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

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NAVY ACQUISITION

AN/BSY-1 Combat System Operational Evaluation

GAO/NSIAD-93-81

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National Security and
International Affairs Division

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November 19, 1992

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

Dear Mr. Chairman:

In response to your request, we assessed the results of the AN/BSY-1 operational evaluation, including testing limitations and their impact on the evaluation. We also attempted to determine whether the operational evaluation was conducted independent of the AN/BSY-1 program office and its contractors and reviewed the Director, Operational Test and Evaluation's (DOT&E) oversight of the test. This report is a follow-on to our January 1992 report.[1]

Background

The Navy is equipping improved Los Angeles class nuclear-powered attack submarines (SSN-688I)[2] with the new AN/BSY-1 combat system. The AN/BSY-1 program evolved in 1985 as a result of the restructuring of the Submarine Advanced Combat System program. AN/BSY-1 is designed to support SSN-688Is in conducting combat operations in antisubmarine, antisurface, strike, mine, and other warfare missions. Thus, a fully capable combat system, successfully developed and tested, is critical to SSN-688Is accomplishing their missions.

The Navy contracted with the International Business Machines Corporation to concurrently develop and produce 23 AN/BSY-1 systems, 3 maintenance and team trainers, and a software maintenance facility. In May 1987, the first AN/BSY-1 was delivered to the Navy for installation in the SSN-751, which was later used for the AN/BSY-1 operational evaluation. As of September 1992, the International Business Machines Corporation had delivered 22 systems to the Navy, 14 of which have been installed in newly constructed SSN-688Is. As of September 30, 1992, total development and production cost of the AN/BSY-1 was estimated at $3.8 billion.

[1]Navy Acquisition: Development of the AN/BSY-1 Combat System (GAO/NSIAD-92-50, Jan. 31, 1992).

[2]The Navy refers to the U.S.S. San Juan (SSN-751) and subsequently constructed submarines of the class as the improved SSN-688. In addition to AN/BSY-1, these submarines have all the improvements added to previous submarines of the class, the ability for increased under-ice operations, and several new quieting modifications.

As the Navy's independent agent for operational test and evaluation, the Commander, Operational Test and Evaluation Force, is responsible for planning, conducting, and reporting the results of all operational tests and evaluations, without the participation and influence of the developing agency and its contractors, and providing a recommendation regarding the weapon system's readiness for fleet introduction or need for further testing. Short of war, operational test and evaluation is the primary method used to predict how a weapon system is likely to perform in combat. Operational evaluation, the final phase of operational test and evaluation, is an overall assessment to determine whether the system can perform its mission as intended (operational effectiveness) and whether it will be reliable, maintainable, and operationally available when deployed (operational suitability).

Results in Brief

The Operational Test and Evaluation Force conducted the AN/BSY-1 operational evaluation from November 1, 1990, to May 17, 1991. The Commander concluded that the AN/BSY-1 was operationally effective and suitable and recommended it be approved for introduction into the fleet. We do not disagree with the Commander, Operational Test and Evaluation Force's conclusions or the recommendation that AN/BSY-1 be approved for fleet use, considering that (1) 23 of the 27 critical operational issues[3] examined were satisfactorily demonstrated; (2) AN/BSY-1 is a mature program with no significant programmatic decisions remaining (all systems, trainers, and the software maintenance facility have been approved for production and all contracts awarded); (3) 96 percent of the systems and all trainers have been delivered to the Navy; and (4) initial operating capability has been achieved. However, we note the following:

- Two AN/BSY-1 critical operational issues (reliability and maintainability) were unsatisfactory. System failures decreased AN/BSY-1 reliability. The failures were not corrected in the required time. Changes are being made that are expected to correct these deficiencies.
- Limitations resulted in incomplete demonstration of two critical operational issues (weapon employment[4] and navigation) and unrealistic operational testing. We recognize that operational testing cannot always be done in an environment that totally represents all operational conditions

[3]Critical operational issues are key effectiveness and suitability issues that must be demonstrated during operational test and evaluation to determine the system's capability to perform its mission.

[4]This issue involved the submarine-launched mobile mine. Navy and Department of Defense officials determined that the mine was inappropriately included in the operational evaluation report. As a result, it is not discussed in our report.

and that the Navy has taken steps to improve the realism of operational test and evaluation. Nevertheless, reducing these limitations can be crucial to identifying and correcting problems before a weapon system is produced and deployed.

- We could not reach a conclusion on the independence of the operational evaluation. SSN-751 records show AN/BSY-1 program and contractor personnel were on board the submarine during dedicated testing days. The Navy could furnish no documentation that these personnel left the submarine before AN/BSY-1 operational evaluation began.
- Based on limited observations, DOT&E determined the AN/BSY-1 operational evaluation was adequate. However, because DOT&E does not establish the number of on-site visits required, we could not assess how effectively DOT&E carried out its responsibilities.

AN/BSY-1 Reliability and Maintainability Were Unsatisfactory

Commander, Operational Test and Evaluation Force Instruction 3960.1G requires all critical operational issues be satisfactorily resolved before recommending a system for introduction into the fleet. The AN/BSY-1 operational evaluation report shows 23 of the 27 critical operational issues examined were satisfactorily demonstrated, but two suitability issues (reliability and maintainability) were unsatisfactory. The system was deemed unreliable because operators had difficulty with the system's acoustic software. Primarily, AN/BSY-1's maintainability was degraded because of excessive troubleshooting time. However, the operational evaluation showed AN/BSY-1 would be available over 96 percent of the time. Because operational availability exceeded operational requirements, the Commander concluded that AN/BSY-1's operational availability outweighed the reliability and maintainability issues and that, from an operational standpoint, AN/BSY-1 was suitable. Consequently, the Commander recommended AN/BSY-1 be approved for fleet use. Significant improvements are being installed to correct the reliability and maintainability issues.

System Failures Decreased AN/BSY-1 Reliability

Reliability is the probability that AN/BSY-1 will continuously operate during a mission without critical failures or errors. The measurement is expressed as the relation of total operating time to the number of system failures or errors. AN/BSY-1 did not meet 5 of 11 hardware and software reliability goals.

AN/BSY-1 hardware reliability, expressed as mean time between failure, was assessed for two configurations: (1) with all system functions fully

operational and (2) with only those functions required to preempt enemy attacks and allow the submarine to operate safely. AN/BSY-1's demonstrated mean time between failure for the fully operational configuration exceeded its goal by 76 percent, but the limited, self-defense goal was 7 percent less than the Test and Evaluation Master Plan required.

AN/BSY-1 software longevity, expressed as mean time between error, was computed for various actions required to resume normal computer operations. Overall, AN/BSY-1 software longevity was determined to be unsatisfactory because criteria in four of nine measured areas were not met. For example, AN/BSY-1's demonstrated mean time between error for warm and hot starts for acoustic functions were 28 percent and 37 percent, respectively, below established goals.

System failures were corrected by reloading or reassigning its software. A warm start required the operator to download and then reset the computer to resume system operations. All data was saved except incoming data lost during the interval between error and completion of the recovery action. A hot start allowed the operator to reassign the software or micro-code programs without degrading acoustic performance. Reassigning the software was the preferred recovery action. However, due to its complexity, sonar operators often bypassed this procedure to save time.

System Failures Were Not Corrected Within Required Time

Several measurements were computed to assess the crew's ability to keep the system's equipment in specified operational condition. For hardware, the measurement is expressed as mean time to repair, or the average elapsed time between problem detection and restoration of satisfactory operations. It includes the average time to isolate the defective part, obtain the appropriate shipboard replacement part, disassemble and replace the defective part, reassemble, align, and check out the repair.

The mean time to repair for 12 part failures was 176 minutes, or 85 percent longer than required to meet the operational requirement for hardware maintainability. Two of the 12 parts were not repaired because replacement parts were not carried on board. For these parts, the test measured only the time required to detect and isolate the defects.

About 78 percent of the total repair time was used to identify the cause of system failures. Although AN/BSY-1 has a built-in error-detection system to identify problem areas and provide instructions to correct them, the built-in test did not effectively detect and isolate the problems. According

to the report, troubleshooting instructions were voluminous, did not allow for finding the correct work-around procedure, and did not help the operator to understand the system response in the short amount of decision time allowed during a system casualty.

Planned Changes Expected to Correct Deficiencies

The Navy expects two changes to correct system deficiencies detected during AN/BSY-1 technical and operational evaluations. The first change provides software and hardware modifications to correct 281 technical evaluation deficiencies. For example, the change will improve the speed and performance of the AN/UYK-43 computer and enhance processing. As of September 30, 1992, the change had been installed on 11 systems. Five additional systems are expected to be upgraded by April 1993. The remaining nine systems will be delivered to the ship with the change already installed. Because identical problems were noted during the AN/BSY-1 operational evaluation, some technical evaluation improvements will eliminate the operational evaluation deficiencies.

The second change is an acoustic software modification designed to address 60 system deficiencies observed during operational evaluation. This change will also correct the two unsatisfactory critical operational issues. Improvements, for example, will be made to correct software error-detection and longevity problems and to reduce the number of false alarms and reconfiguration management actions. This change, estimated to cost about $2.1 million, is being installed on all systems. As of September 30, 1992, this change had been installed in 10 systems; 6 additional systems are expected to be upgraded by May 1993. The nine remaining systems will be delivered to the ship with the change already installed. Verification that the deficiencies have been corrected will be made during follow-on test and evaluation.

Testing Conditions and Inadequate Equipment Affected Operational Evaluation

Department of Defense test and evaluation policy requires that, to the extent practicable, (1) testing be done in geographical settings and under weather conditions that are representative of the operating environment and (2) equipment used be representative of the threat. Since the 1970s, we have issued numerous reports on the Department of Defense's need to improve the quantity and quality of operational test and evaluation. In December 1986, for example, we reported[5] that the usefulness of operational test and evaluation in estimating a weapon system's

[5]Weapon Performance: Operational Test and Evaluation Can Contribute More to Decisionmaking (GAO/NSIAD-87-57, Dec. 23, 1986).

performance has been limited because of long-standing problems such as test sites not being representative of the operating environment or test resources not always being available or adequate.

Our assessment of the AN/BSY-1 operational evaluation shows that these problems still exist. During the operational evaluation, the test environment precluded the Operational Test and Evaluation Force from fully assessing all navigation issues. In other instances, testing limitations affected the operational evaluation. None of these limitations, however, prevented the Commander, Operational Test and Evaluation Force, from formulating conclusions regarding AN/BSY-1's operational effectiveness and suitability.

Limitations Result in Incomplete and Unrealistic Operational Testing

One critical operational issue—advanced under-ice navigation—was not satisfactorily demonstrated due to testing limitations. In addition, not all test equipment used for the AN/BSY-1 operational evaluation were adequate. Noise simulators that emitted threat submarine sounds into the water were unrealistic. Further, the weapon range was too small to allow realistic testing of AN/BSY-1's ability to perform, particularly during multiple-ship engagements. In addition, the poor reliability of torpedoes hampered evaluation of AN/BSY-1 operational effectiveness in torpedo engagements. According to DOT&E, programs are available to correct these deficiencies, but funding is inadequate.

The capability to navigate under ice using the forward look sonar was not completely tested. Although AN/BSY-1 demonstrated the capability to safely operate while piloting and to detect and perform other maneuvers in an area where the ice cover varied in thickness and size, a pack ice environment[6] was not available due to the scheduling of the operational evaluation. Advanced under-ice navigation will be tested during the Navy's 1993 Ice Exercises.

During testing on the range and the ocean, a noise augmentation unit, which is designed to simulate the radiated noises and tones of threat submarines, was attached to submarines supporting the test. However, according to a DOT&E official, the noise unit did not always emit submarine noise levels that were representative of threat submarines. Because the unit does not accurately replicate threat submarines, we believe some operational problems may not emerge until AN/BSY-1 actually performs in

[6]A pack ice environment is any area of sea ice that forms, but does not remain attached to the coast.

its intended operational environment. However, according to an AN/BSY-1 program official, no detrimental effect or risks exist because of the difference in emitted submarine noise patterns.

The Navy uses the Atlantic Undersea Test and Evaluation Center weapons range, a deep-water facility with fixed hydrophones, to make underwater noise measurements, test and calibrate sonars, and provide accurate tracking data. According to DOT&E, the tracking range is too small to provide the diversity required for operational realism because sensor systems have become more advanced and threat submarines much quieter. For example, the DOT&E staff assistant told us that, with the AN/BSY-1 submarine and the threat submarine at opposing ends of the range, AN/BSY-1 was able to pick up the target submarine's acoustic signature without ever moving. As a result, full capability of AN/BSY-1 could not be tested at the range. Full capability of the system was tested in the open ocean and successfully demonstrated.

AN/BSY-1 demonstrated the ability to effectively launch and control torpedoes. However, 56 percent of the torpedoes that missed the target did so due to the torpedoes' failures. Operational Test and Evaluation officials told us that since the test was conducted on an instrumented range, it could determine if the torpedoes would have hit their target had they continued on course.

Independent Testing Was Not Fully Documented

We were unable to determine whether AN/BSY-1 program and contractor personnel were improperly involved in the actual tests, data analysis, or other operational evaluation activities for the AN/BSY-1 combat system. Personnel not needed to support the testing agency's mission are not supposed to be on board testing units during testing. Authorization can be granted if such visits are necessary to support the test submarine or other unit requirements or provide technical assistance if the operational test director requests it. However, these personnel are to leave the testing units before testing resumes. While testing agency and program officials stated that all interaction between them ceased when AN/BSY-1 was certified for operational evaluation in October 1990, SSN-751 records show AN/BSY-1 program and contractor personnel were on board the submarine during dedicated testing periods. Sufficient data did not exist or was not available to verify if the operational evaluation was ongoing while the personnel were on the submarine. Nevertheless, their presence creates the appearance of a conflict of interest. For example:

- The TOMAHAWK missile is one of four weapons the AN/BSY-1 combat system launches. In November 1990, the Chief of Naval Operations granted the Program Executive Officer for Submarine Combat and Weapons Systems a waiver for the horizontal and vertical TOMAHAWK missile test launch during the AN/BSY-1 operational evaluation. Because testing was deferred after the AN/BSY-1 had been certified as ready for operational evaluation, the AN/BSY-1 program office was required to recertify the TOMAHAWK missile for the operational evaluation. On February 1, 1991, a dedicated testing day, AN/BSY-1 program, International Business Machines, and Naval Undersea Warfare Center personnel were on board the SSN-751 to provide an operational test launch of the missile to recertify it for the AN/BSY-1 operational evaluation. Later that day, the AN/BSY-1 operational evaluation resumed. The Navy could not provide documentation that program and contractor personnel had left the submarine before testing resumed.
- On May 11, 1991, another dedicated testing day, AN/BSY-1 program, International Business Machines, and Naval Undersea Warfare Center personnel were on board the SSN-751 to replace the TB-23 towed array and repair the UYK-43 acoustic computer—components of the combat system. The equipment had experienced problems earlier during the operational evaluation that the ship's crew were unable to repair. Because the operational test director prepared formal reports reflecting these problems, the AN/BSY-1 program and contractor personnel were allowed to begin solving the problem. Testing resumed the same day, but the Navy could not provide documentation that the program and contractor personnel had left the submarine before testing resumed.

In discussions with Operational Test and Evaluation Force officials, they told us that a personnel transfer was conducted between the demonstration test and the operational test of the TOMAHAWK missile. They further stated that only authorized operational evaluation participants were on board the submarine during testing, otherwise agency reports would have shown exceptions.

Adequate Documentation for Some Operational Test and Evaluation Force Activities Did Not Exist

Operational Test and Evaluation Force guidance provides that documents comprising the project case file be forwarded to the appropriate record center and never destroyed. However, the Operational Test and Evaluation Force did not maintain a record of all its activities. The lack of documentation made it difficult to verify actions taken during the operational evaluation, especially when personnel rotations and retirements are involved. For example, Operational Test and Evaluation

Force guidance states that the operational test director should maintain an on-scene, running account of the operational evaluation, including discussions at meetings, meeting attendants, unusual events, etc. The purpose of the journal includes (1) serving as a historical record for future reference, (2) serving as a source for answers to new questions about the test, and (3) substantiating data if events are later questioned. Although a journal consisting of the operational test director's and other participants' hand-recorded observations was available, it did not provide a complete chronological record of the project or its participants. One reason such documentation is important is because the operational test director, who was responsible for the AN/BSY-1 operational evaluation, left the Navy and subsequent directors did not have firsthand knowledge of the operational evaluation.

DOT&E Observation of AN/BSY-1 Operational Evaluation Was Limited

Concerned that operational test and evaluation was not receiving the needed emphasis and independent oversight, the Congress established the Office of the DOT&E within the Office of the Secretary of Defense. The Director's responsibilities include, among other things, (1) prescribing policies and procedures for conducting operational test and evaluation, (2) issuing guidance to and consulting with the military departments on major defense acquisitions, (3) monitoring and reviewing operational test and evaluation in the Department of Defense, (4) analyzing the results of operational test and evaluation, and (5) reporting to the Secretary of Defense and the Senate and House Committees on Armed Services and on Appropriations on whether the test and evaluation performed was adequate.

In a March 1987 report,[7] we identified several deficiencies affecting DOT&E's effectiveness in carrying out its oversight responsibilities. Specifically:

- DOT&E appeared to be making only limited numbers of actual on-site observations of operational tests.
- DOT&E's analysis of operational testing was primarily based on military service test reports with little assessment of actual test results.
- DOT&E had not provided policy and procedural guidance or maintained reliable records on some of its principal activities.

[7]Testing Oversight: Operational Test and Evaluation Oversight Improving But More is Needed (GAO/NSIAD-87-108BR, Mar. 18, 1987).

In June 1989, during testimony on the adequacy of Department of Defense operational test and evaluation, we noted that DOT&E had not taken corrective action to resolve these problems. For example, DOT&E had not established policy and procedures or maintained reliable records on test observations and had not developed a formal system to document how DOT&E staff spend their time.

Our assessment of DOT&E's oversight activities for the AN/BSY-1 operational evaluation shows improvement, but reaffirms some of these long-standing problems. While DOT&E had reviewed and approved the AN/BSY-1 Test and Evaluation Master Plan and the Operational Test Plan, it had made only a few on-site observations of the AN/BSY-1 operational evaluation. In addition, DOT&E has not provided policy or procedural guidance addressing the number of on-site visits needed to properly monitor operational tests and evaluations. Rather, the number of visits was left to the discretion of the staff assistants and their supervisors.

During the 6-month operational evaluation, over 250 tests were conducted to resolve the 27 critical operational issues. However, the DOT&E staff assistant and its contractor, the Institute for Defense Analyses,[8] made only four visits to monitor AN/BSY-1 testing. During two visits, torpedo operations and mine detection and avoidance vulnerability testing were conducted. Records indicate that no testing was ongoing during the other visits.

In deciding which tests to observe, the DOT&E staff assistant said professional judgment and prior development history are considered.[9] He also said that visits are timed to coincide with the most critical phases of the tests so DOT&E can obtain the maximum information.

In addressing the adequacy of a test, the DOT&E staff assistant said the staff conducts reviews to ensure that there is agreement between the requirements documents, the Operational Test Plan, Test and Evaluation Master Plan, and raw test data. DOT&E's fiscal year 1991 annual report to the congressional committees indicates that its activity for 1991 involved oversight of 208 programs, including the AN/BSY-1. DOT&E concluded that

[8]The Institute for Defense Analyses primarily provides studies, analyses, computer software, models, and other technical or analytical support for policy and program planning and management.

[9]The current staff assistant is not the individual who made the on-site visits to observe the AN/BSY-1 operational evaluation; the former staff assistant is no longer with the Navy, having retired in July 1991.

the total scope of the AN/BSY-1 operational evaluation was adequate and that the AN/BSY-1 was operationally effective and suitable.

Recommendations

We recommend that the Secretary of Defense direct the Director, Operational Test and Evaluation, to formally establish, before the start of a system's operational evaluation, (1) the number of on-site observations required to properly monitor operational tests and evaluations and (2) which tests should be observed.

As agreed with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from its issue date. At that time, we will send copies to the appropriate congressional committees, the Director of the Office of Management and Budget, and the Secretaries of Defense and the Navy. We will also make copies available to others upon request.

Please contact me at (202) 275-6504 if you or your staff have any questions concerning this report. Other major contributors to this report are listed in appendix II.

Sincerely yours,

Richard Davis

Richard Davis
Director, Navy Issues

Scope and Methodology

To determine the status and results of the AN/BSY-1 operational test and evaluation and limitations to the test, we analyzed the operational evaluation report and verified its accuracy by randomly selecting and reviewing the raw data (charts, plots, logs, questionnaires, and technical and tactical documents) collected during the test. We also reviewed the Test and Evaluation Master Plan, the Operational Test Plan, and administrative reports. We compared these documents with the operational evaluation report to identify inconsistencies.

To determine whether the operational evaluation was conducted independently of the AN/BSY-1 program office and developing contractors, we analyzed documents relating to the control of test data and visitors on board the ship. We also reviewed the Operational Test Director Journal.

In assessing DOT&E's oversight of the operational evaluation, we reviewed applicable laws and regulations to ascertain specific responsibilities. Further, we examined the DOT&E Fiscal Year 1991 Annual Report to Congress, which includes an assessment on the adequacy of the AN/BSY-1 operational evaluation.

We discussed each issue 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 Operational Test and Evaluation, Program Executive Office for Submarine Combat and Weapons Systems, and the Office of the Director of Naval Test and Evaluation and Technology Requirements. We also discussed these issues with officials at the Operational Test and Evaluation Force, Norfolk, Virginia; Naval Undersea Warfare Center, Detachment Hawaii, Lualualei, Hawaii; and Submarine Development Squadron Twelve, Groton, Connecticut.

We conducted our work from January through October 1992 in accordance with generally accepted government auditing standards. At your request, we did not obtain official agency comments on the report; however, we discussed the information with Department of Defense and Navy officials and incorporated their comments as appropriate. Generally, they concurred with our findings and conclusions.

Major Contributors to This Report

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