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Report to the Chairman, Subcommittee on Projection Forces and Regional

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National Security and
International Affairs Division

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January 31, 1990

The Honorable Edward Kennedy
Chairman, Subcommittee on Projection Forces
and Regional Defense
Committee on Armed Services
United States Senate

Dear Mr. Chairman:

In response to your November 2, 1987, request, we assessed the ability of the Navy's new advanced combat system programs—AN/BSY-1 and AN/BSY-2—to meet cost, schedule, and performance goals.

As agreed with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 7 days from the date of this letter. At that time, we will send copies to the Chairmen, Senate Committee on Government Affairs, House Committee on Government Operations, Senate and House Committees on Armed Services, and Senate and House Committees on Appropriations; the Director, Office of Management and Budget; and the Secretaries of Defense and the Navy. We also will send copies to interested parties and make copies available to others upon request.

This report was prepared under the direction of Martin M. Ferber, Director, Navy Issues, who may be reached on 275-6504 if you or your staff have any questions. Other major contributors are listed in appendix III.

Sincerely yours,

Frank C. Conahan
Assistant Comptroller General

Executive Summary

Purpose

To meet new Soviet threats and ensure continued U.S. submarine superiority, the U.S. Navy has initiated development of two new advanced combat systems. These systems—the AN/BSY-1 and the AN/BSY-2—are to be installed in improved Los Angeles (SSN-688) and new Seawolf (SSN-21) class nuclear attack submarines, respectively. The life-cycle costs for the two systems have been estimated at over $26 billion.

The Chairman, Subcommittee on Projection Forces and Regional Defense, Senate Committee on Armed Services, requested that GAO examine the status of the Navy's submarine combat system development programs. Specifically, GAO determined whether these two combat systems will meet cost, schedule, and performance goals and whether the combat system being developed for SSN-21s can avoid developmental problems experienced with the SSN-688 combat system.

Background

In 1980 the Navy began developing an advanced combat system for improved SSN-688s authorized in fiscal year 1989 and beyond. Originally, it planned a single-phased program. However, in October 1983 the Secretary of Defense accelerated the program and approved a three-phased plan to apply to SSN-688s authorized, starting in fiscal year 1983—a 6-year acceleration.

Because of ambitious program objectives and schedules, cost, schedule, and technical problems surfaced causing the Navy to restructure the program into two separate development efforts—AN/BSY-1 for use on improved SSN-688s and AN/BSY-2 for SSN-21s. These combat systems are designed to improve data processing and management capabilities. With the use of new and more capable computers, new data displays, and additional software, certain tasks, such as searching for, detecting, and tracking targets, will be more automated. System operators can thus perform multiple tasks, address multiple targets concurrently, and process tactical data faster and more accurately than they can with prior systems. Collectively, these capabilities are designed to reduce the response time between initially detecting a target and launching a weapon.

Results in Brief

The Navy's submarine combat system development programs are experiencing problems. AN/BSY-1 program problems raise questions as to when the improved SSN-688s will be fully mission capable. Because of continued ambitious development objectives and schedules for the combat system development program, the Navy allowed insufficient time in

the development schedule to resolve technical problems. As a result, the AN/BSY-1 systems will provide the SSN-688s improved performance capabilities in the acoustics and weapons launch areas, but the systems will be less capable in other areas. Also, the capabilities will be delivered later and cost more than originally planned under the earlier program.

The Navy has taken steps to reduce risks in the AN/BSY-2 program. However, it appears that potential problems in the AN/BSY-2 are similar to those experienced in developing prior submarine advanced combat systems, including the AN/BSY-1. In order to meet the SSN-21's construction schedule, the Navy also has established ambitious objectives and schedules for the AN/BSY-2 development program. As a result, the first combat system will not have full capabilities when delivered to the shipbuilder. In addition, combat system development problems could adversely affect the planned cost, schedule, and performance of the first SSN-21.

Principal Findings

The Navy continues to establish ambitious program objectives and schedules in its development of complex submarine combat systems. As a result, the Navy must accept less than fully capable combat systems in order to meet the shipbuilders' schedule.

AN/BSY-1 Has Experienced Problems

The estimated life-cycle costs for the AN/BSY-1 have increased from $5.4 billion to $12.1 billion for 19 and 24 systems, respectively. The first four systems will not have full AN/BSY-1 offensive capabilities and will be upgraded during the submarines' post shakedown availability period. Therefore, these submarines will not be able to perform a full range of missions. In addition, the AN/BSY-1 will provide less capabilities than originally planned under the original submarine advanced combat system program.

AN/BSY-1 design changes were the major cause of several improved SSN-688s under construction being modified. These changes also resulted in one shipyard being awarded almost $82 million for changes to five submarines and another requesting a $150 million contract adjustment for modifications for nine submarines. The first nine AN/BSY-1-equipped submarines will be delivered an average 17 months late to the Navy.

AN/BSY-2 Will Not Have Full Capabilities When Delivered

Like the improved SSN-688 program, the need to meet the SSN-21 ship construction schedule also is affecting the AN/BSY-2 development program. As a result, the prime contractor does not have sufficient time to deliver the first combat system with full capabilities to the Navy. Remaining capabilities are scheduled to be delivered to the Navy in November 1994.

AN/BSY-2 Development Problems Could Adversely Delay Further System Delivery

As of November 1989, AN/BSY-2 development was about 3 months behind the program's current schedule and further delays are expected. Delays have resulted in deferring two Navy critical system design reviews and some critical item testing. Until the Navy completes these reviews, the prime contractor is unable to begin developing most hardware and writing most system software code.

Recommendations

GAO is not making recommendations in this report.

Agency Comments

The Department of Defense (DOD) generally agreed with GAO's report and with the facts as presented on the AN/BSY-1 but only partially concurred with GAO's findings on the AN/BSY-2. In those cases where it partially agreed with the report, DOD provided further elaboration. (See app. II.)

DOD agreed that AN/BSY-1 combat system design changes were a major contributor to submarine delivery delays and cost increases but added that other design changes also contributed to the submarines' delays and cost increases. Regarding the AN/BSY-2, DOD stated that the slippage of the preliminary design review and the critical design review had no impact on the scheduled delivery of the system to the Navy. Although DOD agreed that some critical item tests have been delayed, it stated that many have been satisfactorily completed. Also, DOD agreed slowness in subcontract definitization increased program risks but added that no subcontractor design effort is being delayed.

Contents

Abbreviations

DOD	Department of Defense
OPTEVFOR	Operational Test and Evaluation Force
PSA	post shakedown availability
SSN	nuclear attack submarine
SUBACS	Submarine Advanced Combat System

Introduction

The nuclear attack submarine (SSN) is one of the nation's most important antisubmarine warfare assets. To enhance the performance and ensure the continued superiority of U.S. nuclear attack submarines, the Navy will equip both the improved Los Angeles class (SSN-688) and the new Seawolf class (SSN-21) nuclear attack submarines with new and improved combat systems—AN/BSY-1 and AN/BSY-2, respectively. The two computer-based combat systems are designed to detect, classify, track, and launch weapons at enemy subsurface, surface, and land targets; locate enemy targets faster than previous systems; allow operators to perform multiple tasks and address multiple targets concurrently; and reduce the time between detecting a target and launching weapons. Fully capable combat systems, which are successfully developed, fully tested, and delivered on schedule, are critical to the improved SSN-688 and the SSN-21 achieving full combat capability.

Background

Advanced submarine combat system development began in 1980 with the Submarine Advanced Combat System (SUBACS)[1] program. SUBACS was started to meet the improved SSN-688's expanded mission and to counter the Soviet antisubmarine warfare threat through the 1990s. SUBACS was to be a single-phase program and was to upgrade improved SSN-688s authorized in fiscal years 1989 and beyond. In October 1983, however, the Secretary of Defense accelerated the program and approved a three-phased plan (SUBACS Basic, SUBACS A, and SUBACS B) for improved SSN-688s authorized in fiscal years 1983 and beyond—6 years earlier than originally planned.

SUBACS Basic was intended to be a new combat system to add new sonar subsystems and to process and integrate acoustic and combat control information by using a new fiber optic technology called a distributive system data bus. SUBACS A was to use new and upgraded software to integrate SUBACS Basic's acoustic and combat control processing and was to be used in improved SSN-688s authorized in fiscal years 1986 through 1988. SUBACS B was to introduce sonar improvements into the integrated combat system on improved SSN-688s authorized in fiscal years 1989 and beyond. Once completed, a modified SUBACS B system was to serve as the baseline design for the SSN-21's combat system. The three-phased plan, however, was not carried to full implementation.

[1]For further information on the SUBACS program, see our report entitled SUBACS Problems May Adversely Affect Navy Attack Submarine Programs (GAO/NSIAD-86-12, Nov. 4, 1985).

In December 1983 the Navy awarded the International Business Machines Corporation a $772 million contract for concurrent full-scale development and production of five SUBACS Basic systems and for an engineering development model. In 1985, because of program cost, schedule, and technical problems, the Navy restructured SUBACS into two separate development efforts—AN/BSY-1 and AN/BSY-2.

Emergence of AN/BSY-1

In redesigning the SUBACS Basic effort, the Navy named the program AN/BSY-1, deleted the fiber optic distributive system data bus, and reintroduced the heavier and bulkier copper cable and some previously developed hardware to accomplish data distribution. These actions reduced the system's planned performance capabilities. The SUBACS Basic contract was renegotiated in February 1986 to establish AN/BSY-1 requirements. The renegotiation also established maximum liability of the government at $1.03 billion for development and production of the first five systems. Because there was insufficient time to correct all design and development problems and meet the improved SSN-688 construction schedule, two versions of the AN/BSY-1 combat system were delivered.

The first version, preliminary product baseline system, was installed on four submarines (SSN-751 through SSN-754). The preliminary systems provide those submarines with limited self-defense capabilities (acoustic, safety, and weapon firing functions) necessary to operate until the systems are upgraded to include all offensive capabilities. These four systems will be upgraded[2] to full performance capabilities during each submarine's post shakedown availability (PSA)[1] and before the submarine's initial operational date. A second version, product baseline system, is to have full performance capability and will be installed on the 20 remaining improved SSN-688s, starting with SSN-755.

The AN/BSY-1 replaces the AN/BQQ-5 sonar and the CCS MK-1 fire control systems and is designed to address shortfalls in these systems. The

[2]The upgrade will include improved software, replacement of the old AN/UYK-7 computer with the new Navy standard AN/UYK-43 computer that was not available during the early design phase of SUBACS, and addition of hardware for signal processing and under ice operations.

[1]An availability is an assignment of a ship to a repair facility for repairs or maintenance. A PSA occurs after a newly built, activated, or converted ship has completed its shakedown cruise. The Navy estimates the PSA for the SSN-751 through SSN-754 will be 9 to 10 months each.

Navy expects to buy 24[4] AN/BSY-1 combat systems and associated equipment, at a total cost of about $4.7 billion. The AN/BSY-1 is nearing completion of full-scale development.

Emergence of AN/BSY-2

The Navy combined SUBACS A and SUBACS B performance requirements and renamed this effort the AN/BSY-2. This multibillion dollar combat system is currently in full-scale development and is to be installed on 29 new SSN-21s. The AN/BSY-2 will be highly automated, will use existing technology, and will include larger and more sophisticated sensors, greater data processing capabilities, and more new computer software than the AN/BSY-1.

To reduce AN/BSY-2 development risks, the Navy undertook a 2-year development program to design a combat system and implemented a leader/follower arrangement. In early 1986, the Navy awarded fixed-price system design development contracts to the General Electric Company and the International Business Machines. In December 1987 the Navy selected General Electric as the prime contractor and International Business Machines as the "follower" contractor. On March 31, 1988, the Navy awarded General Electric a $1.84 billion fixed-price-incentive fee contract to develop and produce three AN/BSY-2 combat systems and related items. General Electric will develop and qualify International Business Machines as a competitor for fiscal year 1992 production systems.

Objectives, Scope, and Methodology

The Chairman, Subcommittee on Projection Forces and Regional Defense, Senate Committee on Armed Services, asked us to assess the status of the Navy's AN/BSY-2 combat system development program. Specifically, we were asked to determine whether the AN/BSY-2 program would meet cost, schedule, and performance goals, including software development and system test and integration requirements. We also were asked to assess the Navy's AN/BSY-1 combat system program in terms of cost, schedule, and performance goals.

To evaluate AN/BSY-1 and AN/BSY-2 program progress, we discussed cost, schedule, and performance issues with officials in Washington, D.C., at the Office of the Under Secretary of Defense for Research and

[4]The total number of systems and associated costs reflects a 24 AN/BSY-1 combat system program. However, the program's size has been reduced to 23 as a result of fiscal year 1990 appropriation decisions made for the SSN-688 construction program.

Engineering, the Office of the Under Secretary of Defense for Test and Evaluation, the Office of the Secretary of Defense for Program Analysis and Evaluation (Cost Analysis Division), the Naval Sea Systems Command program offices responsible for these two programs, and the Navy's Board of Inspection and Survey. We also discussed these issues with officials at the

- International Business Machines Corporation, Manassas, Virginia;
- General Electric Company, Syracuse, New York;
- Naval Underwater Systems Center, Newport, Rhode Island, and its on-site office at International Business Machines Corporation, Manassas, Virginia;
- Supervisors of Shipbuilding, Conversion, and Repair, Groton, Connecticut, and Newport News, Virginia;
- Operational Test and Evaluation Force, Norfolk, Virginia;
- Newport News Shipbuilding and Drydock Company, Newport News, Virginia;
- Electric Boat Division of General Dynamics Corporation, Groton, Connecticut; and
- Charles Stark Draper Laboratory, Cambridge, Massachusetts.

We also reviewed and analyzed documents that describe and track system requirements, development, and acquisition.

We discussed internal control system compliance with officials in Washington, D.C., at the Department of Defense's (DOD) Office of the Inspector General; the Naval Sea Systems Command's, the Naval Space and Warfare Command's, and the Naval Underwater System Center's Offices of Internal Review; and the Naval Audit Service. We also discussed General Electric's Underwater Systems Division's internal control compliance with officials at the Defense Contract Audit Agency and the Defense Contract Services Administration in Syracuse, New York. We reviewed the Defense Contract Audit Agency's audit of General Electric's AN/BSY-2 full-scale engineering development proposal.

We conducted our review between April 1988 and November 1989 in accordance with generally accepted government auditing standards. DOD provided written comments on this report. These comments are presented and evaluated in chapters 2 and 3 and are included in appendix II.

SSN-688 Combat System Problems Affect the Readiness of Some Submarines

Ambitious development objectives and schedules have caused the AN/BSY-1 combat system program to experience cost increases and schedule delays. AN/BSY-1 life-cycle cost[1] estimates more than doubled between February 1986 and November 1988. In addition, AN/BSY-1 design changes were the major contributor to several submarines being delivered later and costing more than originally planned. As a result, AN/BSY-1 delivery dates were revised to coincide with shipyard requirements. Revised AN/BSY-1 delivery dates have been met and, as of November 1989, two of the four system upgrades have been delivered. However, only one of the two upgrades has been installed on improved SSN-688s. Thus, these four submarines are not fully mission capable or able to counter the evolving threat until the upgrades are completed.

The fully compliant AN/BSY-1 combat system has not been operationally tested under realistic at sea conditions. However, land-based assessments show the system has the potential to be operationally effective and suitable, although it will provide less performance capabilities than originally planned under the SUBACS Basic program to alleviate program schedule and cost risks.

Program Costs

Total estimated AN/BSY-1 program costs have increased 125 percent since February 1986 when the Navy estimated the life-cycle costs at about $5.4 billion for 19 systems, trainers, and spares. In November 1988, the Navy estimated these costs at $12.1 billion for 24 systems and associated equipment. (See table 2.1.)

Table 2.1: Estimated AN/BSY-1 Life-Cycle Costs

Escalated dollars in millions

	Feb. 1986	Nov. 1988	Difference
Development	$1,227.7	$1,211 0	$−16.7
Production	2,588 3	3,513 8	925 5
Operation and support	1,578.1	7,424 7	5,846 6
Total	**$5,394.1**	**$12,149.5**	**$6,755.4**

[1]Life-cycle costs refer to total costs to the government to develop, produce, construct, operate, support, and own a system over a specified life span.

Production costs increased primarily from the addition of five systems, six new wide aperture arrays,[2] spares, and repair parts. Operation and support cost estimates increased about $6 billion, from $83 million per system in February 1986 to $309 million per system in November 1988. The substantial increase was attributed to a revised cost estimating model that corrected assumptions made in calculating the 1986 operating and support cost estimate. For example, according to an AN/BSY-1 program official, the February 1986 estimate did not include all operating expenses and reflected a significant error in calculating the life expectancy of the systems.

System Capabilities Not Provided on Schedule

Timely delivery of the combat systems to the shipyards is essential to ensure that improved SSN-688 delivery schedules are met. However, early combat system development, design problems with AN/BSY-1, design changes to the SSN-688s to accommodate AN/BSY-1, and other ship design changes led to ship construction delays and shipbuilder claims against the Navy. Further, a labor dispute at one shipyard led to an additional 6-month construction delay. Original and revised AN/BSY-1 delivery dates based on shipyard need for the first five combat systems with initial and full capabilities are shown in table 2.2.

Table 2.2: Delivery Schedules for First Five Combat Systems

	Initial capabilities		Full capabilities	
SSN	Original	Required delivery to shipbuilder[a]	Original	Current[b]
751	5/87	11/87	9/88	11/89[a]
752	8/87	4/88	12/88	4/90
753	11/87	1/89	3/89	6/91
754	1/88	7/88	4/89	12/90
755			4/88	5/89[a]

[a]These dates are also the actual delivery dates

[b]Schedule is as of June 1989 but, according to a Navy official, these dates are tentative and further delays may occur if shipyard requirements change

In accordance with the revised delivery schedule, the Navy accepted delivery of 5 of the 24 required AN/BSY-1 systems. However, because of ship construction delays, the shipbuilders were not prepared to install

[2]A wide aperture array is a passive sonar that will be mounted on SSN-688 and SSN-21 hulls. It will provide enhanced capabilities over previous systems because it will locate targets faster and provide more accurate range and target motion analysis. It was originally planned for implementation in the SUBACS B time frame.

the systems so the AN/BSY-1 contractor retained them. Later, the Navy delivered the systems to the shipbuilders as government-furnished equipment. The four systems with initial capabilities were installed on the SSN-751 through SSN-754. However, upgrades to make the four systems fully capable will be installed an average 19 months later than originally scheduled. Upgrades for the SSN-751 and SSN-752 systems were delivered to the shipbuilder, but only the SSN-751 upgrade was installed.

In its comments on this report, DOD stated that the two system upgrades delivered through November 1989 were delivered on time. However, DOD's milestone assessment is based on revised delivery to the shipbuilder, whereas our late delivery assessment is based on the program's original installation schedule or the PSA ending date. According to the Navy, the remaining upgrades will be delivered in time for installation during each submarine's PSA. The fifth system, with full performance capabilities, was delivered to the shipbuilder in May 1989 and installed in September 1989. The Navy does not expect delivery of the remaining 19 systems to be a problem.

Performance

Although the Navy has taken delivery of five systems, the first four were delivered without full performance capabilities. Until the systems are upgraded, the improved SSN-688s will not be able to accomplish their expanded mission or to counter the evolving threat. According to Navy officials, these submarines would not normally be operated outside U.S. waters.[1]

The AN/BSY-1 systems have not yet been subjected to operational testing under realistic, at sea conditions. Instead, the Navy has conducted developmental and preliminary tests on some AN/BSY-1 subsystems[2] and a land-based operational assessment. On the basis of these tests, the Navy is confident that a fully capable AN/BSY-1 will improve the SSN-688's performance. Even though DOD requires that a production representative system undergo operational testing before proceeding beyond low rate production, the first full system testing under realistic, at sea

[1]Although this is a normal sequence for newly constructed submarines between delivery and PSA, PSAs for the improved SSN-688s have been continuously delayed due to ship construction slippage.

[2]According to the Navy, the SSN-751 fired 12 torpedoes with 9 hits during a weapon system accuracy test and tactical weapons training and certification firings. Three torpedo failures occurred. According to the AN/BSY-1 program manager, this performance is above the fleet average. The passive sonar also tracked MK-30 targets at ranges greater than any previous submarine.

conditions will not be performed until after commitment is made to procure all systems. Whether the AN/BSY-1 is more effective and is an improvement over older systems, however, cannot be fully demonstrated until a complete system is subjected to operational and technical testing under these conditions. This testing is planned to occur in fiscal year 1990 when the first improved SSN-688 with a complete AN/BSY-1 system is subjected to technical and operational evaluation.

System Deficiencies Preclude the Use of Some SSN-688s for Intended Missions

In June 1988 the Navy's Board of Inspection and Surveys conducted an underway acceptance sea trial of the first AN/BSY-1-equipped submarine, the SSN-751. The Board's July 15, 1988, report identified 20 deficiencies of such significance that the submarine's ability to perform its missions was degraded and cited additional deficiencies relating to combat system reliability and maintainability. Most of the 20 significant deficiencies involved the AN/BSY-1 and existed because the upgrade to full performance had not been installed. Therefore, the first four submarines had limited acoustic and combat control capabilities.

The Board recommended that the submarine be accepted and that a retrial be conducted after the system upgrades are installed. However, according to a Chief of Naval Operations official, a retrial will not be necessary because the Navy will rely on operational and technical evaluation results to determine the SSN-751's suitability for deployment. In an October 11, 1989, letter, the Board's President agreed that a retrial of the first AN/BSY-1-equipped submarine was not required. In its comments on this report, DOD noted that all deficiencies the Board identified and attributed to the AN/BSY-1 had been corrected.

Operational Testing

DOD regulations require that a major defense acquisition program undergo operational testing on a production representative system before proceeding beyond low rate production to confirm that the items or components actually tested are effective and suitable for combat. However, operational testing has not been conducted on a fully compliant AN/BSY-1 under realistic, at sea conditions, even though 20 of the 24 systems are under contract and the contractor has delivered five systems to the Navy. According to DOD, this is a consequence of having a program enter low rate production concurrent with development.

The Naval Underwater Systems Center has conducted a comparative analysis of the AN/BSY-1 and its predecessor systems—the AN/BQQ-5 sonar and the CCS MK-1 fire control systems. The analysis shows the

AN/BSY-1 has the potential to provide significantly improved effectiveness over these systems in the acoustics and weapon launch areas, but the AN/BSY-1's performance capabilities are less than originally planned under SUBACS Basic. In September 1987 the Navy's Operational Test and Evaluation Force (OPTEVFOR) provided an observation of the AN/BSY-1, and in September 1988 it recommended continuing the development process. However, it emphasized that the findings must be viewed in the context of extreme limitations. For example, OPTEVFOR officials cautioned that, because of the lack of suitable data for projecting the system's potential effectiveness and suitability, the observation was based on OPTEVFOR's review of such items as development specifications, personnel, training concepts, and resource documents.

The first AN/BSY-1 operational assessment, a land-based computer simulation, was conducted in July 1989. In August 1989 OPTEVFOR released an assessment of that simulation but again stated that the assessment was preliminary and the testing scope limited. On the basis of an incomplete analysis of the test data and within the constraints of the testing scope, OPTEVFOR projected that the AN/BSY-1 had the potential to be operationally effective and suitable and again recommended continued system development.

Although no major deficiencies were noted in most areas, additional testing to resolve critical operational issues and to complete evaluation of operational effectiveness and operational suitability is required due to limitations in the land-based test facility and in the testing scope. These limitations precluded the evaluation of certain effectiveness thresholds. For example, the land-based test facility was not representative of the shipboard environment with respect to heat, noise, vibration, ship motion, electrical power, accessibility, electromagnetic compatibility and interference, and interfacing systems. Additionally, mine laying, mine field navigation and avoidance, under ice operations, and underwater communications could not be simulated. OPTEVFOR stated that the assessment may be modified as a result of additional analysis.

According to DOD, the final assessment of operational effectiveness and suitability will occur with technical and operational evaluation. However, a fully compliant AN/BSY-1 system was not available for actual at sea operational testing until November 1989—when the SSN-751 completed PSA. DOD also stated that the start of the evaluation is contingent upon the SSN-751's schedule following PSA. The Navy plans to start technical and operational testing on the SSN-751 in March and August 1990, respectively. According to AN/BSY-1 officials, the testing delay is due to

the limited number of systems being procured, concurrent system production, and program schedule. However, by the time testing is completed and results are reported, all 24 systems will be under contract and several additional systems will have been delivered. Thus, problems identified during testing will have to be corrected on all systems delivered as well as those in production. The Navy will have to pay to correct any existing technical problems on systems.

The next Defense Acquisition Board review for the AN/BSY-1 is the fiscal year 1991 full production review. Because all systems will be under contract before the review, DOD will consider eliminating the AN/BSY-1 review based on several factors, including the land-based test results. However, such test data are normally used to support approved limited production, while more comprehensive testing is used to support approval for full production.

Conflicting Combat System and Submarine Schedules Increase Risks

When SUBACS Basic was changed to AN/BSY-1, nine improved SSN-688s—five by Electric Boat and four by Newport News Shipbuilding—were under construction. With the approval of the AN/BSY-1 design, portions of these submarines had to be redesigned to accommodate the AN/BSY-1 rather than the SUBACS Basic design. Thus, the Navy was required to provide various design and configuration data to the ship design agent in time to meet the SSN-688 construction schedule if it was to avoid government liability for delay. However, untimely and defective data caused Electric Boat to incur significant delays and additional construction costs, resulting in Electric Boat submitting a request for equitable adjustment. Newport News Shipbuilding also has submitted a similar request.

Between September 1986 and October 1986, Electric Boat alerted the Navy on several occasions that late and/or faulty AN/BSY-1 design data were affecting the SSN-688 construction schedule. During September 1986, Electric Boat notified the Navy that work on the SSN-751 was significantly behind schedule, that major design problems, primarily with AN/BSY-1, were causing the delay, and that the design must be finalized immediately to meet the submarine delivery date. On October 7, 1986, Electric Boat again cautioned the Navy that these major design problems were causing rework, delays, and stoppages to the construction of the SSN-751. Electric Boat again stated that the AN/BSY-1 must be delivered on schedule to support the improved SSN-688 construction schedule.

On July 17, 1987, Electric Boat submitted a request for equitable adjustment for about $97.1 million and schedule adjustments for five improved SSN-688s. The request for equitable adjustment is based on the impact of formal and constructive changes (untimely and defective data) for the AN/BSY-1 design, retractable bow planes, and the placements of lead ballast. The Navy awarded Electric Boat a $82.4 million cost adjustment, including about $27 million for delivery delays. (See table 2.3 for cost and delivery information for specific submarines.)

Table 2.3: Costs and Schedule Delays Due to SUBACS Basic Redesign

Dollars in millions

SSN	Total adjustment	Adjustment for delay	Contract date	Revised date	Delay months
751	$35.3	$6.1	Nov. 1987[a]	June 1988[b]	7
752	20.5	5.5	Mar. 1988[a]	Jan. 1989[b]	10
754	12.9	6.3	July 1988	Sept. 1989[b]	14
755	8 9	6.1	Dec 1988	May 1990	17
757	4.8	3.0	June 1989	July 1991	25
Total	**$82.4**	**$27.0**			

[a]Because the Navy accelerated the delivery dates for the SSN-751 and SSN-752, we used this date rather than the contract delivery date to determine the schedule variance

[b]Submarine was delivered on this date.

According to a Navy official, the total $82.4 million adjustment, with the exception of $650,000,[5] was exclusively for AN/BSY-1 design changes and delivery delays. As a result of changing the AN/BSY-1 program and a labor strike,[6] Electric Boat will deliver five submarines to the Navy an average of about 14 months late. In addition, Newport News has submitted a similar request for its first nine submarines.

As of June 1989, Newport News had submitted three of eight increments to its request for equitable adjustment. These three increments represent an increase to the ceiling price[7] of about $198 million, including about $150 million for AN/BSY-1 design changes. It will deliver its first four submarines an average of 25 months late.

[5]The $650,000 is for material for the retractable bow planes. The bow planes resulted in no delay.

[6]In June 1988 Electric Boat shipyard workers went on strike over wage increases An agreement was reached in October 1988; a phased comeback of employees was initiated and continued through December 1988. As an aftermath of the strike, Electric Boat was unable to rehire sufficient qualified workers.

[7]The contract ceiling is the total dollar amount for which the government is liable.

Conclusions

In an attempt to resolve cost, schedule, and performance problems experienced with SUBACS Basic, the Navy established the AN/BSY-1 combat system program. However, ambitious program objectives and schedules also have caused problems within the AN/BSY-1 program. AN/BSY-1 has experienced significant increases in total program costs and system design problems. In addition, because the time to correct all AN/BSY-1 design and development problems was insufficient, the AN/BSY-1 became the major contributor to delays in the improved SSN-688 construction program. This resulted in increased SSN-688 submarine costs and delayed the introduction of new and fully mission capable submarines into the fleet. These construction delays, in turn, caused a rippling effect on AN/BSY-1 schedules.

To meet the improved SSN-688 construction schedule, the Navy accepted delivery of the first four systems without full performance capabilities. These four systems are to be upgraded to full performance during each ship's PSA. However, since PSA cannot occur until after the improved SSN-688 construction is completed, only the SSN-751's system has been upgraded to full performance.

The Navy has accepted three AN/BSY-1-equipped improved SSN-688s. However, with the exception of the SSN-751, these submarines have only limited performance capabilities and cannot accomplish their mission of conducting prompt and sustained operations at sea until the systems are upgraded during PSA. In addition, because PSA for the first AN/BSY-1-equipped submarine was only recently completed, a fully compliant AN/BSY-1 has not been field tested under realistic, at sea conditions. Nevertheless, AN/BSY-1 assessments indicate the systems have the potential to improve performance significantly and to be operationally effective and suitable. However, it is not known how much improvement the AN/BSY-1 will achieve over existing systems or if operational thresholds will be obtained until the tests are conducted.

Agency Comments

DOD generally agreed with the facts on the AN/BSY-1 system as presented. It partially agreed with our statement that AN/BSY-1 design problems led to submarine construction delays and cost increases. It stated that other ship design changes also contributed to schedule delays and cost increases. However, during subsequent discussions, DOD officials agreed that AN/BSY-1 design changes were the major contributor to ship construction delays and cost increases.

Early AN/BSY-2 Combat System Problems Could Increase Costs and Delay SSN-21 Delivery

The successful development of a fully capable AN/BSY-2 combat system is critical to the SSN-21 achieving its mission requirements. Dedicated to the SSN-21, the Navy has no backup combat system planned should the AN/BSY-2 be unavailable when needed. The AN/BSY-1 cannot be substituted because its configuration does not permit its installation on the SSN-21 without modifying the ship design and the combat system hardware and software. The AN/BSY-2 is intended to take advantage of significant noise reductions expected of the SSN-21; however, if the SSN-21 does not meet its noise quieting requirements, the AN/BSY-2 will be less effective.

The AN/BSY-2 development program is in the first year of full-scale development and indications are that ambitious goals and development schedules may cause problems. Total program costs have decreased, from an estimated $16 billion to about $14 billion, but the program has experienced some schedule slippage and performance problems. Further schedule slippage and performance problems are possible and the potential also exists for costs to increase. The greatest risk is the development of AN/BSY-2 software. An analysis of combat system program features shows many similarities between the AN/BSY-2 and its predecessors—SUBACS and AN/BSY-1. Problems or delays in the development and production of the AN/BSY-2 could affect the SSN-21 program.

Program Cost

Estimated life-cycle costs for 29 AN/BSY-2 systems have decreased. As shown in table 3.1, total life-cycle costs decreased from about $15.6 billion to about $13.9 billion because the Navy eliminated one shore facility from which SSN-21s were to be deployed. As a result, the resources (personnel, equipment, training, spares, etc.) committed for the facility over the program's life span are no longer required.

Table 3.1: Estimated Life-Cycle Costs for AN/BSY-2 Systems

Dollars in millions

Phase	May 1986	June 1989[a]	Difference
Development	$1,596	$1,737	$141
Procurement	5,698	5,711	13
Operation and Support	8,291	6,542	−1,749
Total	**$15,585**	**$13,990**	**$−1,595**

[a] These are preliminary cost estimates not yet approved by DOD

Program Schedule

The AN/BSY-2 program's ambitious development schedule is beginning to slip, and the Navy has no backup system planned for use in the SSN-21 should the AN/BSY-2 not be available when needed. The Navy states that a backup combat system is not required because the AN/BSY-2 hardware and software are being designed to be built and written modularly. The Navy expects the software to be delivered incrementally, with final delivery taking place before technical and operational testing. Should software delays happen, the Navy believes that the modular development and the incremental delivery approaches will give the system and the SSN-21 basic warfighting capabilities while problems are resolved.

To meet the SSN-21 construction schedule and to reduce the software development risk, the Navy plans to have AN/BSY-2 performance capabilities for the first SSN-21 delivered in two phases. During the first phase, all hardware and most software are to be provided to the shipbuilder in November 1993. During the second phase, the remaining software is to be delivered to the Navy in November 1994. The Navy will continue to evaluate installation plans to incorporate this software at the earliest feasible date consistent with the ship's schedule but before completion of PSA, tentatively scheduled during fiscal year 1996. However, the AN/BSY-2 program is behind its development milestones and schedules. As a result, two critical Navy system design reviews have been delayed. In addition, late subcontractor deliveries have caused some critical item testing to be delayed. Unless these problems are resolved, AN/BSY-2 delivery schedule could be adversely affected.

Navy Program Assessments Show Concern About Schedule Delays

Navy program assessments express concern regarding AN/BSY-2 schedule delays. Between March 1988 and November 1989, the AN/BSY-2 development program had fallen 3 months behind schedule. Several factors contributed to the delay, including initial understaffing, late and incomplete changes in system requirements, changes in acoustic and weapons designs, and the need to perform additional wide aperture array testing. A June 1989 Navy assessment also shows understaffing continues to be a serious problem. According to the assessment, General Electric's overall staffing level, except at one subcontractor location, is considered seriously short of planned levels in certain hardware and software critical skill areas, which could seriously affect future costs and schedule.

A March 1989 assessment indicates that because of the amount of work required, the lack of sufficient available resources, and the current

schedule, architecture[1] development was considered a high risk area. The assessment also indicates that history with other programs shows that early schedule problems become future cost growth and the AN/BSY-2 program is no different.

Critical Design Reviews Delayed

Two important Navy design reviews that will determine the extent to which General Electric's design meets system specification requirements have been delayed. The first is a preliminary design review to assess the Company's hardware and software design approach. The second is a critical design review to assess whether detailed design specifications meet performance requirements before producing hardware and writing software.

In March 1989 the Navy and General Electric agreed to delay the completion of the preliminary design review from April 1989 to October 1989 and the critical design review from August 1989 to January 1990. Delaying these reviews will result in compressing the hardware and software development for at least 5 months to meet the unchanged system integration test schedule. In addition, the Navy's February 1989 program assessment indicates that delays in completing the preliminary design review could prevent the ship design agent from receiving updated AN/BSY-2 data in a timely manner. Further delays will only exacerbate the problem.

According to an AN/BSY-2 program official, two factors contributed to the delays. One, General Electric's contract was awarded later than planned. Two, system specifications and designs were not detailed enough for the Navy to conduct the reviews on schedule. This occurred because General Electric needed more time to establish a firm system design before preparing detailed specifications and writing software. According to the official, the additional time should result in a better system design baseline and less problems as the system progresses through development and testing. The official also believes these schedule delays will not adversely affect the planned delivery of the first system. However, a June 1989 program review shows that General Electric's performance to meet the critical design review has not improved, bringing into question the Navy's ability to complete this review by January 1990.

[1] According to the Navy, system architecture is the structural framework for all hardware and software components that are combined and integrated to implement the total system's functions.

According to DOD, the action taken concerning the design review delays will result in both cost and schedule savings and has not affected the scheduled delivery of the systems to the Navy. The preliminary design review, rescheduled to October 1989, was completed on schedule, and all required contractual documents were provided.

Whether the actions taken will provide the Navy with cost and schedule savings, with no affect on delivery schedules, will not be known for sometime. However, the 5-month delay in conducting the reviews is a fact and results in 5 months less time to correct any system design deficiencies. Because of the tight time frame, little flexibility is provided to deal with developmental problems. Therefore, we continue to believe that compressing AN/BSY-2 hardware and software development for 5 months makes it difficult to achieve the overall schedule and that the potential exist for delays in the scheduled delivery of the systems to the Navy.

Some Critical Item Testing Delayed

During the system design definition phase of the development program, according to the Navy, General Electric and the Navy identified several critical system items that could present significant cost, schedule, or performance risks during full-scale development. To mitigate these risks early and allow contingency plans or approaches to be developed in time to ensure that the overall development program would be successfully implemented, General Electric developed a critical item demonstration test schedule. However, Navy program assessments show that some critical item tests have been delayed. Should problems occur when these tests are conducted, additional time will be needed to correct and retest the items.

One subcontractor's inability to deliver a cathode ray tube for AN/BSY-2 display consoles and another's lag in designing the console hardware have resulted in delaying a critical shock test of this tube from December 1988 to August 1989. In another instance, critical item tests to demonstrate system response times for the database management system, operator display consoles, and submarine switch network[2] have been delayed from October 1990 to March 1991. General Electric had planned to perform demonstration tests on prototype hardware and then on tactical hardware. Now such tests will be conducted only on tactical hardware. The assessment indicates that, although the tests

[2]The submarine switch network transfers data between various computers and links all functional processors for the workstations, supervisory displays and combat control.

have been delayed, contingency plans to mitigate risks have not been submitted.

Subcontractors Not Under Contract

As of September 1, 1989, General Electric had not awarded final contracts for the development and limited production phase of the program to two subcontractors—International Business Machines and Librascope Corporation—that have important roles in developing hardware and software and assuring that the first system is delivered as planned. The central issue between General Electric and the subcontractors is determination of a mutually agreeable contract price. It is important that final contracts be awarded as soon as possible after the beginning of the development phase to ensure that subcontractors "buy into" work they are responsible for performing and that a viable, overall system test schedule is developed.

The International Business Machines is to perform work amounting to about 15 percent of the total value of General Electric's contract. This work will include developing and producing a wide aperture array, a land-based engineering system, and other related AN/BSY-2 components. Also, General Electric will qualify International Business Machines as a competitor for fiscal year 1992 production systems. Librascope is to develop and produce the weapons launch group and the operator display consoles. These subcontractors were performing work under sustaining engineering or letter contracts.

According to the Navy, delays in awarding these subcontracts have raised questions as to the subcontractors' commitment to the overall development and testing program, introduced potential delays for testing and delivering critical hardware and software, and decreased confidence in the validity of the current test schedule. For example, a June 1989 Navy program review indicated that the absence of a contract with Librascope was posing a great risk in the completion of a General Electric system integration test. In the long term, delays in awarding International Business Machines a contract may affect not only the leader/follower acquisition strategy but also its ability to be a qualified competitor for the fiscal year 1992 production systems.

According to DOD, slowness in subcontract definitization added to program risk. However, General Electric's full-scale development contract with Librascope was definitized on October 6, 1989. Although the subcontract with International Business Machines is not definitized, General Electric and International Business Machines have agreed on both scope

and price. As of December 31, 1989, the contract had not been signed. The Navy states that no subcontractor design efforts are being delayed and all are being performed to the correct baseline.

Combat System and SSN-21 Schedules Conflict

Conflicts with the AN/BSY-2 and the SSN-21 design schedule have resulted in additional costs to the SSN-21 construction program. To ensure that the submarines' design and subsequent construction will accommodate the AN/BSY-2, the ship designer (Newport News) needs system configuration data and information before construction begins. The Navy has taken actions to assure that the ship designer is aware of system changes and has provided General Electric data to reflect those changes. However, General Electric did not provide the ship designer with combat system data in a timely manner nor has it provided final design data. As a result, portions of the submarines had to be redesigned to accommodate late combat system data, increasing SSN-21 design cost an estimated $5 million. If final AN/BSY-2 design data result in further changes to the SSN-21 design, additional costs and delays could occur.

In June 1988 General Electric provided the ship designer with preliminary combat system design data that resulted in design changes to the submarine's interior. The ship designer estimated that this would increase submarine design costs by $3.4 million. Subsequently, General Electric, among other actions, changed the AN/BSY-2 design by replacing a Navy standard computer with a commercially available processor. The Navy Supervisor of Shipbuilding, Conversion and Repair, Newport News, estimates that the redesign will cost an additional $1.6 million.

The changes and data provided do not fully represent the final AN/BSY-2 design. A General Electric official stated that the ship designer was urging General Electric to provide it with final AN/BSY-2 space and weight requirements to ensure the submarine design is compatible with the system. However, General Electric will not be able to provide all final ship design data and information until the Navy completes its critical design review in January 1990.

DOD, in its comments on this report, stated that attributing the estimated $5 million increase in SSN-21 design cost to late delivery of combat system design data reflects a misunderstanding of the sequence of events. Before the AN/BSY-2 contract was awarded, the ship design agent was provided with a "notional" system baseline, which was the Navy's best estimate of the system configuration prior to having a definitized contract. After contract award, the winner's system baseline was disclosed

to the agent. According to DOD, the fact that the cost of this change was less than $5 million illustrates the accuracy of the Navy's initial estimates.

DOD also stated that although AN/BSY-2 design changes have affected the ship's design, many AN/BSY-2 changes have been made to accommodate the ship design agent's requests. Potential changes in both ship and combat system designs continue to be discussed and evaluated in open forums as to impact, necessity, and desirability among all affected parties.

An AN/BSY-2 program official stated that because of the standard risks of concurrent development efforts, changes to the AN/BSY-2 design resulting from the Navy's design review could increase the submarine's cost and delay submarine delivery. Thus, the Navy has taken precautionary measures, even though significant changes are not expected. For example, the Navy and the ship designer have biweekly meetings to address combat system issues and concerns. Also, the ship designer has been provided current AN/BSY-2 changes and has prioritized the data it needs from General Electric, and General Electric has scheduled its work to meet the ship designer's needs.

According to DOD, concurrent development programs for the ship and the combat system pose risks for both contractors and the Navy's program offices; these risks have been mitigated to the maximum possible extent by the close coordination of the contractors and the Navy program offices. These risks were well understood from the Seawolf program inception. The Navy has provided a continuous stream of data to the agent and has prioritized the generation of design data to accommodate the agent's needs. According to DOD, as of November 21, 1989, no unresolved interface issues between the ship and combat system designs existed.

First AN/BSY-2 Will Not Be Delivered With Full Performance

The first AN/BSY-2 will not be fully capable or meet mission capabilities when delivered to the shipbuilder in November 1993. According to a General Electric official, General Electric is unable to develop, test, produce, and deliver a fully capable system in time for the first delivery. Therefore, in November 1987 General Electric proposed—and the Navy agreed—that the first AN/BSY-2 would be delivered to the shipbuilder in November 1993 complete with hardware but not all software. An AN/BSY-2 program official stated that software would be delivered in two phases to mitigate software development schedule risks. The official

stated that delivering all software in November 1993 would have significantly increased software development risks and General Electric's contract price.

During the first phase, General Electric plans to deliver about 2.7 million lines of the required software (about 86 percent) in November 1993. According to an OPTEVFOR official, the planned capabilities to be delivered at that time will be sufficient to meet the expected threat. The second phase, which includes the remaining 426,000 lines of software (14 percent), will primarily add acoustic functions. This software is to be provided to the Navy in November 1994, before technical evaluation begins in July 1995.

The extent to which system performance capabilities will be delivered depends on the nature and the seriousness of problems General Electric encounters as the program progresses through development and testing. Although it is too early in AN/BSY-2 development to determine how the AN/BSY-2 will function under realistic operational conditions, software development risks could jeopardize performance capabilities.

In its comments on this report, DOD stated the decision to install the final portion of software on the system after ship delivery is a factor of ship construction, integration and testing schedules, and system availability. As both the ship and the combat system are being developed, the Navy will continue to evaluate the installation schedule of the final portion of software.

Technical Performance Development Problems

The Navy is developing a new computer, the enhanced modular signal processor, for the AN/BSY-2 combat system. The original model selected (SIM B) had problems meeting its monitoring and fault localization and AN/BSY-2 initial program loading requirements. In addition, the estimated cost of providing the model increased $65 million because several planned users switched to another model (SIM E). In June 1989 the Secretary of the Navy approved the SIM E model for the AN/BSY-2 program. Program officials expect the conversion to occur by fiscal year 1992. Because the SIM E model will be more widely used, the Navy believes the cost will be reduced and savings will occur over the program's life. However, there will be nonrecurring and replacement costs. In November 1989 the Navy estimated it would cost about $50 million to modify the SIM E model to meet AN/BSY-2 requirements and $52 million to retrofit three SSN-21s, one maintenance trainer, and one land-based engineering system with the SIM E model.

General Electric also is experiencing other system architecture problems. The Navy requires all key AN/BSY-2 components to have redundant capabilities. However, redundant capabilities do not exist for the system receiver and beamformer cabinets. Also, General Electric is resolving a technical problem that could result in a significant loss of display data and make target detection nearly impossible over a large area.

Software Development Risks

Under the AN/BSY-2 program, the Navy will be significantly challenged to meet performance requirements within tight time frames and budgets. For example, our March 1989 report[1] on the combat system identified several areas where the Navy's early and continued management attention is desirable if it is to meet this challenge. Among them are the Navy's ability to maintain the software development schedule due to massive software requirements and its use of Ada computer language.

The AN/BSY-2 requires designing, developing, and testing about 2.8 million lines of new tactical software, the largest new computer software development effort ever undertaken for a submarine combat system. During system design definition, it appeared that this system would retain a significant amount of software from previous systems that, according to a technical direction agent official, would have greatly reduced risks associated with this effort. However, recent software estimates show that none will be retained from prior systems and that about 83 percent, or 2.3 million lines, of the AN/BSY-2 new design software will be accomplished using Ada language. Although DOD believes Ada has matured and over 100 DOD programs either use or plan to use Ada, our recent report[2] shows that most experts agree that the Ada language had not yet matured.

The Navy's June 1989 AN/BSY-2 program review document shows the shortage of Ada qualified (experienced) personnel in software was particularly a serious concern. Staffing, in certain functional areas, was 93 percent below the software plan for May 1989. Additionally, it shows General Electric's ability to recruit qualified Ada personnel could severely affect both cost and schedule should General Electric have to contract out portions of its tasks. The AN/BSY-2 contractor's software

[1]Submarine Combat System: Technical Challenges Confronting Navy's Seawolf AN/BSY-2 Development, (GAO/IMTEC-89-35, Mar. 13, 1989).

[2]Computer Language Standardization: Status, Costs, and Issues Associated With Defense's Implementation of Ada (GAO/IMTEC-89-9, Mar. 24, 1989).

development plan estimates that up to 900 software personnel will be required to develop and integrate all software.

According to DOD, whether retaining software from prior systems decreases or increases risk is a matter of opinion and depends on many technical factors: architecture/partitioning, depth and quality of documents, interface definition, standards and conventions used, and language and operating system compatibility.

Similarities Between Submarine Combat System Programs

The Navy, on the basis of problems with the SUBACS and AN/BSY-1 combat system programs, has adjusted its strategy for the AN/BSY-2. These measures include establishing a 2-year system definition phase, developing and testing software as separate modules called partitioning, and procuring and providing General Electric with hardware early enough to allow an additional year of development and testing within the overall schedule. Many similarities, however, still exist between the AN/BSY-2 program and its predecessors, SUBACS and AN/BSY-1 programs, that indicate the program could encounter future problems. An analysis of various program features (see app. I) shows similarities exist between schedules, software developments, concurrency, combat system capabilities, and at sea testing. Of particular concern is the similarities in program schedule and software development features.

To meet the SSN-21 lead ship construction schedule, the Navy established ambitious development objectives and schedules for the AN/BSY-2 program. Initially, the first AN/BSY-2 system delivered was to be fully capable; however, to maintain the required delivery schedule, the Navy is having it delivered in phases. Other schedule delays—overall, the program is 3 months behind and two important system design reviews have been delayed 5 months—have surfaced that indicate the potential for further slippages. Essentially, the same events (ambitious schedules and phased delivery) were experienced within the SUBACS and AN/BSY-1 programs.

The AN/BSY-2 system requires twice as much new tactical software as the AN/BSY-1 system required. To attempt to design, develop, test, and integrate 2.8 million lines of new software, including 2.3 million lines written in Ada language, without adequately trained, experienced programmers could affect the development schedule. Because of the software volume and the ambitious schedules, AN/BSY-2 software development will lag behind the hardware development and will be delivered in phases. Final software installation is planned to take place

in January 1995, more than 13 months after the hardware is scheduled to be delivered. AN/BSY-1 program software development, although not written in the Ada language, also lagged behind the hardware development. As a result, the first four systems were delivered without a full software package.

In its comments on this report, DOD stated the lessons learned in developing earlier combat control and acoustics systems, including AN/BSY-1, were incorporated into the planning for the AN/BSY-2 development effort. It is the first submarine system, for instance, to use the software development requirement of DOD-STD-2167. This, combined with (1) the longer development time for AN/BSY-2, (2) the benefits derived from the two-contractor, 2- year system design definition phase, and (3) the intensive early oversight, should allow AN/BSY-2 to profit from the similarities to earlier programs. In addition, the AN/BSY-2 phased software delivery is different from the AN/BSY-1's in that the AN/BSY-2's approach was taken before award of the development contract rather than as a mid-development mitigation plan.

DOD further stated that, although more new code development is required for AN/BSY-2, the integration job will be easier since all code is written to the same standards, conventions and style guides; code partitioning was done from scratch; computer software configuration item interfaces were defined before detailed design; and code is written in the same language, developed with a common tool set and written for the same operating system.

Also, DOD believes that on the basis of the training programs in use at General Electric and its subcontractors and the nature of the standards, tools, conventions and guides being used in the program, AN/BSY-2 software programmers will be adequately trained.

Conclusions

The AN/BSY-2 combat system program, like its predecessor SUBACS and AN/BSY-1 programs, must meet ambitious objectives and schedules in order to meet the needs of the SSN-21 lead ship construction schedule. Critical to the SSN-21 meeting its performance goals and missions requirements, the AN/BSY-2 program has little flexibility for delays.

In developing the AN/BSY-2 combat system, the Navy took measures to mitigate the problems encountered within the SUBACS and AN/BSY-1 programs. Despite these measures, the AN/BSY-2 program is experiencing technical and performance problems and is behind schedule, and the

potential exists for program cost increases and further schedule slippages. In the software development and testing areas, the Navy needs to take additional steps to maximize the possibility of delivering the first system as planned and without jeopardizing the cost, schedule, and performance of the SSN-21 program. The Navy's attempt to design, develop, test, and integrate the large amount of new tactical software in the Ada language without adequately trained and experienced programmers could severely affect program cost and schedule. Moreover, two important system design reviews, which will establish the system's final configuration, have been delayed at least 5 months, and could affect program cost and schedule. This delay could prevent General Electric from providing the ship designer with final AN/BSY-2 design data. Should further changes be required, the SSN-21 program's cost could increase and its schedule could incur delays.

Agency Comments

DOD partially agreed with the facts presented on the AN/BSY-2 combat system program. In those instances where DOD partially agreed with our presentation or provided further clarification, we modified the report accordingly.

DOD stated that although some critical item tests have been delayed, many have been satisfactorily completed. The wide aperture array successfully passed its flow noise test in July 1989, the beamformer chip met requirements with significant margin on the first pass, the cathode ray tube successfully completed both shock and magnetic susceptibility tests in August 1989, and the database manager and executive were successfully ported to switchnet, meeting all timing requirements.

We note, however, that the tests conducted were not as comprehensive as the scheduled critical item tests and did not include all hardware. For example, the tests did not include operator display consoles that were to have been a part of the original August 1989 tests.

Comparison of Past and Present Combat System Program Features

Program features	SUBACS Basic and AN/BSY-1	AN/BSY-2
Cost cap	Set under AN/BSY-1 after cost, schedule, and performance problems surfaced	Set before full-scale engineering development and limited production
Development objectives and schedules	Ambitious development objectives and schedules established to meet ship construction schedule. Insufficient time to address problems and deliver fully tested and fully capable systems.	Ambitious development objectives and schedules to meet SSN-21 construction schedule Insufficient time to deliver fully tested and capable system
Software intensiveness	Originally required 1.4 million lines of new software	Requires 2 8 million lines of new tactical software In addition, most new software written in Ada programming language
Concurrency	Program delivery schedule required five systems to be developed and produced concurrently	Program delivery schedule requires three systems be developed and produced concurrently
Combat capabilities	Software and hardware not fully developed when four systems were delivered to shipbuilder. First system was to be fully capable about 17 months after the submarine was delivered to Navy.	Not all software to be developed and tested when first system delivered to shipbuilder First system to be fully capable within 2 months after submarine delivered to Navy
At sea testing	Limited testing before 14 production combat systems were to be delivered.	Limited testing to be completed before two production systems are to be delivered
Management	Sufficient visibility and management authority. Navy report, however, identified several program management weaknesses.	Sufficient visibility to witness and observe development and testing No authority under fixed-priced incentive contract to direct changes to ensure goals are met unless the contract is modified. This could potentially increase cost and delay the schedule
Oversight	Program manager was responsible for informing the Navy, DOD, and the Congress of program goals and problems	Program manager primarily responsible for informing the Navy and the Congress of program goals and problems DOD to review program status annually, with emphasis on software development.

Comments From the Department of Defense

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING

WASHINGTON, DC 20301-3010

2 [illegible] 1989

Mr. Frank Conahan
Assistant Comptroller General, National Security
and International Affairs Division
U.S. General Accounting Office
Washington, DC 20548

Dear Mr. Conahan:

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) draft report, "NAVY ACQUISITION: Progress and Problems in Implementing Navy Submarine Combat System Programs," dated October 2, 1989 (GAO Code 394236/OSD Case 8135). The DoD generally concurs with most of the report findings.

The detailed DoD comments on the report findings are provided in the enclosure. The opportunity to comment on the draft report is appreciated.

Sincerely,

Robert C. Duncan

Enclosure

GAO DRAFT REPORT - DATED OCTOBER 2, 1989

(GAO CODE 394236) OSD CASE 8135

"NAVY ACQUISITION: PROGRESS AND PROBLEMS IN IMPLEMENTING NAVY SUBMARINE COMBAT SYSTEM PROGRAMS"

DOD RESPONSE TO THE GAO DRAFT REPORT

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FINDINGS

- **FINDING A**: **Background**: **Improved Combat Systems**. The GAO reported that, to enhance the performance and ensure the continued superiority of U.S. nuclear submarines, the Navy will equip both the Los Angeles class (SSN-688) and the new Seawolf class (SSN-21) nuclear attack submarines with new and improved combat systems--the AN/BSY-1 and AN/BSY-2, respectively. The GAO explained that these systems are designed to reduce the time between detecting a target and launching weapons. The GAO observed that advanced submarine combat development began in 1980 with the Submarine Advanced Combat System (SUBACS) program. The GAO noted that, initially, this was to be a single-phase program to upgrade improved nuclear attack submarines authorized in FY 1989 and beyond. The GAO reported , however, that in October 1983 the Secretary of Defense approved a three-phased plan (SUBACS Basic, SUBACS A and SUBACS B) for the SSN-688s authorized in FY 1983 and beyond--six years earlier than originally planned. The GAO also reported that a modified SUBACS B system was to serve as the baseline for the SSN-21 combat system. The GAO found that, in 1985, because of program cost, schedule and technical problems, the Navy restructured SUBACS into two separate development efforts--the AN/BSY-1 and AN/BSY-2.

  The GAO reported that the SUBACS Basic contract was renegotiated to establish AN/BSY-1 requirements. The GAO found that, because there was insufficient time to correct all design and development problems and meet the improved SSN-688 construction schedule--two versions of the AN/BSY-1 combat system have been delivered. The GAO noted that the first version (the preliminary product baseline system) was installed on SSN-751 through SSN-754--providing those four submarines with limited self-defense capabilities necessary to operate until the systems are upgraded to include offensive capabilities. The GAO found that

Now on pp 8-11

the second version will be installed on the remaining 20 SSN-688s--starting with SSN-755.

Finally, the GAO reported that the Navy combined SUBACS A and SUBACS B performance requirements and renamed this effort the AN/BSY-2, which is currently in full-scale development and is to be installed on 29 new SSN-21s. (pp. 7-13/GAO Draft Report)

- **DoD RESPONSE**: Concur.

- **FINDING B**: **AN/BSY-1 Cost Increases and Schedule Delays**. The GAO reported that, between February 1986 and November 1988, the AN/BSY-1 life cycle cost estimate more than doubled--from about $5.4 billion to $12.1 billion. The GAO noted that the substantial increase (shown in table 2.1) is attributed to a revised cost estimating model that corrected assumptions on operating and support costs.

  The GAO also reported that the program has experienced schedule delays. The GAO compared original and revised AN/BSY-1 delivery dates for initial and full capabilities. The GAO noted that, according to a Navy official, the current dates for full capabilities are still tentative and further delays may occur. The GAO found that, while four systems have been installed, upgrades will be delivered--on average--19 months later than originally scheduled. The GAO observed, however, the Navy nevertheless maintains that the upgrades will be delivered in time for each submarine's post shakedown availability. The GAO further observed the Navy also takes the position that the delivery of the remaining systems (including one already delivered) will not be a problem. The GAO concluded that ambitious program objectives and schedules have caused problems with the AN/BSY-1 program. The GAO further concluded that the SSN-688 combat system problems affect the readiness of some submarines. (pp. 14-17, P. 25-26/GAO Draft Report)

Now on pp 12-14 and 17-18

- **DoD RESPONSE**: Concur. It should be noted that each of the five systems delivered to date has met shipyard construction schedules. The two system upgrades delivered to date (for SSN 751 and SSN 752) were delivered on time. The research, development, test and evaluation costs have not changed. Only the production costs increased to reflect an increase in the number of systems. Overall, cost growth was basically a result of changes in assumption of ship's operating years.

- **FINDING C**: **AN/BSY-1 Performance**. The GAO reported that, until the first four systems already delivered are upgraded, the improved SSN-688s will not be able to accomplish their expanded

mission or to counter the evolving threat. The GAO noted that, according to Navy officials, these submarines normally would not be operated outside U.S. waters. The GAO found that, in June 1988, the Navy's Board of Inspection and Surveys conducted an underway acceptance sea trial of the first AN/BSY-1-equipped submarine, and listed 20 significant deficiencies (most involving the AN/BSY-1) that degraded the submarine's ability to perform its missions. The GAO noted that, although the Board recommended a retrial after the system upgrades are installed, a Chief of Naval Operations official stated that a retrial will not be necessary because the Navy will rely on operational and technical evaluation results to determine the submarine's suitability for deployment. (pp. 17-19, pp. 25-26/GAO Draft Report)

Now on pp 14-17

- **DoD RESPONSE**: Concur. The President, Board of Inspection and Survey, in a letter dated October 11, 1989, stated that a retrial of the first AN/BSY-1 equipped submarine is not required. (Note: All deficiencies attributable to AN/BSY-1 program noted by the Navy's Board of Inspection and Surveys have been corrected.)

- **FINDING D**: **Operational Testing Not Conducted on AN/BSY-1**. The GAO reported that, despite the fact Federal and DoD regulations require that a major defense acquisition program undergo operational testing on a production representative system before going beyond low-rate production--a fully compliant AN/BSY-1 has not been operationally tested under realistic, at-sea, conditions. The GAO did note that the Naval Underwater Systems Center conducted a comparative analysis that showed the AN/BSY-1 has the potential to provide significantly improved effectiveness over its predecessor systems. The GAO also noted that in, September 1987, the Commander, Naval Operational Test and Evaluation Force, provided observations on the system and recommended continuing development--but at the same time cautioned on the lack of suitable data for projecting the system's potential effectiveness and suitability. The GAO further noted that, in August 1989, the Naval Operational Test and Evaluation Force assessed a land-based computer simulation of the AN/BSY-1--but again cautioned that the testing scope was limited. The GAO reported that the Naval Operational Test and Evaluation Force stated that, within the described constraints, the system had the potential to be operationally effective and suitable. The GAO observed that, although no major deficiencies were noted in most areas, additional testing is nonetheless required to resolve critical operational issues and to complete the evaluation--due to the land-based test facility limitations and to the limitations in the testing scope.

The GAO found that a fully compliant AN/BSY-1 system will not be available for actual at-sea operational testing until November 1989, when the SSN-751 completes post shakedown availability. The GAO observed that the Navy plans to start technical and operational testing in March and August 1990, respectively. The GAO reported that, according to Navy officials, the delay in testing is due to (1) the limited number of systems being procured, (2) the concurrent system production, and (3) the program schedule. The GAO concluded that, by the time operational testing is completed and the results are reported, all 23 systems will be under contract and several additional systems delivered. The GAO observed that those problems identified during testing will have to be corrected on systems already delivered. The GAO also observed that, once post shakedown availability is completed, the Navy will have to pay to correct any existing technical problems on the systems--if the warranties have expired. The GAO also noted that the next Defense Acquisition Board review of the AN/BSY-1 is the FY 1991 full production review, but because all systems will be under contract the DoD is considering eliminating this review. The GAO concluded that it will not be known how much improvement the AN/BSY-1 will achieve over existing systems or if operational thresholds will be obtained until the tests are conducted. (pp. 18-22, p. 26/GAO Draft Report)

Now on pp 15-17 and 19

- **DoD RESPONSE**: Concur. A land based assessment was accomplished. The preliminary assessment had generally favorable results.

  The Acquisition Strategy of concurrent development and low level production included the provision for the Commander, Operational Test and Evaluation Force, periodically to assess the AN/BSY-1 capabilities. These assessments occurred in 1988 and 1989, with the conclusion that the system is potentially operationally effective and operationally suitable for its mission. The final assessment of operational effectiveness and suitability will occur with Technical and Operational Evaluation. The start of Technical and Operational Evaluation is contingent on the SSN 751 post-Post Shakedown Availability schedule.

- **FINDING E: Conflicting AN/BSY-1 and Submarine Schedules Increase Risks**. The GAO reported that, when SUBACS Basic was changed to AN/BSY-1, nine submarines were under construction. The GAO found that, with the approval of the AN/BSY-1 design, portions of the improved SSN-688s had to be redesigned to accommodate the AN/BSY-1 and the Navy was required to provide various design and configuration data to the ship design agent in time to meet the ship construction schedules. The GAO noted

that, on several occasions between September and October 1986, due to non-receipt of sufficient ship design data from the ship design agent (Newport News Shipbuilding), the Electric Boat Company alerted the Navy that late or faulty AN/BSY-1 design data were affecting the construction schedule. The GAO also noted that, on July 17, 1987, the Electric Boat Company submitted a request for equitable adjustment in the amount of $97.1 million and, subsequently, the Navy awarded the company a $84.4 million cost adjustment. (The GAO listed these costs and the related schedule delays in table 2.3.) The GAO also reported that Newport News Shipbuilding has submitted a similar request for its first nine submarines. The GAO noted that the first three of eight increments of this request include about $150 million for AN/BSY-1 design changes. The GAO concluded that the amount of time required to revise the SUBACS design, produce AN/BSY-1 ship design data, and develop changes to ship construction/installation drawings was insufficient to support the shipbuilder's construction schedule. This resulted in increased SSN-688 submarine costs associated with incorporating corrective ship design efforts. Further the GAO noted that even though the phased approach minimized the length of time operational capability was lost in the early improved SSN-688's (SSNs 751-754), the delay in delivery of fully capable submarine resulted from restructuring SUBACS. The GAO further concluded that the construction delays have caused a rippling effect with new construction SSN-688I schedules. (pp. 22-25/GAO Draft Report)

Now on pp 17-19

- **DoD RESPONSE**: Partially concur. A number of submarine design changes, including those attributable to AN/BSY-1, resulted in the request for equitable adjustment.

- **FINDING F: AN/BSY-2 Cost and Schedule**. The GAO reported that the successful development of a fully capable AN/BSY-2 combat system is critical to the SSN-21 achieving its mission requirements, as the Navy has no backup combat system planned. The GAO noted that the Navy maintains that a backup combat system is not required because the AN/BSY-2 hardware and software were being designed to be built and written modularly.

  The GAO reported that the AN/BSY-2 system development program is in the first year of full-scale development and indications are that the ambitious goals and development schedule may cause problems. The GAO noted that (as shown in table 3.1) total life cycle cost decreased from about $15.6 billion to a preliminary cost estimate of about $13.9 billion, because the Navy eliminated one shore facility from which the SSN-21s were to be deployed. The GAO also noted that, to meet the SSN-21 construction schedule and to reduce the software development risk, the

Navy plans to have AN/BSY-2 performance capabilities for the first SSN-21 delivered in two phases--(1) during the first phase, all hardware and most software are to be provided to the shipbuilder in November 1993, and (2) during the second phase, the remaining software is to be installed within 2 months after the submarine is delivered to the Navy in May 1995.

-**Schedule Slippage**. The GAO also reported that, between March 1988 and March 1989, the AN/BSY-2 development program has fallen three months behind schedule. The GAO observed that, according to a Navy assessment one of the causative factors--understaffing--continues to be a serious problem except at one contractor location. The GAO also noted other areas of concern identified by the Navy--such as architecture development and early program schedule slippage .

-**Design Reviews Delayed**. The GAO reported that, in addition, two important Navy design reviews have been delayed--reviews designed to determine the extent to which the contractor meets system specifications. The GAO found that, in March 1989, the Navy and the contractor agreed to delay the completion of the preliminary design review from April to October 1989, and the critical design review from August 1989 to January 1990. The GAO noted that, according to an AN/BSY-2 program official, two factors contributed to the delays--(1) the prime contract was awarded later than planned and (2) the system specifications and designs were not detailed enough for the Navy to conduct the reviews on schedule. The GAO noted that the same Navy official also maintained these schedule delays will not adversely impact the planned delivery of the first system. The GAO observed, however, that preliminary design review completion could be delayed further, since program assessments show delivery of key documentation has been delayed and documentation quality may not be adequate for Navy review purposes. The GAO pointed out the assessment shows that the contractor's performance to meet critical design review has not improved--bringing into question the Navy's ability to complete that review by January 1990. The GAO also observed that delaying the reviews will compress the hardware

development and software writing by at least five months in order to meet the system integration schedule. In addition, that the GAO noted the Navy's February 1989 assessment indicates that delay in the preliminary design review could delay the ship design agent's receipt of updated AN/BSY-2 design data.

-**Critical Tests Delayed**. Finally, the GAO reported that the Navy had identified several items for critical tests that could present significant cost, schedule or performance risks. The GAO noted that Navy assessments indicated that some of these tests have been delayed. (The GAO cited some examples, such as shock testing of a cathode ray tube for the display consoles, as well as tests of various system response times.) The GAO concluded that these delays (of at least five months) could affect program cost and schedule. (pp. 27-34, pp. 42-43/GAO Draft Report)

Now on pp 20-23 and 30-31

- **DoD RESPONSE**: Partially concur. Although most of the facts in this finding, coming from internal Navy documents, are correct, the conclusions inferred from the facts are not always correct. Slipping both Preliminary Design Review and Critical Design Review to allow for more maturity in the design specification has been assessed to have no impact in the scheduled delivery of the system to the Navy. In fact, modeling, using the Pugh Roberts Association Program Management Model, indicates that taking these actions will result in both cost and schedule savings. The Preliminary Design Review Executive Session, rescheduled to October 3, was conducted on schedule and was fully supported by all of the documentation required from the contractor.

  Although some critical item tests have been delayed, many have been satisfactorily completed. The Wide Aperture Array successfully passed its flow noise test in July; the beamformer chip met requirements with significant margin on the first pass; the cathode ray tube successfully completed both shock and magnetic susceptibility tests in August; and the database manager and executive were successfully ported to switchnet, meeting all timing requirements.

- **FINDING G**: **Problems With Contractor Interfaces**. The GAO reported that, as of September 1, 1989, the contractor had not awarded final contracts to two important subcontractors--the

central issue being a mutually agreeable price. The GAO noted that, according to the Navy, problems in awarding these contracts raises questions as to the subcontractor's commitment to the overall development and testing program, introducing potential delays. The GAO concluded that, in the longer term, delays in awarding one of these contracts may also affect the leader-follower acquisition strategy.

The GAO also reported that the submarine designer needs firm system configuration data on the AN/BSY-2 before construction begins. The GAO noted that the Navy has taken actions to assure that the ship designer is aware of system changes and has provided the AN/BSY-2 contractor preliminary data--but the AN/BSY-2 contractor has provided the ship designer neither timely data nor final design data. The GAO found that, as a result, portions of the submarines have had to be redesigned, increasing SSN-21 design cost an estimated $5 million. The GAO observed that, if final design data requires further changes to the submarine design, additional costs and delays could occur. The GAO found, however, that the AN/BSY-2 contractor cannot provide all final ship design data until the Navy completes its critical design review in January 1990. The GAO noted that, according to a AN/BSY-2 program office official, changes resulting from the Navy design review could increase cost and delay delivery of the submarine. The GAO recognized that the Navy has taken precautionary measures, such as biweekly meetings with the ship designer. The GAO reported that, in addition, the ship designer has prioritized the data it needs and the AN/BSY-2 contractor has scheduled its work accordingly. The GAO concluded, however, that the AN/BSY-2 design schedule is not compatible with the SSN-21 design schedule--resulting in additional costs to the SSN-21 construction program. The GAO also concluded that, should further changes be required, this could affect SSN-21 program cost and schedule. (pp. 27-37, pp. 42-43/GAO Draft Report)

Now on pp 24-26 and 30-31

- **DoD RESPONSE**: Partially concur. As noted, slowness in definitization of subcontracts added to program risk. However, the General Electric Full Scale Development contract with Librascope was definitized on October 6. Although the subcontract with International Business Machines is not yet definitized, General Electric and International Business Machines have agreed on both scope and price. The contract is expected to be signed by the end of the year. The Navy continues to press this issue, but it should be noted that no subcontractor design efforts are being delayed and all are being performed to the correct baseline.

Concurrent development programs for the ship and the combat system pose risks for both the contractor and Navy program offices, but these risks have been mitigated to the maximum possible extent by the close coordination between the contractors, as well as with the Navy program offices. These risks were well understood from the SEAWOLF program inception. It is not true that "the ship designer...needs firm system configuration data and information before construction begins." The Navy has provided a continuous stream of data to the ship design agent and has prioritized the generation of design data to accommodate the ship design agent's needs. As of this date, there are no unresolved interface issues between the ship and combat system designs.

The "late combat system data, increasing SSN-21 design cost an estimated $5.0 million" statement reflects a misunderstanding of the sequence of events. Prior to award of the AN/BSY-2 contract, the ship design agent was provided with a "notional" system baseline, which was the Navy's best estimate of the system configuration prior to having a definitized contract. After contract award, the winner's system baseline was disclosed to the ship design agent. The fact that the cost of this change was less than $5 million illustrates the accuracy of the Navy's initial Navy estimates.

Although AN/BSY-2 design changes have impacted the ship design, it is also true that many AN/BSY-2 changes have been made to accommodate ship design agent requests. Potential changes in both ship and combat system designs continue to be discussed and evaluated in open forums as to impact, necessity and desirability in the presence of all affected parties.

- **FINDING H: First AN/BSY-2 Will Not Be Delivered With Full Performance**. The GAO reported that the first AN/BSY-2 will not be fully capable when delivered to the shipbuilder in November 1993--because (according to a contractor official) the contractor is unable to deliver a fully capable system in time. The GAO noted, therefore, that with the agreement of the Navy, the first system delivery will include all hardware but not all software. The GAO also noted that this first phase of the software, comprising 2.7 million lines, is planned for November 1993, and according to a Naval Operational Test and Evaluation Force official, will be sufficient to meet the threat. The GAO found that the remaining 426,000 lines, primarily for acoustic functions, are scheduled for January 1995. (pp. 37-38/GAO Draft Report)

Now on pp 26-27

- **DoD RESPONSE**: Concur. The decision to install the final portion of software after ship delivery is a factor of ship construction and the integration and testing schedules, as much as system availability. As both the ship and combat system are being developed, the Navy will continue to evaluate the installation schedule of the final portion of software.

- **FINDING I**: **Software Development Risks**. The GAO reported that, under the AN/BSY-2 program, the Navy will be challenged to meet performance requirements within tight time frames and budgets. The GAO noted that its March 13, 1989, report "Technical Challenges Confronting Navy's Seawolf AN/BSY Development" (OSD Case 7944) identified the software development schedule as one of these challenges. The GAO observed that the AN/BSY-2 software represents the largest new software development effort ever undertaken for a submarine combat system. The GAO further observed that, while it appeared initially that the system could retain a significant amount of software from existing systems, a recent software estimate shows that it will all be new, including 2.3 million lines in the Ada language. The GAO also referred to its March 24, 1989, report "Status, Costs, and Issues Associated With Defense's Implementation of Ada" (OSD Case 7832), which indicated most experts agree that the Ada language has not yet matured. The GAO also noted (1) that the June 1989 Navy program review documentation shows a shortage of Ada qualified personnel as a serious concern and (2) that the contractor's ability to recruit such personnel could seriously affect both cost and schedule. The GAO concluded that, in the software development and testing areas, additional steps are needed to maximize the possibility of delivering the first system as planned and without jeopardizing the cost, schedule, and performance of the SSN-21 program. The GAO also concluded that the Navy's attempt to design, develop, test, and integrate the large amount of new tactical software in the Ada language--without adequately trained and experienced programmers--could severely affect program cost and schedule. (pp. 39-40, p. 43/GAO Draft report)

Now on pp 28-29 and 31

- **DoD RESPONSE**: Partially concur. Whether or not retaining code from prior systems decreases or increases risk is a matter of opinion and depends on many technical factors, (1) architecture/partitioning, (2) depth and quality of documentation, (3) interface definition, (4) standards and conventions used, and (5) language and operating system compatibiltiy.

- **FINDING J: Similarities Between Submarine Combat System Programs.** The GAO reported that, based upon its experience with the SUBACS and AN/BSY-1 combat system programs, the Navy has

adjusted its strategy for the AN/BSY-2. The GAO noted that measures taken include--(1) establishing a 2-year system definition phase, (2) developing and testing software as separate modules, and (3) procuring and providing the contractor with software early enough to allow an additional year of development and testing. The GAO observed, however, that many similarities still exist between the AN/BSY-2 program and its predecessors--which tend to indicate the program could encounter future problems. The GAO pointed to an analysis of various program features (Appendix 1), which showed similarities between the systems' schedules, software development, concurrency, combat system capabilities, and at-sea testing. In the areas of particular concern, i.e., program schedule and software development, the GAO noted the ambitious development objectives to meet the ship construction schedule and the attempt to write 2.8 million lines of new software, without adequately trained programmers. The GAO concluded that, despite the Navy measures to mitigate problems encountered in earlier programs, the AN/BSY program is nonetheless experiencing problems and delays and the potential exists for cost increases and further slippages. (pp. 40-44/GAO Draft Report)

Now on pp 29 and 30-31

- **DoD RESPONSE**: Partially concur. The lessons learned in developing earlier combat control and acoustics systems, including AN/BSY-1, were incorporated into the planning for the AN/BSY-2 development effort. It is, for instance, the first submarine system to employ the software development requirements of DoD-STD-2167. This, combined with (1) the longer development time for AN/BSY-2, (2) the benefits derived from the two-contractor, two year System Design Definition phase, and (3) the intensive early oversight, should allow AN/BSY-2 to profit from the similarities to earlier programs. In addition, the AN/BSY-2 phased software delivery is different from AN/BSY-1 in that this approach was taken prior to award of the development contract for AN/BSY-2, rather than as a mid-development mitigation plan.

  Although more new code development is required for AN/BSY-2, the integration job will be easier since (1) all code is written to the same standards, conventions and style guides, (2) code partitioning was done from scratch, (3) Computer Software Configuration Interfaces have been defined prior to detailed design, and (4) code is written in the same language, developed with a common tool set and written for the same operating system.

Based on the training programs in use at General Electric and its subcontractors and on the nature of the standards, tools, conventions and guides being used in the program, the AN/BSY-2 software programmers will be adequately trained.

RECOMMENDATIONS

NONE.

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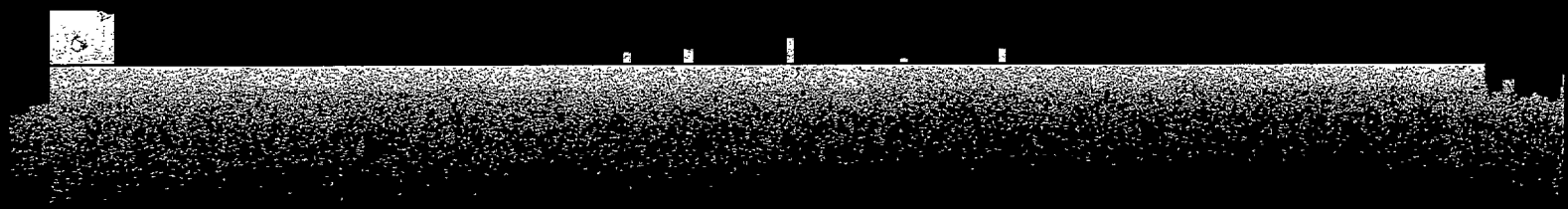

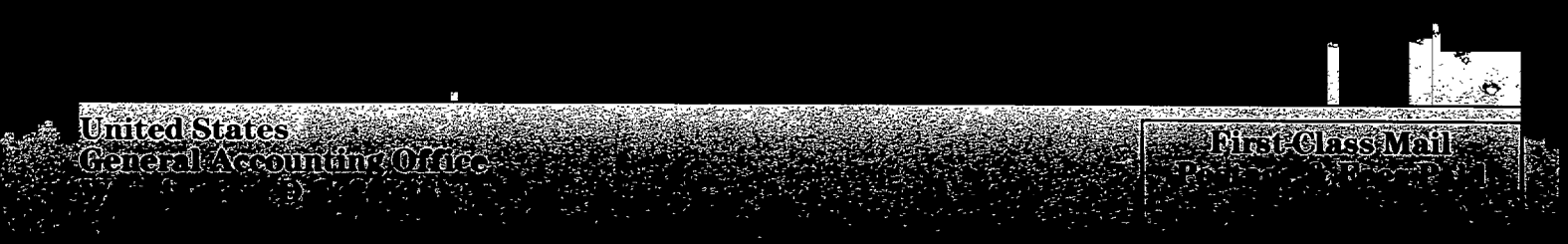
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