data processing system in sufficient time to meet the May 1987 delivery of the first SUBACS Basic system to the shipbuilder.

First Navy SUBACS Committee

On April 24, 1985, the Assistant Secretary of the Navy for Research, Engineering and Systems appointed a high-level committee to review Replan II, Replan III, and a new alternative, a "BQQ-5 Like" combat system. The "BQQ-5 Like" system would replace the SUBACS beamformer and Multi-Array Signal Conditioner with the corresponding BQQ-5 hardware and software. The committee reached the following conclusions:

- The SUBACS bus approach must be abandoned.
- Replan III is overly optimistic because of the low chance of meeting SSN 751 delivery schedules, because of its unpredictable cost and schedule risks, and because it may not achieve pre-SUBACS combat system capability.
- The "BQQ-5 Like" architecture is recommended because of its known configuration and capability and its relatively predictable cost and schedule impact.

In addition, the committee identified several program management problems, including the following:

- The Navy management structure did not provide the necessary focus.
- Use of fundamental management controls was not apparent.
- NUSC, the Navy's lead laboratory for SUBACS, had not provided strong technical input to the program.

Although the committee recommended returning to the "BQQ-5 Like" architecture, it had low confidence that the system could be delivered to Electric Boat by May 1987. In addition, the committee did not determine the impact on shipbuilder costs because the data was not available. On May 28, 1985, the committee presented its recommendations to the assistant secretary.

Second Navy SUBACS Committee

On May 31, 1985, the assistant secretary requested more detailed information on the cost, schedule, and hardware risks for "BQQ-5 Like" and Replan III alternatives. The NAVSEA Command established a second committee to develop this information. Several changes were made to

Replan III after the first committee completed its review. These changes included freezing the design of a critical piece of equipment, thereby reducing software development; increasing the time available for test and integration by adding additional test facilities; delaying completion of final system design certification testing[1] until September 1988 and adding a critical acoustic function earlier than originally planned. This committee concluded:

- The "BQQ-5 Like" system could not be delivered as rapidly as estimated by the first committee. Ship delivery delays would be much greater for the "BQQ-5 Like" system than the Replan III.
- Total costs of implementing the "BQQ-5 Like" approach would be six times greater than those of implementing Replan III.
- Neither approach meets the top-level requirements of the original SUBACS program; therefore, top-level requirements need to be revised to reflect reduced capabilities.
- Replan III has the potential to delay the delivery of the first two SUBACS-equipped submarines.

Replan III Approved

On August 9, 1985, the assistant secretary approved Replan III. According to the SUBACS Project Manager, detailed program plans, work breakdown structures, critical path analyses, and work packages would be completed for Replan III in October 1985. In addition, the program still faces some high risks. The chairperson of the second committee stated that these risks include

- developing, integrating, and producing software for the program, particularly for one critical hardware item called a common beamformer;
- potential impacts to ship deliveries;
- reduced capability at ship delivery; and
- delaying completion of system design certification testing until after delivery of the first SUBACS submarine.

[1]System design certification testing is the validation of a production system for meeting performance requirements before it is accepted for use on a ship.

Comments From the Department of Defense

THE UNDER SECRETARY OF DEFENSE

WASHINGTON, DC 20301-3010

RESEARCH AND ENGINEERING

(TWP)

25 OCT 1985

Mr. Frank C. Conahan
Director, National Security and International Affairs Division
U.S. General Accounting Office
441 G Street, NW.
Washington, D.C. 20548

Dear Mr. Conahan:

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) draft report entitled "Submarine Advanced Combat System Problems May Adversely Affect Navy Attack Submarine Programs", dated September 23, 1985 (GAO Code No. 394030 - OSD Case No. 6842).

The DoD generally agrees with the GAO findings. The DoD also generally agrees with the GAO recommendations, with the exception of delaying release of FY 1986 funding. The Defense Systems Acquisition Research Council (DSARC) is scheduled to review the Submarine Advanced Combat System Program in November 1985. The Navy has been asked to provide key program documentation, budget quality estimates, and review the program's progress at that briefing.

The detailed DoD comments on the findings and recommendations are provided in the enclosure. The Department appreciates the oportunity to comment on the draft report.

Sincerely,

Donald A. Hicks

Enclosure

GAO DRAFT REPORT - DATED SEPTEMBER 23, 1985
(GAO CODE 394030) - OSD CASE 6842

"SUBMARINE ADVANCED COMBAT SYSTEM PROBLEMS MAY ADVERSELY AFFECT NAVY ATTACK SUBMARINE PROGRAMS"

DOD COMMENTS TO THE GAO DRAFT REPORT

* * * * *

FINDINGS

FINDING A: Cost Problems In The Submarine Advanced Combat System (SUBACS) Program. GAO found that cost control has been a continuing problem in the SUBACS program, resulting in significant cost increases. According to GAO, even before the October 1983 Secretary of Defense program approval, an April 1983 Naval Material Command audit found that the SUBACS Basic phase was underestimated by about $105 million. After the contract was negotiated with International Business Machines (IBM) Corporation in December 1983, GAO reported that in June 1984, the Navy decided to delay several portions of the SUBACS development program to absorb early cost increases estimated by IBM. GAO found that an additional cost problem was identified in November 1984 when the Navy estimated the total SUBACS program would require $853 million more in RDT&E funding due to new and unfunded requirements, program stretchouts resulting from budget cuts, future funding needs, and cost overruns in the SUBACS Basic contract. Although the Navy restructured the development program to address this problem, GAO found that SUBACS costs have continued to escalate. GAO reported that in June 1985, IBM estimated a $146.2 million cost overrun to complete SUBACS Basic full-scale development, about $78 million of which was not included in the November 1984 Navy estimate. GAO noted that the June 1985 overrun was primarily due to increased software and system development, additional test and integration requirements, and subcontractor and vendor production problems. According to GAO, IBM is currently evaluating $46.9 million in contract scope reductions to partially offset the cost overruns. (pp. 4-5, Letter, and pp. 11-12, Appendix IV, GAO Draft Report)

Now on pp. 3-4, and 20-21.

DOD POSITION: Partially concur. DoD concurs except that the GAO incorrectly states that IBM estimated a $146.2 million cost overrun in June 1985, stating that this estimate showed that costs continued to escalate after the Navy had restructured the program to contain costs. In fact, the IBM estimate was known to the Navy before the restructuring and formed part of the basis for the Navy-initiated scope reduction effort. The IBM estimate, therefore, does not reflect poor performance of the restructured program. Additionally, since the GAO audit was completed, the Secretary of the Navy has approved the contract scope reductions discussed in the last sentence of this finding.

Now on pp. 1-2, 4-5,14, and 21-22.

FINDING B: Schedule Problems Affecting The SUBACS Program. GAO reported that in October 1983, the Secretary of Defense approved the Navy's plan to introduce SUBACS as a three-based Pre-planned Product Improvement program rather than a single phase program as originally planned. Under this new approach, GAO reported that SUBACS was to be introduced on SSN 751, an SSN 688 class submarine authorized in fiscal year 1983 and scheduled for delivery in November 1987, rather than a submarine scheduled for authorization in fiscal year 1989. Although designed to introduce additional capabilities earlier than planned and spread program risks and costs over time, GAO found that in fact the schedules provided little flexibility to deal with problems normally encountered when introducing new and unproven technology through a concurrent development and production program. GAO reported that as early as June 1983, a Naval Underwater Systems Center (NUSC) risk assessment predicted that development of the distributive system data bus was a high risk and would be completed 9 to 12 months later than scheduled to meet delivery of the SSN 751. GAO found that a February 1985 NUSC risk assessment identified eight major hardware subsystems as a medium to high risk for delayed delivery to the shipbuilder, and that software development was also a high schedule risk. GAO also noted that in February 1985, IBM estimated six critical software deliveries would be delayed from 2 months to more than 2 years. (pp. 2 and 5-6, Letter; p. 5, Appendix II; and pp. 13-14, Appendix IV, GAO Draft Report)

DOD POSITION: Concur.

- The GAO report gives much emphasis to the June 1983 NUSC risk assessment which predicted delays in development of the distribution data bus. In retrospect, NUSC was correct. It should be recognized, however, that risk assessments from various sources, including Bell Laboratories, were considered in reaching decisions on this program. While none claimed the development was risk-free, the aggregate showed the risk was acceptable, particularly when recommended additional modeling and testing was incorporated into the program. To mention only the assessment which (in retrospect) proved correct is to mislead the reader to believe that overwhelming evidence of impending risk was ignored by the decision-makers, which was not the case.

- The February 1985 NUSC hardware risk assessment, commissioned by the program Office, was a primary consideration in defining Replan III.

Now on p. 5 and 22-23.

FINDING C: SUBACS Program Performance Problems. GAO reported that the distributive system data bus was a major technological innovation in the SUBACS program, intended to integrate acoustic and combat control subsystems into one major system, provide error-free communications, and process more data at higher speed. GAO found that preliminary critical items tests by IBM in December 1984 showed that the software system for the data bus processed data about six times slower than the original program requirements which, according to NUSC, would prevent combat system operators from receiving, interacting, and responding to acoustic information fast enough to solve combat problems on a real time basis. GAO also reported that one IBM subcontractor, Hughes Aircraft, has encountered problems designing modules for the submarine active detection sonar system, one of which may adversely affect the ability of the first SUBACS submarines to perform their missions. Based on its analysis, however, GAO concluded that development of the data bus and its associated software is the most serious performance problem affecting SUBACS implementation. (p. 6, Letter; and pp. 14-15, Appendix IV, GAO Draft Report)

DOD POSITION: Concur. The modules mentioned in the GAO report are for the receive group of the sonar. Problems with these modules and with the ceramic modules have been solved and all modules for the first ship set are on hand.

Now on pp. 10 and 16-17.

FINDING D: Other Factors Contributing To Program Problems. GAO identified two other factors that have contributed to SUBACS program problems. First, GAO found that the Navy's decision to accelerate ship delivery schedules for the first two SUBACS-equipped submarines has reduced the time available for installation of the SUBACS Basic system from 12 months to 5 months before delivery of SSN 751. The second factor identified by GAO relates to the Navy's management of the program. According to GAO, a high level committee report in 1985 stated that the Navy's management structure provided neither the necessary focus nor the effective use of program management control procedures. GAO also pointed out that, according to the report, NUSC has not provided a strong technical input to the development program. (pp. 6-7, Letter; and pp. 16-17, Appendix V, GAO Draft Report)

DOD POSITION: Concur. NAVSEA and NUSC are currently restructuring their respective organizations for both the SUBACS and FY 1989 Combat System Programs. Both commands are defining, in concert, responsibilities, lines of communication, and accountability to ensure proper roles are established and performed. This effort will be completed and the structure in place by November 1, 1985.

Now on pp. 7-8, 9-10, and 24.

FINDING E: Navy Actions To Replan The SUBACS Program. To address the problems experienced in the SUBACS Basic, GAO reported that the Navy and IBM revised the program plan several times between October 1984 and May 1985. According to GAO, Replans I and II were developed in late 1984 and early 1985 respectively, but both were displaced by Replan III, initiated in March 1985. GAO found that Replan III had the most significant impact on SUBACS design since it deleted the data bus entirely from the program and proposed replacing it with a standard computer-based processing system. Further, GAO reported that because of the problems encountered during SUBACS Basic, the SUBACS A and B phases have been deferred until 1989 or later. In effect, GAO noted that Replan III would convert the three-phased SUBACS program to a one-phase effort for all SSN 688 class submarines authorized from fiscal years 1983 through 1988. GAO concluded that this system will have less capability than the system originally planned and approved by the Secretary of Defense. (pp. 7-8 and 11, Letter; and p. 16, Appendix V, GAO Draft Report)

DOD POSITION: Partially concur. The SUBACS A and B phases were not "deferred until 1989 or later," but were combined into the FY 1989 Combat System. The three phases planned for 1983/4/5, 1986/7/8 and 1989 and later, were converted to a two-phase program with SUBACS Basic for the 1983-1989 submarines and the FY 1989 Combat System for the 1989 and later submarines, including SSN 21.

Now on pp. 8-9 and 24-25.

FINDING F: Navy's Review of Replan III. GAO reported that because Replan III was a major design change to SUBACS, on April 24, 1985, the Assistant Secretary of the Navy for Research, Engineering and Systems appointed a high level committee to review the program. According to GAO, in its report of May 28, 1985, the committee agreed with the Replan III proposal to delete the bus, but recommended an alternative combat system, the BQQ-5 Like, similar to those deployed on SSN 688 class submarines. GAO pointed out that the committee believed Replan III was overly optimistic, had a low chance of meeting delivery schedules, and had unpredictable cost and schedule risks. GAO reported that a second committee was then established to develop more detailed information on cost and schedule impacts, and on July 1 concluded that (1) neither BQQ-5 Like or the revised Replan III alternatives would meet the original SUBACS performance requirements; (2) the cost increase of implementing the BQQ-5 Like alternative was six times greater than the increase under Replan III; and (3) the BQQ-5 Like would have a greater adverse impact on ship delivery schedules. According to GAO, the Assistant Secretary then approved Replan III on August 9, 1985. (pp. 9-10, Letter; and pp. 16-18, Appendix V, GAO Draft Report)

DOD POSITION: Concur. It should be recognized, however, that the "BQQ-5 Like" system is essentially the same system being developed under SUBACS Replan III, with certain high-risk hardware replaced with proven, less-capable components from the AN/BQQ-5 sonar system. The remaining hardware, developed under the SUBACS program, is still required, since the combat system currently deployed in 688 Class SSNs is too large to fit in the space allocated for the combat system in the FY 1983-88 688 Class SSNs.

FINDING G: Replan III Implementation Risks. GAO identified several risks which it believes could adversely affect program implementation. GAO reported that according to the SUBACS Project Manager, detailed program plans, work breakdown structures, critical path analyses, and work packages for Replan III will not be completed until October 1985, and that contract modifications required to implement Replan III must then be negotiated and approved. In addition, GAO reported that the second committee identified major technical risks and uncertainties, including problems with developing, integrating, and producing system software. According to GAO, this will cause the software for the first two systems to be incomplete when delivered to the shipbuilder, which could result in late delivery of the first two SUBACS-equipped submarines, and may subject the Navy to costly shipbuilder claims. Further, GAO reported that according to the committee, these submarines, at delivery, will have a combat system with less performance than required under Replan III, and that since software test and integration planning was incomplete, a meaningful assessment of schedule risk could not be done. GAO concluded that because of the changes made in the SUBACS program and the risks and uncertainties identified with the latest plan, the scheduled Defense Systems Acquisition Review Council (DSARC) review is needed to assure that all alternatives are fully considered to minimize SUBACS cost, schedule, and technical performance problems, and lessen the potential adverse impacts on the Navy's attack submarine programs. Based on its assessment of the committee reviews, GAO also concluded that all available alternatives were not fully considered, such as delaying delivery of the SSNs 751 and 752, terminating the SUBACS program, and returning to the current BQQ-5 system, and developing a new distributed data bus system. Further, GAO concluded that lessons learned from the SUBACS problems should be applied in developing the new combat system for the SSN 21. (pp. 10-12, Letter; and p. 18, Appendix V, GAO Draft Report)

Now on pp. 9-10 and 25.

DOD POSITION: Partially concur. DoD concurs except for the conclusion that all available alternatives were not fully considered. The alternatives, such as delaying the SSNs 751 and 752, terminating the SUBACS program and returning to the current BQQ-5 system, and developing a new distributed data bus system, were considered. Although in retrospect the options should have been included, the prohibitive cost and serious operational impact were so unacceptable that they were not seriously considered or mentioned in the committees' reports.

Now on p. 11.

Now on p. 11.

Now on p. 11.

RECOMMENDATIONS

RECOMMENDATION 1: GAO recommended that the Secretary of Defense, through the DSARC review process, evaluate the Navy's justification for adopting Replan III from among alternative acquisition strategies to ensure the best course of action is taken for providing SSN 688 class submarines, near- and long-term, with the needed combat system performance, while minimizing the adverse effects on SUBACS and submarine construction costs, schedules, and contracts. (p. 12, GAO Draft Report)

DOD POSITION: Concur. A DSARC Program Review is scheduled for November 1985.

RECOMMENDATION 2: GAO recommended that the Secretary of Defense, through the DSARC review process, condition approval of the program on the establishment of a plan for management control, including specific criteria, reporting requirements, and periodic reviews of the program adopted to assess the progress in reaching SUBACS program objectives. (p. 13, GAO Draft Report)

DOD POSITION: Concur. This will be done through the DSARC process.

RECOMMENDATION 3: GAO recommended that the Secretary of Defense, through the DSARC review process, require the Navy to provide key program documentation and budget quality cost estimates before releasing fiscal year 1986 program funds, and base the future release of funds on demonstrated program progress. (p. 13, GAO Draft Report)

DOD POSITION: Partially concur. As stated above, the SUBACS program will be reviewed by the DSARC in November 1985. The Navy will be required to provide key program documentation and budget quality cost estimates for the DSARC review. DoD does not, however, agree that fiscal year 1986 program funds should be withheld. The Navy will limit the funding for the program as required by the continuing resolution. To withhold release of fiscal year 1986 program funds before the DSARC review would result in stop-work orders, costly termination/restart proceedings, and guarantee further costly delays in a program with an already ambitious schedule. The Navy is pursuing the limitation of government liability on the IBM contract as directed by the Joint Committee Report on Defense Authorizations. Capping of the contract is expected to be complete by February 1, 1986, as directed.

Comments From International Business Machines Corporation

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

IBM International Business Machines Corporation

Office of the Vice President
Federal Systems Division
Submarine Advanced Combat System Program

9500 Godwin Drive, Manassas, Virginia 22110

October 24, 1985

In Reply Refer To: 85-CCA-IBM-02999

United States General Accounting Office (GAO)
Washington, DC 20548

Attention: Mr. F. Conahan

Subject: IBM Response to the Draft GAO Report on the Submarine Advanced Combat System, GAO Code 394030 dated September 1985

Attachment: IBM Comments on GAO Report GAO Code 394030 dated September 1985

Dear Sir:

IBM appreciates this opportunity to provide the enclosed comments to the General Accounting Office Report on the SubACS Program. In order to make your review of our comments more convenient the attachment is formatted to first restate the sentence or paragraph in the GAO Report followed by our comment. We hope the information provided herein will be helpful to you in writing your final report.

If you have any questions or wish to have further discussion relative to this matter please contact me on (703) 367-4268.

G. G. Houser

Attachment

ENCLOSURE

GENERAL COMMENT:

Although the report is generally, factually accurate for the time period for which it was written, many of the issues highlighted as problems are no longer applicable as risk factors to the program. Program redirection implementation progress and problem resolution which have occurred since June 1985 permit the program to meet the ship delivery (5/87) and ship deployment (9/88) requirements on schedule.

The following specific comments address points IBM believes need to be clarified and expanded upon to reflect present status, problem correction, and additional information which have resulted during the six months since the data for the report was gathered.

In summary, IBM believes that the current program plan and status support Navy delivery requirements.

Now on p. 3.

1. Page 4, Paragraph 3

"Moreover, a $3.8 Million increase to the contract was estimated in IBM's first SubACS Basic cost performance report in March 1984. To absorb the increased costs in SubACS Basic the Navy in June 1984 decided to delay several portions of the overall SubACS development program."

See GAO comment 1.

IBM Comment

The first Cost Performance Report submitted after contract award showed a $3.8M growth in factory costs at completion. It also showed an unassigned budget line of $5.9M set aside as a management reserve. This could have been used to offset the growth. IBM is not aware of Navy plans in June 1984 to delay portions of the development program. At that time, we were fully funded and performing to the total contract scope.

Now on p. 4.

2. Page 5, Paragraph 1

"While about $68.2 million of this increase was accounted for in the November 1984 estimate, $78 million was not."

See GAO comment 2.

IBM Comment

IBM was not privileged to know and did not have input to the $853 million number and therefore can neither verify nor dispute those numbers. Later reference is made to $853 million increase in R&D and the fact that it did not include $78 million of IBM's increase. It is not known why the total increase was not accounted for.

Now on p. 5

3. Page 6, Paragraph 1

"In addition, IBM estimated in February 1985 that six critical software deliveries would be delayed from 2 months to more than 2 years because of insufficient time to test, integrate, and modify system software."

See GAO comment 3.

IBM Comment

The original program plan for development included partitioning the software functions into seven drops and completely integrating to support a full system delivery in May 1987. In February, 1985, IBM completed a detailed assessment of the System Integration activity and concluded that there was insufficient time remaining to integrate and test 100% of the SubACS Basic function as defined in the November 1983 Prime Item Development Specification. The full system functions were prioritized with individual integration times assigned. The prioritized list was broken into three segments, or deliveries; May 1987, September 1988, and post 1988. The seven software drops were mapped against the priorities and consequently rescheduled. The six lowest priority functions were identified as "Category II" functions and delayed beyond the Ship Deployment delivery. These functions were mutually agreed to be lowest priority and represent 92.5 KSLOCS of software of the total 4000 KSLOCS or approximately 2.3% of the software. After one function (HF PPS) was added back into September 1988 delivery, the Navy agreed that the remaining Category II functions were not critical to mission performance.

Now on p. 5.

4. Page 6, Paragraph 2

"Preliminary critical item tests by IBM in December 1984 showed that the bus' software system processed data about six times slower than the original program requirements."

See GAO comment 4.

IBM Comment

The audit report is accurate that this milestone was not achieved. However, it should be noted that a workaround plan was developed in March 1985 showing 1) an interim solution to protect the integration schedule and the early system deliveries and 2) a final solution to meet full system requirements and support original ship deployment deliveries.

4. IBM Comment (Continued)

In July 1985, bus performance was demonstrated on production hardware showing performance more than adequate to support the ship delivery system in May 1987. Current status in bus development shows IBM accurately tracking the plan of March 1985. This item is no longer a critical path for system delivery.

Now on p. 7.

5. Page 8, Paragraph 5

"Replan III, initiated in March 1985, had the most significant impact on the SubACS design. It deleted the data bus entirely from the program and proposed replacing it with a standard computer-based processing system."

IBM Comment

See GAO comment 5.

Replan III was initiated within the Navy in March via a briefing to CNO. IBM started planning tasks in April and was given direction to implement Replan III via contract mod on May 6, 1985.

Replan III did not delete the bus in its entirety as stated. The fiber optics data bus (array bus) was deleted. However, an equivalent architecture wire bus internal to the beamformer units was maintained in its original configuration. This bus uses the identical software and has the same protocol as the array bus deleted. It was, therefore, important continue the original bus development for ship deployment. In July 1985 (after the GAO audit was completed), a demonstration of the wire bus performance was successfully completed on production hardware elements of the beamformer unit.

Now on p. 8.

6. Page 9, Paragraph 1

"Further, because of system design changes and reduced performance under Replan III, the Navy no longer plans to install SubACS on the SSN-21 attack submarine class and has initiated a new combat system development program for the class."

See GAO comment 6.

6. IBM Comment

The statement is true that SubACS Basic is not planned for the SSN-21. It has been planned from the inception of the SSN-21 to evolve from SubACS Basic in order to accommodate the ship improvements of the SSN-21. These include the new large spherical array, wide aperture array, larger horizontal weapon tubes, etc.

The new FY-89 Combat System development which is planned for the SSN-21 incorporates the needed improvements and allows use of modified hardware and software from SubACS Basic. This evolution includes modifying SubACS Basic hardware and software for all but the new ship sensors. Candidate evolution includes retaining or modifying the Weapon Launch Console, SADS, MIDAS, TBX, Combat System Display Console, SUBRASS, Multi-Purpose Console, Ship Data Display/Data Coverter, etc. The only currently planned new equipment developments are the new sensor interfaces and the addition of new large screen displays. These are the same developments that were planned in the SubACS evolution.

Now on p. 8-9.

7. Page 10, Paragraph 1

"The July 1 committee report concluded that neither alternative would meet the original SubACS performance requirements even though the Navy has made several changes to Replan III. Changes included freezing the design of critical equipment, delaying tests, and adding an essential capability earlier than planned."

IBM Comment

See GAO comment 7.

Changes referred to here really fall into the category of completing planning rather than changing Replan III. The "essential capability" refers to the addition of the PNB capability to the ship delivery configuration. Although this capability could not be completed for initial delivery in May 1987, all of the supporting hardware is included in that delivery. The associated software (only) is available for installation on the ship in September 1987, at the option of the Navy. At the time of the committee report, planning for this step was incomplete. Since that time detailed planning for the PNB capability has been completed and supports the September 1987 delivery option.

7. IBM Comment (Continued)

Also, the beamformer design (a "critical equipment") was being assessed in view of the system architecture change. The design has since been baselined after it was determined to meet the requirements of Replan III.

Now on p. 9.

8. Page 10, Paragraph 3

"These included problems with developing, integrating, and producing system software, particularly for one critical hardware item, a common beamformer."

IBM Comment

See GAO comment 8.

This unit contains a wire bus, uses the identical software and has the same protocol as the array bus which was deleted with Replan III. In July, 1985, (after the GAO audit), a demonstration of the wire bus performance was successfully completed on production hardware elements of the beamformer unit.

The schedule for delivering a common beamformer to Test and Integration was later than required; all risks have been mitigated by reconfiguring existing Replan II beamformer units into the Replan III configuration as Engineering Evaluation Models (EEM) to support the integration schedule.

(See, also, Comment #5)

Now on p. 9-10.

9. Page 11, Paragraph 1

"For example, software for the SSN 751 combat system will be upgraded twice -- once, 2-3 months after submarine delivery and again, 9 months after submarine delivery. With respect to the later upgrade, the report also stated that test and integration planning for the system's software was incomplete ...."

IBM Comment

See GAO comment 9.

The software delivery in September, 1987, is not an upgrade - it is an initial delivery of an additional function.

9. IBM Comment (Continued)

The GAO obtained data and status while resident at IBM from December 1984 through May 1985. The formal Replan III direction was received on May 6, 1985. The planning and committed schedules had not been completed prior to their leaving the facility. It is now complete and supports the overall program schedule with buffer to allow for contingency.

Now on p. 19.

10. Appendix III, Page 10, March 1985

"Replan III, which deleted the distributive system data bus from the program and replaced it with a AN/UYK-7 (later AN/UYK-43) standard computer-based processing system, was developed."

IBM Comment

See GAO comment 10.

March, 1985 is when the Replan was initiated by the Navy in a briefing to CNO. IBM supported the Navy in planning the change throughout the month of April and was given contractual direction to implement Replan III on May 6, 1985.

Now on p. 21

11. Appendix IV, Page 12, Paragraph 3

"The Navy has indicated that without this model it is not possible to effectively test and integrate the SubACS system prior to delivery to the submarine. The second SubACS committee considered it necessary to have a full-time model..."

IBM Comment

See GAO comment 11.

With the inherent parallelism of the production systems it was clearly shown that an Engineering Model is not required for the development. The second committee considered a seventh test bay as an essential element of risk reduction to provide integration bay time buffer for schedule contingency. This bay was added to the plan using contractor Capital Funds and, again, populated with available production assets. Little risks exists in the Program Plan today due to the lack of development facilities.

11. IBM Comment (Continued)

While an Engineering Development Model would be a more optimum approach for development, it is not essential and would add additional cost to the program. The above approach using production assets meets program needs.

Now on p. 21.

12. Appendix IV, Page 13, Paragraph 2

"In addition, the average cost of a ceramic module has almost doubled."

See GAO comment 12.

IBM Comment

Ceramic Module costs have grown by 35%, not 100% as stated. The growth is attributed to lower quantities of modules resulting from Replan III Baseline changes and early producibility problems. (The producibility issues have all since been resolved.)

In addition, one non-ceramic module's recurring cost did increase significantly. The technical problems which drove the cost increase are now under control.

Now on p. 22.

13. Appendix IV, Page 14, Paragraph 1

"On March 26, 1985, IBM advised the SubACS Project Office that it had underestimated software schedule deliveries by 15 percent. As a result, IBM estimated that test and integration for six software schedule deliveries would be delayed from 2 months to more than 2 years."

IBM Comment

See GAO comment 13.

The schedule issues referenced were associated with Test & Integration. The "underestimate" was the time allocated to Integration and sell off of a full-up system. As a result, the capability at system delivery was broken into two segments, May 1987 and September 1988. When the software functions were re-mapped, some functions moved in the schedule. Those functions associated with post 1988 moved "more than two years". (These functions comprise 2.3% of the total software.)

Now on p. 5.

Also, see comment, same point, on Page 6, Paragraph 1.

Now on p. 22.

14. Appendix IV, Page 14, Paragraph 3

"In addition, units that interfaced with the bus had to be redesigned due to ceramic module problems."

IBM Comment

See GAO comment 14.

This statement cannot be supported. Ceramic module performance has not been an issue. Over the six month period of the audit, ceramic module production was the issue. This has since been resolved with no impact to the end deliveries.

Now on p. 22.

15. Appendix IV, Page 14, Paragraph 4

"The original system was too complex, and the data bus was eventually taken out of SubACS primarily because of performance and funding considerations."

IBM Comment

See GAO comment 15.

As stated in an earlier comment, the entire bus was not deleted. Although performance was an early factor, IBM was projecting recovery through a two phased (interim/final) plan of improvements. Present status shows all problems corrected and proceeding on plan.

The ultimate decision to eliminate the fiber optic array bus was more out of a concern for the risk to the integration schedule and how long it would take to integrate the "distributed system" and recurring cost of future systems beyond SubACS Basic. Front-end schedule delays were already impacting the planned start of system integration.

Now on p. 24-25.

16. Appendix V, Page 17, Paragraph 3

"Several changes to Replan III were made after the first committee completed its review. These changes included freezing design of a critical piece of equipment, thereby reducing software development; increasing the time available for test and integration by adding additional test facilities, delaying system design certification testing until September, 1988 and reducing crew training;"

IBM Comment

See GAO comment 16.

The report failed to represent the Program Plan as briefed to the Second Navy SubACS Committee and subsequently implemented. The Plan shows that system certification is accomplished on each delivered system configuration prior to delivery with final System Design Certification completed in September, 1988. The integration plans and schedules clearly show a full System Design Certification (SDCT) of the Combat Control system in 4th quarter of 1986 and acoustic certification of PBB & PNB (total functions delivered) prior to delivery and well ahead of the November 1987 ship delivery date.

Now on p. 25.

17. Appendix V, Page 18, Sentence #3

"--- Neither approach meets the top level requirements of the original SubACS program; therefore, top level requirements need to be revised to reflect reduced capabilities."

IBM Comment

See GAO comment 17.

The Prime Item Development Specification (PIDS) represents the Navy's implementation of the top level requirements and in the governing requirements document between the Navy and IBM. The PIDS have been modified to accomodate the system architecture change and use of AN/BQQ-5D software associated with Replan III. In our judgement, these modifications to the original PIDS are minimal (i.e., changes are primarily in the area of operability) and do not impact mission performance. It is our understanding that the top level requirements were minimally modified by the Navy to accomodate the Replan III PIDS.

Now on p. 25

18. Appendix V, Page 18, last sentence

-- delay of system design certification testing until after delivery of the first SubACS submarine.

IBM Comment

See GAO comment 18.

This point does not accurately reflect the Program Plan as briefed to the Second Navy SubACS Committee. The plan provided details of incremental functional deliveries in May 1987 and September 1987 with full system capability delivered in September 1988. Each incremental delivery is certified to the maximum extent the system configuration allows.

(See Comment 16)

The following is our evaluation of IBM Corporation's letter, dated October 24, 1985.

GAO Comments

1. No revision to our report is required. IBM agrees with the $3.8 million growth and provides other data reflecting on the Navy's management of the SUBACS program.

2. No revision to our report is required. Comment reflects IBM's views on the Navy's management of the SUBACS program.

3. No revision to our report is required. IBM's comment essentially provides detailed technical reasons for delays in software deliveries.

4. No revision to our report is required. IBM agrees the December 1984 tests showed that the software system for the data bus operated at one-sixth the speed originally planned. Our report addresses technical performance problems encountered during development of the original SUBACS configuration, which included a distributed system data bus. This data bus, a major technological innovation for SUBACS, was to integrate acoustic and combat control subsystems into one major combat system using fiber optics to distribute and communicate data. Under Replan III, the data bus was removed from the configuration and changes were made in the performance parameters for SUBACS.

IBM provides additional information on program replanning efforts, partially taken in response to the data bus development problems. However, the bus discussed later in IBM's comment is a wire bus, retained in the SUBACS beamformer units from the original SUBACS configuration, and not the data bus referred to in our report. IBM provides the development status of the wire bus under Replan III.

5. No revision to our report is required. Data bus, as used in our report, refers only to the fiber optics bus and not to the wire bus internal to the SUBACS beamformer units (retained in the Replan III configuration from the original SUBACS configuration). IBM provides additional information on program replanning efforts and makes a distinction between the wire bus and the data bus developments in the SUBACS (Replan III) configuration.

6. No revision to our report is required. Since our draft report was sent to IBM for comment, we have revised our report to reflect the Navy's separation of the SUBACS effort into two programs—SUBACS (Replan III)

and FY 89 Combat System. Details of the proposed FY 89 Combat System plan and design are still being defined by the Navy. IBM's comment provides additional information on the proposed plan to evolve portions of the FY 89 Combat System design from modified SUBACS (Replan III) hardware and software.

7. No revision to our report is required. At the time of the first SUBACS committee's review, neither Replan III nor "BQQ-5 Like" had been completely defined. However, at the time of the second SUBACS committee, several changes to Replan III, as noted in our report, had been made by the Navy and IBM as more detailed plans were completed for the proposed alternative. After completion of the second committee's report, further refinements were made to Replan III. IBM's comment provides additional information on the completion of planning for Replan III.

8. No revision to our report is required. IBM's comment provides additional information on testing conducted for the beamformer's wire bus after our IBM audit work was completed. Also, see our response to IBM's comment #5.

9. No revision to our report is required. IBM's comment reflects an initial delivery of an additional function in September 1987 (not discussed in our report). Although this function will be delivered before shipbuilder's delivery of the SSN 751 (November 1987), upgrades will be required, as noted in our report, to provide the system with improved capabilities. These upgrades are scheduled for delivery in about January 1988 and September 1988.

10. No revision to our report is required. IBM's comment provides additional information on the implementation of Replan III.

11. No revision to our report is required. Although IBM states that an Engineering Development Model would be a more optimum approach for development, it disagrees with the second SUBACS committee that a full-time model was necessary to effectively test and integrate the system prior to delivery to the submarine. IBM provides its views on the adequacy of using available production assets in meeting program development needs.

12. We have revised our report to show that according to EG&G, the Navy's support contractor, the average cost (including all nonrecurring costs) for all ceramic modules, produced by all vendors, has almost doubled.

13. IBM's comment provides further details on those software deliveries delayed more than 2 years. We changed our report to note that those functions delayed more than 2 years comprise 2.3 percent of the total software.

14. To more accurately reflect the reasons for redesign of the units, our report has been revised as follows:

"In addition, units that interfaced with the data bus had to be redesigned due to ceramic module delivery delays. The delays were due to vendor difficulties in meeting Navy testing requirements and low production yields."

15. No revision to our report is required. IBM's comment provides additional information on the SUBACS replanning efforts, particularly the reason for deleting the distributed system data bus from the original SUBACS configuration. Also, see our responses to IBM's comments #4 and #5.

16. IBM's comment indicates that system design certification testing for the first system will occur in the fourth quarter of 1986 and prior to delivery. (We believe IBM is referring to the May 1987 system delivery to the shipbuilder.) However, IBM acknowledges that final system design certification testing will not be completed until September 1988. We have revised our report to indicate that the September 1988 date is the completion of final system design certification testing.

17. No revision to our report is required. IBM's comments reflect its views and understanding of the planned revisions to the SUBACS top-level requirements.

18. As indicated earlier by IBM (comment #16), final system design certification testing will not be completed until September 1988. Our report refers to one of several possible risks, as indicated to us by the chairperson of the second SUBACS committee, in implementing Replan III. The chairperson believed system design certification testing was a high risk in Replan III and completion of this testing could be delayed until after delivery of the first SUBACS-equipped submarine, SSN 751. We have revised our report to indicate that the risk is in completing certification testing for the system prior to the SSN 751 submarine delivery.

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