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Report to the Chairman, Legislation and National Security Subcommittee, House Committee on Government Operations

January 1992

NAVY ACQUISITION

Development of the AN/BSY-1 Combat System

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National Security and International
Affairs Division

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January 31, 1992

The Honorable John Conyers
Chairman, Legislation and
National Security Subcommittee
Committee on Government Operations
House of Representatives

Dear Mr. Chairman:

As you requested, we reviewed the evolution of the AN/BSY-1 combat system and determined whether its program requirements differ from those established for the Submarine Advanced Combat System program. We also determined the status and results of AN/BSY-1 developmental testing and evaluation and the impact combat system development problems had on the Los Angeles class nuclear attack submarine construction program.

As agreed with your office, unless you publicly announce this report's contents earlier, we plan no further distribution until 7 days from the date of this letter. At that time, we will send copies to the appropriate congressional committees; the Director, Office of Management and Budget; and the Secretaries of Defense and the Navy. We will also make copies available to others.

If you or your staff have any questions concerning this report, please call me on (202) 275-6504. Major contributors to this report are listed in appendix I.

Sincerely yours,

Martin M Ferber
Director, Navy Issues

Executive Summary

Purpose

A fully capable, computerized combat system is critical to the success of the Navy's Los Angeles class nuclear-powered attack submarines (SSN-688s). A new combat system, referred to as AN/BSY-1, is being installed in the final 23 of the 62 SSN-688s.

This report responds to the request of the Chairman, Legislation and National Security Subcommittee, House Committee on Government Operations, that GAO review the evolution of the AN/BSY-1 program and determine the (1) extent that the Navy's requirements for the AN/BSY-1 differ from those established for the Submarine Advanced Combat System (SUBACS), (2) status and results of the AN/BSY-1 developmental testing and evaluation, and (3) impact of combat system problems on the SSN-688 construction program.

Background

AN/BSY-1, a computer-based combat system, is designed to detect, classify, track, and launch weapons at enemy surface, subsurface, and land targets. The Navy expects the AN/BSY-1 system to locate targets sooner 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.

The Navy has contracted with the International Business Machines (IBM) Corporation for 23 AN/BSY-1 systems, maintenance and operational trainers, and a software maintenance facility. Acquisition and 30-year operating costs are estimated at $12 billion. As of November 1991, IBM had delivered 17 systems, 10 of which had been installed in newly constructed submarines.

Results in Brief

The AN/BSY-1 combat system does not have all of the capabilities originally planned for SUBACS. It does not distribute data as quickly or have as many data processing units, and it lacks some of the redundancy and expansion space planned for in the earlier program.

The Navy's developmental testing and evaluation of AN/BSY-1, completed in October 1990, generally concluded that AN/BSY-1 goals were achieved.

The SSN-688 shipbuilders were awarded about $218 million for adjustments related to SUBACS, AN/BSY-1, and other ship design changes. The shipbuilders will also experience schedule delays averaging 19 months. However, GAO was not able to determine the amounts of the awards and delay caused solely by combat system problems.

Principal Findings

AN/BSY-1 Evolution

In 1980, the Navy began to develop a new combat system, commonly referred to as SUBACS, for the SSN-688. SUBACS was structured in three phases—SUBACS Basic, SUBACS A, and SUBACS B. When SUBACS experienced cost, schedule, and technical problems, the Navy divided it into two efforts. SUBACS Basic became AN/BSY-1, the combat system for the SSN-688s, and SUBACS A and SUBACS B formed the basis for AN/BSY-2, the combat system for the Seawolf class nuclear attack submarines (SSN-21s).

Reduced Capabilities With AN/BSY-1

AN/BSY-1 is a less capable system than what was being planned for SUBACS Basic. AN/BSY-1 is a compromise between what was initially planned and what could be developed to meet an accelerated ship installation schedule. With SUBACS, the Navy had planned to use fiber optics to transfer data within the system, but the contractor was not able to meet speed requirements for data distribution. AN/BSY-1 also has fewer data processing units than planned for SUBACS Basic; data processing speed is decreased. Because AN/BSY-1 also consolidates certain sound detection features, it has less room for expansion and less redundancy to overcome malfunctions. Finally, AN/BSY-1 requires two more operators than planned for SUBACS Basic.

Results of AN/BSY-1's Technical Evaluation

The Navy's May 1991 report on AN/BSY-1's technical evaluation concluded that, in most areas, it met or exceeded its expected performance. However, AN/BSY-1's performance varied from the expected performance in the following areas, which the Navy has plans to correct:

- The sonar used to determine the position and size of an ice ridge and help the submarine avoid hitting it did not perform as expected. The Navy attributed this variance to test methodology; alternative test methods successfully demonstrated this function.
- A longevity problem with under ice maneuvering sonar software will limit prolonged under ice missions until the system has been upgraded.
- The combat control subsystem, following detection and recognition of a target, did not arrive at a firing solution within the expected time. The Navy

attributed this variance to time-consuming maneuvers performed for other aspects of the test.

- Large variances were experienced between the predicted and demonstrated times to identify a problem within the system, take corrective actions, and restore operations.

Impact of Development Problems on Submarine Construction Program

The Navy and its contractors experienced problems with the design and development of the SUBACS and AN/BSY-1 systems. As a result of these and other problems, the cost to the Navy increased about $218 million and both shipyards' building SSN-688s—Newport News Shipbuilding and Dry Dock Company and the Electric Boat Division of General Dynamics—are taking an average 19 months longer to deliver completed submarines.

Recommendations

GAO is not making any recommendations in this report.

Agency Comments

As requested, GAO did not obtain official agency comments on this report. However, GAO did discuss the results of its work with Defense and Navy officials and their comments were incorporated in the report where appropriate. Generally, the officials concurred with GAO's findings and conclusions. However, they emphasized that (1) AN/BSY-1 achieved all key performance parameters established for it in 1985, (2) the overall success of AN/BSY-1 performance in the technical evaluation was quite high since the majority of the capabilities were demonstrated, and (3) other ship design changes—besides those changes to the combat system—also contributed to submarine delivery delays and cost increases.

On points (2) and (3), GAO agrees with Navy officials and believes that this report reflects their concerns. Regarding point (1), GAO agrees that AN/BSY-1 achieved all key performance parameters established for it in 1985 but believes that AN/BSY-1 does not provide all the capabilities initially envisioned for SUBACS Basic. GAO believes the elimination of the fiber optic data bus, reduction of the number of processors and trackers, and replacement of SUBACS equipment with less capable AN/BQQ-5 equipment affected data distribution, processing speed, redundancy, and space for growth.

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Abbreviations

GAO	General Accounting Office
IBM	International Business Machines
NUSC	Naval Underwater Systems Center
REA	request for equitable adjustment
SUBACS	Submarine Advanced Combat System
TEMP	Test and Evaluation Master Plan
TLR	Top Level Requirement

Introduction

The nuclear attack submarine (SSN) is one of the nation's most important antisubmarine warfare assets. To enhance performance and maintain the superiority of the SSN, the Navy will equip the newer Los Angeles class nuclear attack submarines (SSN-688s) with a new and improved computer-based combat system. The system is 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.

Evolution of Submarine Advanced Combat System

In 1980, the Navy began developing the Submarine Advanced Combat System (SUBACS)[1] to meet an expanded SSN-688 mission and to counter the former Soviet Union antisubmarine warfare threat through the 1990s. SUBACS was originally conceived as a single-phased program for SSN-688s authorized in fiscal year 1989. However, in October 1983, the Secretary of Defense approved a three-phased plan[2] (SUBACS Basic, SUBACS A, and SUBACS B) for SSN-688s authorized in fiscal year 1983 and beyond. The objective of the three-phased plan was to allow the Navy to introduce additional capabilities earlier than planned and to spread program risks and costs over time.

SUBACS Basic was to improve acoustic and combat control capabilities. Acoustic capabilities were to be increased by adding a submarine active detection sonar, a mine detection and avoidance sonar, and a long thin line towed array.[3] Combat control was to be improved by adding an integrated vertical and horizontal weapon launch system. The use of a fiber optic data bus to distribute acoustic and combat control data was integral to this new capability. SUBACS Basic was to be installed on the U.S.S. San Juan (SSN-751) and eight other SSN-688s authorized through fiscal year 1985.

SUBACS A was to improve combat control significantly by adding common displays and new signal processors. It was to integrate acoustic and combat control processing, using new and upgraded software. Further, targeting capability was to be increased through upgraded sensors and

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

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

[3]A series of listening devices called hydrophones strung together for thousands of feet to provide rearward detection and tracking.

improved data processing. SUBACS A was to be installed on the U.S.S. Annapolis (SSN-760) and 10 other SSN-688s authorized in fiscal years 1986 through 1988.

SUBACS B, the ultimate objective of the phased program plan, was to introduce sonar improvements into the integrated combat system on the U.S.S. Columbia (SSN-771) and all other SSN-688s. These improvements were to include a wide aperture array,[4] capabilities to support the antisubmarine warfare standoff weapon, an integrated communication system, additional operator aids and operability improvements, upgraded functional software, and mining and enhanced countermeasures. A modified SUBACS B system was to serve as the baseline design for the new SSN-21 combat system.

Factors Affecting SUBACS Implementation

In December 1983, the Navy awarded the International Business Machines (IBM) Corporation a $772 million contract for concurrent full-scale development and production of the first five SUBACS Basic systems and for an engineering development model. The first SUBACS Basic system was to be delivered to the shipbuilder by May 1987 to meet the November 1987 delivery of the first SUBACS-equipped submarine to the Navy. However, SUBACS Basic experienced significant cost, schedule, and technical problems. Software development and delivery were considered high risk because the software not only consisted of over 4 million lines of code written in 11 different computer languages, but it was also linked by more than 200 processors to a new, untried, complex distributed system data bus. In March 1985, IBM advised the Navy that six software deliveries would be delayed from 2 months to more than 2 years because of insufficient time to test, integrate, and modify system software.

In addition to software, design and development of ceramic modules and electronic circuits, used in SUBACS equipment to help process data, caused many schedule delays. According to a February 1985 Naval Underwater Systems Center (NUSC) technical risk assessment, the program schedules did not allow enough time to resolve problems normally encountered when introducing new and unproven technology.

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

[4]The wide aperture array is a passive sonar designed to locate targets faster and provide more accurate range and target motion analysis than previous systems.

audit found the SUBACS Basic phase would cost $105 million more than the Navy's $757 million estimate. By June 1985, IBM was estimating a cost overrun of about $146 million to complete SUBACS Basic full-scale development.

Evolution of AN/BSY-1

To address SUBACS's continuing cost, schedule, and technical problems, the Navy initiated three replanning efforts between August 1984 and March 1985. The final replanning effort led to major changes in the SUBACS program. It renamed the SUBACS Basic combat system AN/BSY-1 and eliminated the performance capabilities expected from SUBACS A and SUBACS B. As a result, SSN-688s equipped with the AN/BSY-1 system do not have the combat capabilities originally planned.

The first replanning effort (Replan I) began in August 1984 and was approved in October 1984. It addressed SUBACS Basic ceramic module design, development, and production problems that had caused hardware delivery delays.

Replan II began in December 1984 in response to continued delays in ceramic module production. In January 1985, it addressed escalating cost and performance problems with the fiber optic data bus. The Navy took major actions under this replan to remove the combat control subsystem from the data bus, defer some SUBACS Basic functions from May 1987 to September 1988, and delay implementing the SUBACS A phase from fiscal year 1986 to fiscal year 1989. However, in March 1985, the Secretary of the Navy limited funding requirements for Navy acquisitions to fiscal year 1985 Five Year Defense Program levels. The Navy determined that Replan II could not be entirely implemented with available program funds and decided that additional replanning actions were necessary.

The final plan (Replan III) began in March 1985 and had the most significant impact on the SUBACS design. It proposed deleting the fiber optic data bus and redesigning SUBACS Basic to form the AN/BSY-1 design. It also proposed redesigning cabinets that interfaced with the data bus.

Navy's Review of Replan III

Because Replan III was to be a major design change to SUBACS Basic, on April 24, 1985, the Assistant Secretary of the Navy for Research, Engineering, and Systems appointed a committee to review combat system alternatives, address the immediate cost and schedule problems, and ensure that the SSN-751 would be delivered on time. In its May 28, 1985, report, the committee agreed with the proposal to delete the fiber optic data bus but stated its belief that Replan III was overly optimistic, had a low chance of meeting delivery schedules, and had unpredictable cost and schedule risks. The committee recommended an alternative combat system, the BQQ-5 Like.[5]

A second committee was created to develop more detailed information on the cost and schedule impacts of both alternatives. In its July 1, 1985, report, the second committee concluded that the cost to implement the BQQ-5 Like system was six times greater than the cost for Replan III. It also concluded that the full scope of deviations from the SUBACS Top Level Requirement (TLR)[6]—for SUBACS Basic, SUBACS A, and SUBACS B—could not be clearly defined and that neither alternative would fully satisfy the TLR. Therefore, it recommended that the SUBACS TLR be revised to reflect the reduced capabilities of AN/BSY-1. On August 9, 1985, the Assistant Secretary approved Replan III, which restructured SUBACS into two separate development efforts—SUBACS Basic became AN/BSY-1 for the SSN-688s and SUBACS A and SUBACS B formed the basis for AN/BSY-2, the combat system for the Seawolf class nuclear attack submarine (SSN-21).

System Acquisition

In February 1986, the Navy and IBM renegotiated the SUBACS Basic contract to establish AN/BSY-1 requirements. A total of 23 tactical systems, several operational trainers, and a software maintenance facility are being built for an estimated life-cycle cost of over $12 billion. As of November 1991, IBM had delivered 17 systems to the Navy. Fourteen of these systems had been delivered to Electric Boat Division of General Dynamics Corporation and Newport News Shipbuilding and Drydock Company, the shipbuilders, for installation in newly constructed SSN-688s; 10 of the 14 systems had been installed. Eight SSN-688s equipped with AN/BSY-1 systems have been delivered to the Navy.

[5]The BQQ-5 Like is the acoustic portion of the current SSN-688 combat system. It is essentially the same system developed under Replan III, with certain high-risk hardware replaced with proven, less-capable components from the AN/BQQ-5 sonar system.

[6]TLR describes the implementation of the functional performance and support requirements of a program. It establishes an agreement between the program office and the Chief of Naval Operations as to exactly what is being produced.

Objectives, Scope, and Methodology

As agreed with the Legislation and National Security Subcommittee, House Committee on Government Operations, we reviewed the evolution of the AN/BSY-1 program and determined the (1) extent that AN/BSY-1 program requirements differ from those established for the original SUBACS program, (2) the status and results of the AN/BSY-1 developmental and operational testing and evaluation, and (3) the impact of combat system problems on the SSN-688 construction program. We were also asked to determine whether the system was tested independently of the Navy's program office and the AN/BSY-1 contractor. Operational testing results, which will confirm AN/BSY-1's effectiveness and suitability for combat, have just become available and will be included in a subsequent report. That report also will address the issue of independent testing.

Our overall approach was to analyze the AN/BSY-1 acquisition process from conception through development testing. To determine the difference between original SUBACS and SUBACS Basic/AN/BSY-1 requirements, we reviewed the TLR documents for SUBACS and AN/BSY-1; examined the operational capability of retained, modified, and replaced equipment; and analyzed reports on the estimated performance capabilities of both designs. To determine the impact of problems on the SSN-688 construction program, we analyzed documents that tracked the progress of submarines under construction and reviewed contract change orders and modifications. We also examined the shipbuilders' requests for equitable adjustment (REAs) and the Navy's analysis of the requests. In assessing the status and results of the AN/BSY-1 developmental testing, we analyzed the report of the technical evaluation.

We discussed SUBACS and AN/BSY-1 problems and progress with officials in Washington, D.C., at the Office of the Under Secretary of Defense for Acquisition, the Office of the Under Secretary of Defense for Test and Evaluation, the AN/BSY-1 program office,[7] and the Naval Sea Systems Command's SSN-688 construction program office and Contracts Directorate. We also discussed these issues with officials at the Operational Test and Evaluation Force, Norfolk, Virginia; NUSC, Newport, Rhode Island; and the Supervisors of Shipbuilding, Conversion, and Repair in Groton, Connecticut, and Newport News, Virginia.

As requested, we did not obtain official agency comments on this report. However, we did discuss the results of our work with Defense and Navy

[7] The AN/BSY-1 Submarine Combat Systems Program Office (PMO 417) is the designated program manager for AN/BSY-1. Prior to March 1990, PMO 417 was a part of the Naval Sea Systems Command. In March 1990, the AN/BSY-1 program office was placed under the Program Executive Office for Submarine Combat and Weapons Systems.

officials, and they generally concurred with our findings and conclusions. Their comments are incorporated in the report where appropriate.

We conducted our work between November 1990 and November 1991 in accordance with generally accepted government auditing standards.

AN/BSY-1 Is a Compromise for SUBACS Basic

AN/BSY-1 is a compromise system for SUBACS Basic. In redesigning SUBACS Basic, the Navy eliminated or reduced innovative technology and replaced certain high-risk hardware with proven, but less-capable components from the older AN/BQQ-5 sonar system. Navy assessments show AN/BSY-1 performance capabilities are less than those planned under SUBACS Basic and do not fully meet the SUBACS Basic TLR. While Navy officials acknowledge the lower capability, they stated it was the result of the former Soviet Union's deployment of quieter and more capable submarines rather than the redesign of SUBACS Basic. We could neither confirm nor refute the specific impact of this on combat system performance.

Changes Made to SUBACS Basic

According to the Navy, Replan III was a significant redesign of SUBACS Basic system architecture. The most significant hardware changes were deletion of the fiber optic data bus, replacement of the tactical data processors, and redesign of the common beamformer and the multi-array signal conditioner. Software changes associated with the redesign effort involved the use of AN/BQQ-5 and CCS MK-1 software for acoustic and combat control functions. In addition, some operator aids, such as nontraditional processing, automatic threat detection and classification, and automatic performance prediction, were deleted. These hardware and software changes, according to AN/BSY-1 program officials, affected redundancy (the ability to prevent an entire system from failing if one component fails) and allowed less room for expansion but did not affect mission or functional performance.

Fiber Optic Data Bus Eliminated

Under SUBACS Basic, distributed processors were to transfer information with a wire data bus within cabinets and a fiber optic data bus between cabinets. The fiber optic data bus, a technological advancement, was to integrate acoustic and combat control subsystems into one major system, provide error-free communication, and allow the electronic system to process vast amounts of data with extraordinary speed and accuracy. However, in December 1984, IBM's preliminary critical item test showed that the fiber optic data bus distributed data at a speed about one-sixth of requirements. According to NUSC,[1] this reduction in speed would prevent operators from receiving, interacting, and responding to acoustic information fast enough to solve combat problems on a real-time basis. In addition, NUSC's February 1985 assessment stated that problems related to the data

[1] NUSC is the lead laboratory and the Navy's technical direction agent for the SUBACS and AN/BSY-1 programs. It provides technical guidance to SUBACS/AN/BSY-1 contractors and assists the Navy's program office in technical and design reviews.

bus severely constrained test and integration schedules, leaving virtually no margin for error. Thus, the fiber optic data bus concept was abandoned.

The Navy's decision to delete the fiber optic data bus created the need for an alternative data processing system. The replacement was centralized, computer-based processing using the Navy's standard AN/UYK-43 computer. Although AN/UYK-43 has a form of distributed processing that is internally redundant and has a low probability of failure, it does not have the technological enhancements of the fiber optic data bus. Also, system redundancy and space for growth are significantly limited.

Tactical Data Processors Replaced

Another significant hardware change was to replace the SUBACS tactical data processors and associated embedded disk drives with the Navy's standard computers for acoustic functions and stand alone submarine random access storage set disk drives for secondary data storage. Although AN/BSY-1 retains the AN/BQQ-5 and the CCS MK-1 software codes, it was modified to work with new AN/BSY-1 interfaces rather than the tactical data processors. This change resulted in AN/BSY-1 having fewer processor units than planned for under SUBACS Basic, causing more loss of functions when failures occur and decreasing speed.

AN/BSY-1 program officials stated that this change met all functional requirements but did not support the original plan to introduce a common combat control and acoustic display console in SUBACS A. According to these officials, processing and program and data storage capacities of the two designs are roughly equivalent. The primary difference is the degree of distributed architecture.

Common Beamformer and Multi-Array Signal Conditioner Redesigned

AN/BSY-1 consolidates the components from the multi-array signal conditioner and one of two common beamformers to provide space for the computers and the disk drives that replaced the tactical data processors. According to the Navy, the change resulted in the loss of some redundancy and reserve for expansion, but the functional components are identical to the SUBACS Basic design and use the same advanced technology.

Operator Aids Deleted

The SUBACS design philosophy was to reduce combat system staffing by 25 percent. This reduction was to be accomplished through sophisticated software that would provide automatic processing capabilities in the areas of nontraditional acoustic processing, threat detection and classification, torpedo detection, performance prediction, and medium frequency post processing. These enhancements were to reduce the number of personnel required for battle stations, simplify displays, provide a hierarchy of information, increase contact tracking and solution capability, and speed the process from detection to weapon firing. However, these enhancements, designed to help fleet operators streamline their work load, were deleted because related algorithms could not be further developed cost effectively. According to program officials, the functions associated with these aids are contained in AN/BSY-1 but require more staffing than originally planned. Combat system staffing for SUBACS Basic was to require 25 enlisted personnel while AN/BSY-1 requires 27.

AN/BSY-1 Performance Reduced

NUSC conducted a comparative analysis of SUBACS Basic, AN/BSY-1, and its predecessor systems (AN/BQQ-5 sonar and CCS MK-1 fire control systems). The analysis shows AN/BSY-1's operational performance is better than or equal to its predecessors in all areas. However, AN/BSY-1 will not achieve the target detection, classification, and tracking ranges that were originally planned when SUBACS Basic development began. According to AN/BSY-1 program officials, this decrease in operational performance is predominantly due to the former Soviet Union's deployment of more capable submarines rather than system design changes. Because their newer submarines are much quieter than the older ones and more difficult to detect, SSN-688s must be closer to them to detect them.

Although the United States' relationship with the former Soviet Union has improved, the Navy still considers their advanced submarines as potentially the United States' most formidable challenge. In recent years, the former Soviet Union introduced several new submarine classes with substantially improved capabilities, thereby reducing the United States' qualitative edge. SUBACS was to maintain the qualitative advantage over these submarines through the 1990s. However, according to AN/BSY-1 program officials, a significant improvement in the former Soviet Union's submarine capability was recognized in 1985. Consequently, when SUBACS Basic was restructured, the TLR was revised to recognize the more capable submarines. Defense and Navy officials emphasized that AN/BSY-1 achieved all key performance parameters established for it in 1985.

Conclusions

SUBACS was originally designed to give the SSN-688 class the combat capabilities needed to counter an improving submarine threat. It provided for an evolutionary combat system with incremental improvements over several years. SUBACS was to rapidly integrate the information acquired by all ship sensors, analyze that information, display the various analyses in simplified form for the ship's commanding officer, and simultaneously recommend the types of weapons to be used. It would have constantly updated the integrated information, the analyses, and the recommendations for action. Further, these capabilities would not depend on a single all-purpose computer system, but rather on a series of unusually redundant systems. If one system element failed, a backup system would immediately come on-line.

AN/BSY-1 will not provide the evolutionary combat system capabilities as initially envisioned under the SUBACS program. In substituting AN/BSY-1 for SUBACS Basic, the Navy abandoned some high-technological, high-risk components for Navy standard equipment and components and used more proven software. AN/BSY-1 program officials believe the substitution was accomplished with virtually no discernable differences in the quality or functional performance expected under SUBACS Basic. However, we believe AN/BSY-1 is not as operationally capable because the functions are performed less efficiently. Data distribution, processing speed, redundancy, and space for growth were affected by eliminating the fiber optic data bus, reducing the number of processors and trackers, and replacing SUBACS equipment with less capable AN/BQQ-5 equipment. While the SSN-688's detection and counterdetection capabilities are superior to the former Soviet Union's submarines, SSN-688s equipped with AN/BSY-1 systems have less superiority than planned under the full SUBACS program.

AN/BSY-1 Combat System Technical Evaluation

Department of Defense organizations use developmental testing and evaluation as part of the weapon system acquisition process. Technical evaluation, the final phase of this process, deals principally with instrumented tests and statistically valid data. It is conducted to determine whether (1) a system is functioning in a technically acceptable manner, (2) it meets design and technical performance specification, and (3) it is technically and logistically ready for operational evaluation. The developing organization must plan, conduct, monitor the test program and obtain test results. Test results for the AN/BSY-1 combat system indicate that the system functions in a technically acceptable manner.

Technical Evaluation Test Results

Technical performance of the AN/BSY-1 combat system was evaluated from April 23 to October 9, 1990, to determine whether it met or exceeded the operational effectiveness of the current AN/BQQ-5 and CCS MK-1 systems and other system specifications. The Navy's final report, dated May 10, 1991, concluded that AN/BSY-1 generally met its specifications but did not meet some performance expectations in the acoustic, combat control, and suitability areas. According to NUSC officials, these variances are minor and do not affect the ship's safety, its safe navigation, or the ability of AN/BSY-1 to successfully support SSN-688 warfare missions. In discussions with Defense and Navy officials on this report, they emphasized that the overall success of the AN/BSY-1 performance during the technical evaluation was quite high since the majority of the capabilities were demonstrated.

Acoustics

The AN/BSY-1's acoustic subsystem is a sound detection system that provides the submarine with the capability to detect, track, classify, and localize surface and subsurface targets and objects using advanced sound producing (active) and listening (passive) sonars. Evaluation results showed the subsystem to be a significant improvement over the older AN/BQQ-5 sonar system. However, the performance goals for the function that allows the submarine to avoid ice masses formed on the underside of frozen sea water were not met. According to NUSC, this performance could not be accurately measured against the ocean's natural background noises because of interference caused by sound transmitted into the water by the test itself. NUSC believes the methodology used to measure the performance of this function was not appropriate. However, acceptable performance was demonstrated using a different methodology.

Software longevity (continuous operation) of the under ice maneuvering sonar also was considered unacceptable. Although improvements in longevity were made between phases one and two of the test, NUSC believes that, based on operational experience, prolonged under-ice missions using submarines equipped with the AN/BSY-1 system should be limited until the system is upgraded and verified.

Combat Control

The combat control subsystem is made up of hardware and software that allow the ship's crew to pilot and navigate the submarine, effectively attack enemy targets, and maintain preset, launch, and post-launch control of weapons, countermeasures, and mines. Following detection and recognition of a target, this subsystem did not meet the time needed to achieve an accurate firing solution using sound data obtained from the towed array and another ship sensor listening for narrowband frequency sound. NUSC considered the performance problem using towed array data to be a specification issue rather than a problem with the subsystem because the Test and Evaluation Master Plan (TEMP) requirement for the use of the towed array data was not consistent with tactical guidance. NUSC attributes the performance variance using passive narrowband data to maneuvers carried out by the test ship rather than a system limitation. According to NUSC, the test was conducted in parallel with other ship maneuvers that increased the overall time to develop a solution. NUSC also stated that tests using only passive narrowband demonstrated that AN/BSY-1 could generate a solution in the specified time.

Suitability

AN/BSY-1 did not meet the average time requirements for hardware repairs, software reliability, the number of false alarms within a 24-hour period, and the number of hours needed to conduct preventive maintenance. The average time to accomplish hardware repairs (mean time to repair) includes the average time to detect and locate the problem and disassemble, replace, reassemble, align, and test the part. During the evaluation, it took more than twice as long (44 minutes) to repair the system than the TEMP requires. According to NUSC, this large variance is due to inclusion of total, instead of active, repair time[1] and the time required to troubleshoot intermittent faults.

[1]Total repair time includes the time required to find the part. However, the TEMP threshold assumes complete accessibility to all repairable items.

In the area of software reliability, the time between two software errors and restarting the system was 51.4 and 95.2 hours longer than the TEMP requirement. An upgrade is planned to improve this parameter.

AN/BSY-1 has an internal system to detect at least 95 percent of all subsystem failures within 7 minutes of their occurrence, with no more than one false alarm in a 24-hour period. False alarms also should not exceed one percent of the failures detected. Subsystem failures were detected within the required time frame, but the average number of false alarms exceeded the TEMP's 24-hour goal. Also, potential hardware failures that appeared to be false alarms were difficult for operators to locate. Future enhancements are planned.

Preventive maintenance on combat control subsystem software took about 42 minutes more than allowed. The TEMP requires that preventive maintenance be performed no more than 4 hours per week. NUSC does not consider the variance to be significant.

AN/BSY-1 Technical Evaluation Upgrades

Throughout the technical evaluation, the deficiencies encountered in operating and maintaining AN/BSY-1 were entered into the program trouble report system. Also, five engineering change proposals were developed in response to AN/BSY-1 hardware and/or software problems relating to the TOMAHAWK firing sequence and towed array signal levels, and other system acoustics and combat control functions. According to the Navy, correcting these variances would further enhance AN/BSY-1's capabilities. All SSN-751 combat system variances have been corrected. However, because of the Navy's desire that all SSN-688s equipped with AN/BSY-1 systems maintain the same configuration, upgrades are expected to be made to all systems. The Navy estimates that $7.8 million will be required to make these upgrades.

Conclusions

Technical evaluation of the AN/BSY-1 combat system has successfully demonstrated that all significant design problems have been resolved and that the system functions in a technically acceptable manner. Minor variances in acoustic, combat control, and suitability areas were identified. However, these variances have been or are planned to be corrected and should further enhance the system's capabilities.

AN/BSY-1 Adversely Affects SSN-688 Construction

Late and inaccurate design drawings and ship construction changes related to SUBACS, AN/BSY-1, and other ship systems caused both shipbuilders to incur additional construction costs and significant delays. The Navy made these changes, for the most part, as unpriced modifications[1] to SSN-688 construction contracts. Subsequently, both shipbuilders submitted requests for equitable adjustment (REAs) totaling about $323.9 million. The shipbuilders were awarded about $218 million and will incur an average 19-month delivery delay for changes related to SUBACS, AN/BSY-1, vertical launch system, noise improvements, new propulsion program, and retractable bow planes for 13 submarines. We were unable to specify the exact costs and delay attributed to SUBACS and AN/BSY-1 because of overlapping issues and multiple changes.

Impact of SUBACS and AN/BSY-1 on Electric Boat Submarines

In November 1982 and 1983, the Navy awarded Electric Boat two contracts to build five SSN-688s. Electric Boat alerted the Navy on several occasions between September and October 1986 that late and/or faulty AN/BSY-1 design data were causing rework, delays, and stoppages to the construction of the SSN-751. For example, the structural drawings did not consider the affect of the extended and heavier deck support structure or the added and relocated electronic and electrical components in the space required to install the cable, pipe, and ventilation system. Compounding this problem was the need to install larger cable wireways as a result of eliminating the fiber optic bus. Although the Navy had established a class design mockup to aid in the integration of components, the mockup construction could not keep pace with the many changes to the original design. Thus, in an attempt to alleviate these problems, the Navy entered into a $9.1 million agreement with Electric Boat to incorporate proposed AN/BSY-1 changes on the SSN-751 and the SSN-752.

On July 17, 1987, Electric Boat submitted a REA for about $97.1 million, seeking (1) price adjustments for over 7 months delay associated with the SSN-751 and the SSN-752 and (2) schedule and price adjustment for delays expected on submarines through the SSN-757, based on the experience of the SSN-751. The REA also included the impact of changes for the retractable bow planes and placement of lead ballast. An updated REA, dated February 2, 1988, increased the original REA's amount to $109.4 million for additional delays of 2 and 4 months for the SSN-755 and the SSN-757, respectively, as a direct result of AN/BSY-1 and related problems and discounted the reballasting work as a contributor to SSN-751 delay.

[1] An unpriced modification is a unilateral change to a contract authorizing a contractor to perform specific work; but it does not include the price for doing the work.

In June 1988, the Navy awarded the shipbuilder $82.4 million, including $27 million for an average 8-month delay to five submarines, as shown in table 4.1.

Table 4.1: Costs and Schedule Delays Due to Combat System Changes

(Dollars in millions)

SSN	Total adjustment	Delivery dates: Contract	Delivery dates: Revised	Months delay
751	$35.3	Nov. 1987[a]	June 1988	7
752	20.5	Mar. 1988[a]	Nov. 1988	8
754	12.9	July 1988	Feb. 1989	7
755	8.9	Dec. 1988	Aug. 1989	8
757	4.8	June 1989	Feb. 1990	8
760	0	Feb. 1990	Oct. 1990	8
761	0	June 1990	Mar. 1991	9
762	0	Oct. 1990	July 1991	9
763	0	Feb. 1991	Nov. 1991	9
Total	**$82.4**			

[a]We used Electric Boat's accelerated, rather than contract delivery, dates for the SSN-751 and the SSN-752 since Electric Boat claimed delay from these dates. The settlement agreement made no change to the contract delivery dates.

According to a contracting official, all but $650,000 of the $82.4 million settlement was for AN/BSY-1 design changes. The settlement agreement included full and final resolution of all matters occurring through April 4, 1988, including the unadjudicated claims.

The agreement also revised the delivery dates for the remaining submarines pursuant to an October 1, 1987, letter that described difficulties experienced in hiring production personnel and the impact of the work load caused by AN/BSY-1 changes.

Labor Strike Extends Delivery Schedules

In June 1988, Electric Boat shipyard workers went on strike over wage increases. An agreement was reached in October 1988 and a phased comeback of employees was initiated and continued through December 1988. However, Electric Boat could not rehire a sufficient number of qualified workers and continued to experience critical trade staff shortages that affected the construction schedule. Therefore, in August 1989, it requested revised delivery dates for its submarines, beginning with the SSN-757.

In November 1989, the contract was modified to extend the contract delivery dates. In exchange, Electric Boat agreed to full and final release of actual and potential damages, estimated at $2.22 million and occurring on or before August 31, 1989, on the SSN-752 through the SSN-771. The impact of the labor strike and manpower shortage on the SSN-688 delivery schedule is shown in table 4.2.

Table 4.2: Electric Boat's Revised Delivery Schedule Following Labor Strike

	Contract delivery dates			
SSN	**Original**	**06/08/88**[a]	**11/02/89**	**Month delay**
757	June 1989	Feb. 1990	July 1991[b]	17[b]
760	Feb. 1990	Oct. 1990	Feb. 1992	16
761	June 1990	Mar. 1991	Sept. 1992	18
762	Oct. 1990	July 1991	Mar. 1993	18
763	Feb. 1991	Nov. 1991	Jan. 1994	26
768	Apr. 1993	[c]	Sept. 1994	17
771	Nov. 1993	[c]	Mar. 1995	16

[a]Extensions made as a result of settlement agreement.

[b]Submarine was delivered in June 1991, 1 month earlier than the revised date.

[c]The contract for these submarines was awarded on June 30, 1988, and they were not a part of the settlement agreement.

Impact of SUBACS and AN/BSY-1 on Newport News Shipbuilding Submarines

Between November 1983 and February 1987, the Navy awarded Newport News Shipbuilding two contracts to construct eight SSN-688s, beginning with the SSN-753. When the first contract was modified in August 1985 to include Replan III, construction work on the SSN-753 had been underway almost 2 years. However, Newport News Shipbuilding did not receive the drawings for Replan III when required and the drawings that were received required 530 revisions before they accurately depicted Replan III. While Electric Boat had been pursuing its SSN-751 solution, Newport News Shipbuilding continued to construct its SSN-688s according to the original design. The design, however, did not reflect the changes made to the SSN-751. Consequently, designers could not determine if the redesigned cableways for the AN/BSY-1 would interfere with other systems. As a result, the shipbuilder was eventually faced with rip-outs, recutting of hulls, and rerouting of cables. According to Newport News Shipbuilding, design changes to modify AN/BSY-1 had a major impact on the SSN-753 and a rippling effect through the next seven SSN-688s under construction.

Between August 1988 and July 1989, Newport News Shipbuilding submitted seven REAs, totaling $214.5 million for eight submarines, for the increased costs and time resulting from late and deficient government-furnished drawings provided for SUBACS, AN/BSY-1, the vertical launch system, retractable bow planes, noise improvements, and improved propulsion machinery program.

Three of the seven REAs related to SUBACS and/or AN/BSY-1. Newport News Shipbuilding requested

- $54 million and an average 10-month delay for ordered changes to AN/BSY-1,
- $53 million and an average 14-month delay for late and deficient SUBACS and bow plane drawings, and
- $50.8 million and an average 9-month delay for 17 ordered AN/BSY-1 changes and late and deficient SUBACS, AN/BSY-1, and bow plane drawings.

The Navy's analysis of the REAs identified several factors that contributed to this delay and made it difficult for the shipbuilder and the government to affix the respective responsibilities of added cost, disruption, and schedule slippage. The factors were ship's increased complexity, late and major construction revisions, major changes in the shipbuilding construction techniques, delay in completing new facilities, and time involved in learning modular construction.

Under negotiated agreements dated May 21 and December 31, 1990, the Navy awarded Newport News Shipbuilding $135.7 million for settlement of the seven REAs and about 880 unpriced change orders issued through April 1, 1990. Due to the intermingling of issues and the settlement of unresolved change orders, we could not determine the costs of changes due solely to SUBACS and AN/BSY-1.

As shown in table 4.3, Newport News Shipbuilding will experience construction delays ranging from 14 to 29 months. Several factors have contributed to the delays.

Table 4.3: Newport News Shipbuilding Schedule Delays

SSN	Contract date: Original	Contract date: Current	Months delays
753	May 1988	Mar. 1990	22
756	May 1989	Dec. 1990[a]	19
758	Sept. 1989	Aug. 1991	23
759	Jan. 1990	Jan. 1992	24
764	Feb. 1991	July 1992	17
765	May 1991	Nov. 1992	20
766	Aug. 1991	Jan. 1994	29
767	Nov. 1991	Aug. 1993	21
769	Apr. 1993	June 1994	14
770	Aug. 1993	Nov. 1994	15
772	Feb. 1994	Apr. 1995	14
773	May 1995	May 1995	0

[a]The settlement agreement extended the contract delivery date to February 1991, but the ship was delivered 2 months early.

The settlement agreements extended the contract delivery dates for the first six submarines; the delivery dates for the SSN-766 and the SSN-767 were unchanged. However, the contract was modified in November 1989 to revise the delivery dates of the SSN-766 through SSN-772 to mitigate the overall impact due to government-furnished equipment and government-furnished information problems involving the improved propulsion machinery program.

Conclusions

Concurrent development of the combat system and construction of the new SSN-688s resulted in a difficult and disruptive challenge for the shipbuilders. Although the Navy had established a class design mockup of the redesigned spaces to aid in integrating the components, SUBACS Basic experienced many problems and a number of revisions were made to correct design deficiencies. The mockup could not keep pace with the many changes to the original design. In an attempt to resolve cost, schedule, and technical problems experienced with SUBACS Basic, the Navy replaced SUBACS Basic with AN/BSY-1. The Navy's failure to provide timely, complete, and accurate design data to accommodate AN/BSY-1 and defective design drawings disrupted the construction effort, causing SSN-688 schedule delays and increased costs.

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