REPORT TO THE CONGRESS

Adverse Effects Of Producing The AN/SQS-26 Surface Ship Sonar System For Service Use Before Completion Of Development And Testing B-160877

Department of the Navy

BY THE COMPTROLLER GENERAL OF THE UNITED STATES

MARCH 9, 1971

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

B-160877

To the President of the Senate and the
Speaker of the House of Representatives CW00001

This is our report on the adverse effects of producing the AN/SQS-26 surface ship sonar system for service use before completion of development and testing. Our review was made pursuant to the Budget and Accounting Act, 1921 (31 U.S.C. 53), and the Accounting and Auditing Act of 1950 (31 U.S.C. 67).

Copies of this report are being sent to the Director, Office of Management and Budget; the Secretary of Defense; and the Secretary of the Navy.

Elmer B. Staats

Comptroller General
of the United States

COMPTROLLER GENERAL'S REPORT TO THE CONGRESS

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WHY THE REVIEW WAS MADE

In accordance with a request from Congressman Sidney R. Yates, Rep. the General Accounting Office (GAO) reviewed the Navy's development and acquisition of selected antisubmarine warfare systems. The report which summarized the results of GAO work on one of these--the AN/SQS-26 surface ship sonar system--was made public by Congressman Yates.

In that form the report did not contain comments from the Navy or the manufacturers of the sonar system. In its present form the report includes their comments and related GAO views. GAO's basic findings, however, remain unchanged.

FINDINGS AND CONCLUSIONS

Through June 30, 1969, the Navy spent over $429 million for the development and acquisition of the AN/SQS-26 sonar system. (See p. 15.)

The Navy expected that the AN/SQS-26 sonar could be made to work and desired to provide the fleet with the most up-to-date equipment. Consequently, it began procurement of the sonar for fleet use before initial development and testing were completed. (See pp. 9 and 10.)

Before this system was approved for service use in November 1968, four different models, totaling 87 units, had been contracted for and two of those four had already undergone major modification. (See pp. 9 and 10.)

Throughout its history the sonar system has undergone continued redesign and modification in order to correct numerous equipment deficiencies and to incorporate features to improve performance. (See p. 13.)

The system has provided the Navy with certain antisubmarine warfare capabilities that it previously did not have; however:

--With the possible exception of the most current models, performance of the system has been below expectations. (See p. 13.)

--The system's development cost, which was estimated in May 1960 to be about $12 million, increased to an estimated $101 million, as shown

in the data supporting the fiscal year 1970 budget estimate. Production unit costs also increased. (See p. 14.)

--Delivery of the individual sonar systems often has been later than originally scheduled. (See p. 15.)

GAO believes that the difficulties experienced in this sonar program resulted, in large part, from the Navy's ordering the system into production before it had been developed and tested and, to some extent, from the Navy's failure to recognize, early in the sonar program, the severity of the technical problems to be encountered. (See p. 8.)

The practice of concurrently developing and producing weapon systems was a matter of concern to the Blue Ribbon Defense Panel appointed by the President and the Secretary of Defense in July 1969 to study the organization, structure, and operation of the Department of Defense. In its report of July 1, 1970, the Panel recommended that:

> "A new development policy for weapon systems and other hardware should be formulated and promulgated to cause the reduction of technical risks through demonstrated hardware before full-scale development, and to provide the needed flexibility in acquisition strategies."

The Panel's report stated that the new policy should provide:

> "A general rule against concurrent development and production, with the production decision deferred until successful demonstration of developmental prototypes." (See p. 24.)

RECOMMENDATIONS OR SUGGESTIONS

The concurrent development and production of major weapon systems by the Navy and recommendations on this practice are discussed in GAO's report to the Congress entitled "Adverse Effects Of Large-Scale Production Of Major Weapons Before Completion Of Development And Testing, Department Of The Navy" (B-163058, November 19, 1970).

In that report GAO recommended that the Navy revise its instruction relating to concurrent development and production to provide for the submission of meaningful data to the Assistant Secretaries who make concurrency decisions. In addition, GAO recommended that the Naval Audit Service give consideration to making regularly scheduled audits of the practice of concurrent development and production. In general, the Navy agreed with these recommendations. GAO is not making further recommendations at this time.

AGENCY ACTIONS AND UNRESOLVED ISSUES

The Navy and the manufacturers of the sonar system provided GAO with comments on the matters discussed in this report. The Navy acknowledged

that the sonar program had experienced each of the problems cited in the report. (See pp. 19 and 22.)

Principal among the comments of the Navy and the sonar manufacturers were the views that the current model of the sonar was meeting all cost, performance, and delivery goals and that the Navy had no reasonable alternative to select from when it elected to produce the AN/SQS-26 sonar system before development had been completed. (See pp. 19, 22 and 23.)

In its review GAO found, and the Navy acknowledged, that the problems cited above had been experienced with the first three models of this sonar system. GAO did not evaluate the extent to which the latest sonar models attained specific goals because, in GAO's opinion, at the time it performed its review there was not sufficient information available on the performance of these models to permit such an evaluation to be made. (See p. 19.)

The degree to which the Navy had a reasonable alternative other than concurrent development and production of the AN/SQS-26 sonar is, of course, a matter of judgment. On the basis of Navy records made available to GAO, however, it appears that the substitution of an existing sonar system in new ships was technically feasible and, on the basis of fleet experience, would have been operationally desirable. (See p. 20.)

MATTERS FOR CONSIDERATION BY THE CONGRESS

Several committees and many members of the Congress have expressed a strong interest in major weapon systems and in the means by which their development and procurement can be improved. In a prior report to the Congress, "Need For Management Improvement In Expediting Development Of Major Weapon Systems Satisfactory For Combat Use" (B-163058, November 17, 1969), GAO suggested that, to enable the Congress to exercise appropriate legislative controls over the funding of major defense systems, the Congress may wish to require that the Secretary of Defense:

--Determine, prior to authorizing production of a new system or major modification of an existing system, that all its significant components have satisfactorily met all prescribed developmental tests.

--Notify the appropriate congressional committees in any case where the Secretary considers that authorization of production is essential, even though not all developmental tests have been satisfactorily completed: Such notification should include the reasons for authorizing concurrent development and production and the status of development of each significant component. (See p. 25.)

GAO believes that the Navy's experience with the AN/SQS-26 sonar further illustrates the need for the Congress to be provided with information showing when the practice of concurrent development and production is employed by the Department of Defense to acquire major defense systems.

Tear Sheet

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CHAPTER 1

INTRODUCTION

We have reviewed the Navy's development and acquisition of the AN/SQS-26 sonar system.[1] This is a hull-mounted, surface ship sonar system designed to detect, classify, localize, and track submerged submarines at long range from antisubmarine warfare ships. Pictures provided to us by the Navy--one of a sonar dome mounted on a ship's hull and another of display consoles of the sonar system--are included on pages 6 and 7, respectively. The AN/SQS-26 sonar system has a history spanning about 15 years.

ORIGIN OF THE AN/SQS-26 SONAR SYSTEM

Sonar systems in use prior to 1955 employed two different detection techniques. One technique, referred to as the passive mode, consisted of operating the sonar purely as an acoustic listening device to pick up underwater sounds. The second, known as the direct-path mode, consisted of operating the sonar by emitting from the ship sound signals that were transmitted through a relatively shallow layer of water. When the sound signals touched an object in the water, return signals (echoes) were generated. The echoes were received and used by sensitive listening devices on the ship to determine the detected object's range and depth. Such submarine detection systems usually had effective ranges to about 3.4 miles.

In the early 1950's the Navy evaluated the potential threat that would be posed by the Soviet submarine fleet in future years and concluded that there was a need for more effective antisubmarine warfare capability. The Navy believed that fulfillment of this need required a long-range sensing device capable of detecting and tracking submarines at greater ranges than previously attained.

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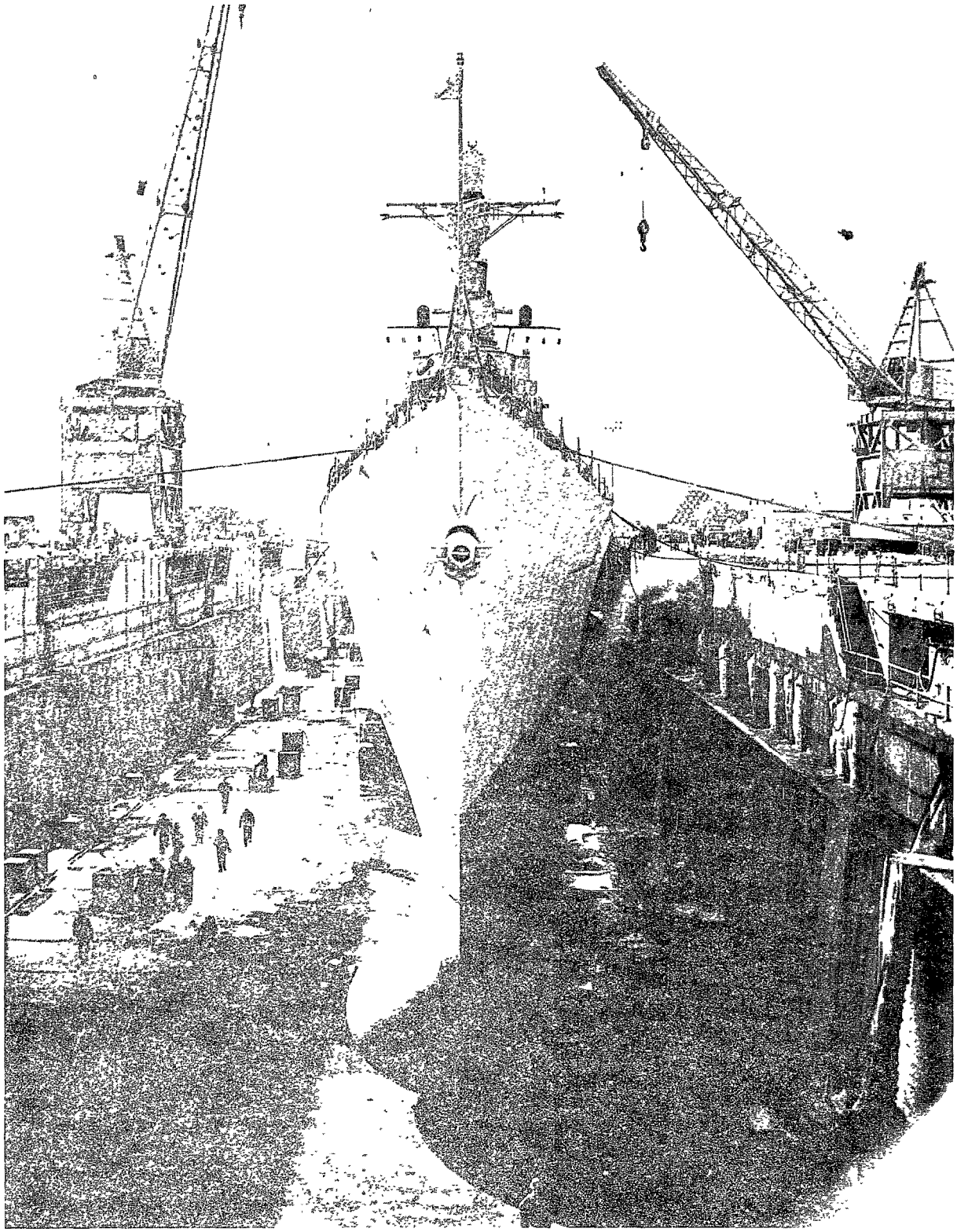
[1]The scope of our review is discussed on page 26.

At about the same time, the Navy was engaged in exploratory research to develop means of detecting and tracking submarines at long range. This research culminated in the development of two new detection techniques, each having long-range capabilities. These techniques are the bottom-bounce mode and the convergence-zone mode.

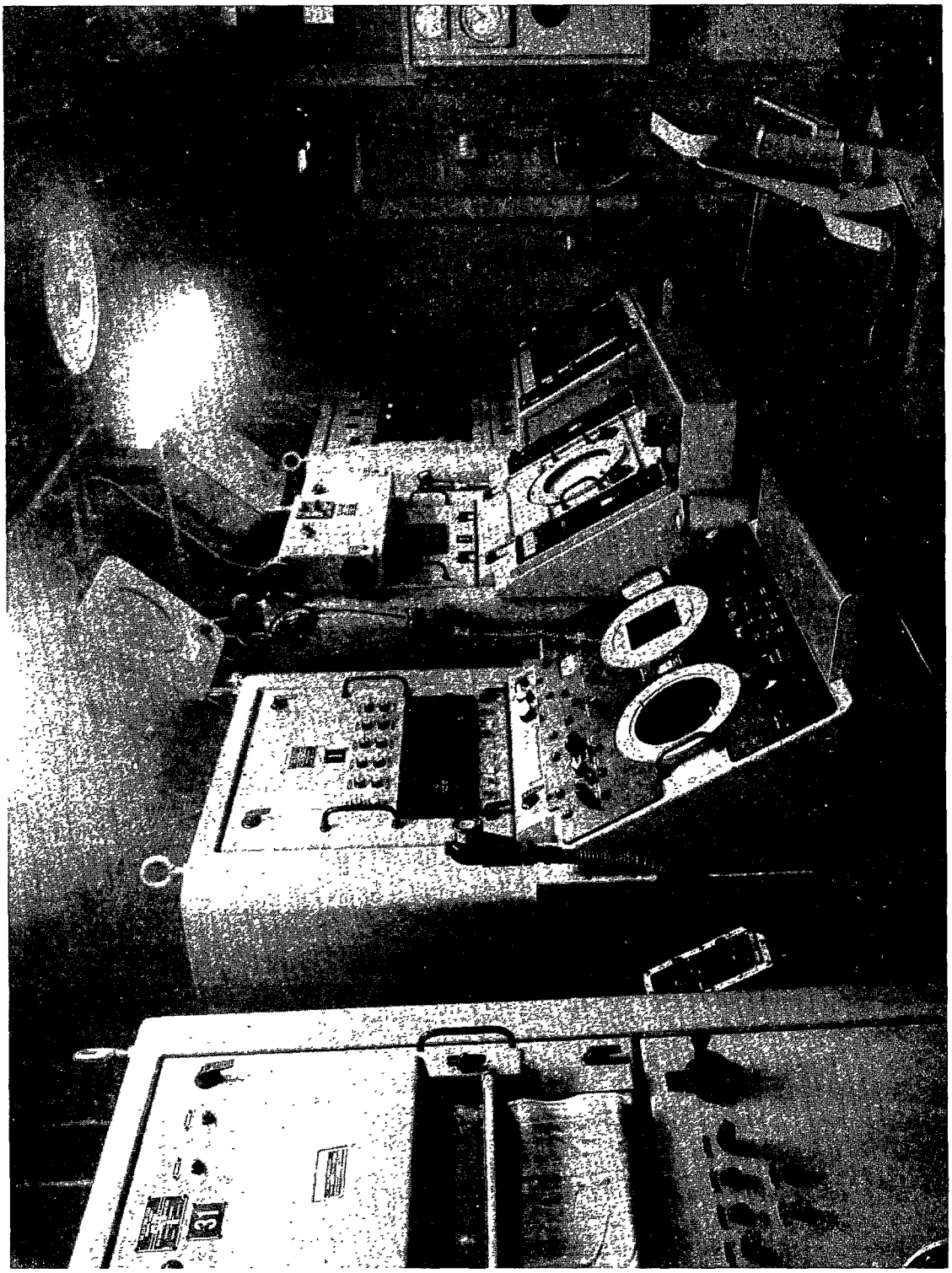
Bottom bounce results when a sound signal is directed at a downward angle so that the signal bounces off the ocean floor and deflects toward the surface. When the signal strikes an object, the echo from the detected object returns to the ship and is picked up by the sonar. In deep water, a downward-directed signal travels through several thermal layers of water until it reaches a layer which bends it back to the surface, and the return echo is picked up by the sonar. This technique is the convergence-zone mode.

In comparison with the direct-path and passive modes, the bottom-bounce and convergence-zone modes were found to provide greater range and depth detection possibilities. In view of this, the Navy decided to embark upon developing a sonar system employing these modes. Thus the AN/SQS-26 sonar system program was initiated.

The principal officials responsible for administration of the activities discussed in this report are identified in appendix IV.



AN/SQS-26 SONAR DOME XN-1 MODEL INSTALLED ON U.S.S. WILLIS A. LEE (DL-4)



DISPLAY CONSOLES AN/SQS-26 AX SONAR SYSTEM

CHAPTER 2

CONCURRENT DEVELOPMENT AND PRODUCTION OF THE AN/SQS-26 SONAR

The Navy expended over $429 million through fiscal year 1969 for the development and production of the AN/SQS-26 sonar system. This system has provided the Navy with certain antisubmarine warfare capabilities it did not previously have. With the possible exception of the most current models, however, performance of the system has been below expectations. Moreover, the system has experienced a substantial cost growth, and delivery of the system often has been delayed. In our opinion, the difficulties experienced with the system resulted, in large part, from the Navy's ordering the AN/SQS-26 sonar into production before it had been fully developed and tested and, to some extent, from the Navy's failure to recognize early in the sonar program the severity of the technical problems to be encountered.

INITIATION OF THE AN/SQS-26 SONAR SYSTEM PROGRAM

The Navy awarded a contract to Edo Corporation, College Point, New York, in May 1958 and another contract to General Electric Company, Syracuse, New York, in June 1958, each for an experimental model of the AN/SQS-26 sonar. The Edo model, designated the XN-1, and the General Electric model, designated the XN-2, were ordered for test-and-evaluation purposes. These models were to operate in the same frequency band and were to employ the four detection modes previously discussed--i.e., passive, direct path, bottom bounce, and convergence zone. The two models differed, however, both in equipment design and in operator controls and displays.

The XN-1 was scheduled for delivery to the Navy in November 1959 and the XN-2, in June 1960. It was the Navy's plan to perform an operational evaluation on the sonar in 1962 to determine its acceptability for service use. Delays were experienced, however, in the development programs for both experimental models. The XN-1 was not delivered until August 1961, and the XN-2 was not delivered until

February 1962--late delivery of 21 and 20 months, respectively. Further, the sonar was not approved for service use until November 1968, more than 6 years after the last experimental model was delivered.

While the experimental models were being developed, the Navy embarked upon a major shipbuilding program designed to modernize its destroyer escort force, a key element in the Navy's antisubmarine warfare operations. The shipbuilding plans for the new destroyer escorts included provision for installing the AN/SQS-26 sonar on these ships.

In May 1960, before either experimental model of the sonar had been delivered, the Navy awarded a contract to General Electric for the production of two operational AN/SQS-26 sonars that were to be installed on two of the new destroyer escorts. At the time that the contract was awarded to General Electric, it was known that difficulties were being encountered on both experimental models of the sonar and that there would be lengthy delays in their delivery. General Electric was selected to produce these two operational sonars primarily because the Navy believed that the XN-2 experimental model which General Electric was developing offered certain technical advantages over the XN-1 being developed by Edo.

In deciding to order the two AN/SQS-26 operational systems into production by General Electric, the Navy recognized that there were elements of technical risk involved. However, the Navy decided to accept the technical risks because it expected that the AN/SQS-26 sonar could be made to work; and, more important, the Navy believed that it was necessary to begin production as soon as possible in order not to delay construction of the ships for which the systems were intended.

SUBSEQUENT PROCUREMENT OF AN/SQS-26 SONARS

From September 1961 through January 1968, the Navy ordered 85 additional AN/SQS-26 sonar systems to meet the needs of its new antisubmarine warfare ships under construction. These 85 systems--purchased during a period when serious design and performance problems were known to exist

in the AN/SQS-26 sonar and before the Navy had completed its test-and-evaluation program and had approved the system for service use--were purchased under four contracts, three awarded to General Electric and one to Edo, for three different models of the system, as follows:

Month of contract award	Type of contract	Contractor	Model	Number of systems
Sept. 1961	Fixed price-redeterminable	General Electric	AN/SQS-26AX	12
June 1962	Fixed price	Edo	AN/SQS-26BX	18
Oct. 1964	do.	General Electric	AN/SQS-26CX	28
Jan. 1968	do.	do.	AN/SQS-26CX	27
				85

The Navy plans to continue buying these sonar systems through fiscal year 1973 and expects that they will all be identical to the CX model to the greatest extent practicable.

Each of these models incorporated changes over the previous models, and many of these changes were made to overcome numerous system problems revealed by the Navy's test-and-evaluation program conducted during the years 1962-68 (discussed in ch. 3) and by operational experience with the system after it was introduced into the fleet (discussed in ch. 4).

Further, after the Navy became aware of the problems with the earlier models of the system, an improvement program was initiated. In March and April 1965, General Electric was awarded contracts to replace the original two production systems and to provide kits that would modify the AX model to eliminate critical design deficiencies and to incorporate various new features. Deliveries of the modification kits to the Navy have been completed. The kits, however, had not been installed on all AX sonars aboard ships at December 31, 1969. The modified AX model became known as the AXR model.

CHAPTER 3

TEST-AND-EVALUATION PROGRAM

Navy testing of new electronic equipment leading to service approval usually consists of a two-phase program. The first phase is a technical evaluation designed to determine whether the new equipment meets technical design specifications. Following successful completion of the technical evaluation, the Navy conducts an operational evaluation. The operational evaluation determines the suitability of the new equipment for use under normal operating conditions when it is maintained and operated by regular Navy personnel.

The Navy selected the XN-2 experimental model to be the sonar system upon which the test-and-evaluation program would be conducted. The XN-1 was used for certain other tests which were conducted, for the most part, as supporting development and evaluation to complement the test-and-evaluation program on the XN-2.

In the technical evaluation of the XN-2, a number of tests were conducted at sea aboard the U.S.S. WILKINSON during the period November 1962 through March 1963. These tests were carried out under controlled conditions and were supervised by engineers and highly skilled technicians.

During the technical evaluation, XN-2 performance was adversely affected by considerable downtime due to equipment reliability problems which, according to the Navy, resulted from the inherently low reliability of components used in this system and in the early production models.

In March 1963, because of serious problems with systems performance, the technical evaluation was suspended and a special test program was undertaken to identify and correct system deficiencies. Following this, the XN-2 underwent major modification and refurbishment to improve system performance. In September 1963 sea tests were resumed and continued through December of that year. Finally, although additional problems were encountered, submarine detection performance, with certain exceptions, was demonstrated in all modes; and the Navy concluded that the XN-2 was ready for operational evaluation.

In January 1964 the operational evaluation of the XN-2 began. The evaluation was suspended about 6 months later because of a multitude of deficiencies, the most important of which was that, because of component reliability problems, the bottom-bounce capability of the XN-2 was found to be virtually nonexistent in operational application. Further, significant downtime was experienced because of numerous equipment failures and because fleet personnel were having considerable difficulty in maintaining the equipment.

In June 1964 a special program was initiated to correct the problems encountered during the operational evaluation. The XN-2 underwent additional tests and a major retrofit program to correct design deficiencies. Upon completion of this program, the XN-2 became known as the XN-2R. After a checkout period, a technical evaluation on the XN-2R began in July 1967. Serious design problems and inconsistencies were encountered again; and, during numerous sea trials, equipment performance varied. The technical evaluation team reported that the system could detect submarines in all four detection modes; however, reports on this technical evaluation indicate that the system was not tested to determine its performance under a number of operating conditions in which the sonar system was required to operate--i.e., prescribed ship speeds, wind velocity, and sea state. According to the Navy, ship speed was lowered in order to compensate for the high self-noise level of the test ship. Nevertheless, in October 1968 the Navy reported that the XN-2R had successfully completed the technical evaluation; and, on November 4, 1968, the AN/SQS-26 sonar system was approved for service use.

The Navy has informed us that, because the AN/SQS-26 sonar has already been service approved, an operational evaluation will not be performed. Instead, the Navy will conduct an "operational appraisal" of the AN/SQS-26 sonar. The objective of an operational appraisal is to obtain controlled test performance data, to determine whether training and support is adequate, and to determine whether changes are needed and retrofit is justifiable. This operational appraisal will be conducted using the CX model because the ship on which the operational evaluation originally was being done has been decommissioned.

CHAPTER 4

EFFECT OF CONCURRENT DEVELOPMENT AND PRODUCTION OF THE AN/SQS-26 SONAR SYSTEM

The degree to which objectives of the AN/SQS-26 sonar program have been achieved is difficult to assess because many program objectives were not defined when the program was initiated. For example, detection ranges and reliability/maintainability standards were not prescribed when the program began. Also there were a number of changes made to the objectives and the sonar equipment after the program had begun. To the extent that objectives were stated, however, it appears that many were not met. In this regard, performance of the sonar has not met the Navy's expectations, costs of the equipment have substantially exceeded original estimates, and delivery of equipment has often been delayed. These and other matters related to the management of this program are discussed below.

PERFORMANCE

Although this sonar system has provided the Navy with certain antisubmarine warfare capabilities that the Navy did not previously have, system performance requirements have not been achieved in a number of areas for early models of the AN/SQS-26 sonar installed on operational ships. Information regarding the areas where performance has not met requirements is not included in this report because the Navy informed us that this information is classified.

Operational AN/SQS-26 systems also experienced frequent periods of inoperability due to component failures. In many instances the inoperable periods were quite lengthy because of material shortages or inability to repair the equipment. This was especially true in the early years of the program. Over the years design deficiencies were identified and corrected by modifications to existing models or by redesign of succeeding models. Some of the problems, however, still persist today, such as deficiencies involving reliability and safety of the power supply and maintainability of the sonar dome.

The Navy has informed us that the current models of the AN/SQS-26 sonar are meeting or exceeding operational requirements. As discussed in chapter 5, we believe that the available information on the operation of these models is not sufficiently conclusive to permit us to form a judgment on the adequacy of their performance.

COSTS

Current funding data provide for greater quantities of the sonar system than were provided for in such data during the early stages of the program. Consequently, comparison of today's total program costs with earlier cost estimates is not meaningful. Substantial increases over an earlier estimate have been experienced, however, in system development costs and in production unit costs; and we believe that, in large part, these increases reflect the problems encountered by the Navy in attempting to obtain a system that meets its original expectations.

The Navy's development plan for the AN/SQS-26 sonar, dated May 1960, showed an estimated development cost of about $12 million for the system. This plan, which showed data for a 7-year period beginning in fiscal year 1958, indicated that the major portion of development funding would be incurred by the end of fiscal year 1962. Development and related funding of the system, however, have been extended to the present time. Expenditures for development of the AN/SQS-26 system through fiscal year 1969 amounted to about $92.6 million.

As of January 1969 the Navy's estimate of total development funding for the program, as shown in the supporting data for the fiscal year 1970 budget estimate, was about $101 million. This represents an increase in estimated development cost of about $89 million, a cost growth of about 740 percent over the $12 million estimate prepared in 1960.

The 1960 development plan also showed an estimated unit cost of about $1.03 million for each production model. Data provided to us by the Navy indicate that the cost for each production model has been substantially higher than the 1960 estimate. This was especially true of the first two production models which had to undergo substantial modification

during the improvement program initiated in 1965 (see p. 10) to overcome deficiencies and to incorporate new features deemed necessary after the test-and-evaluation program got under way and the fleet began obtaining experience in using the sonar system. The unit costs, including the power supply but exclusive of installation costs, were as follows:

	Unit costs		
	Original system	Modifications	Total
	(millions)		
AN/SQS-26	$2.6	$2.1[a]	$4.7
AN/SQS-26AX	1.8	2.1	3.9
AN/SQS-26BX	1.9	-	1.9
AN/SQS-26CX	2.3	-	2.3

[a]The original model was replaced with new systems which were identical to the AXR model.

Navy records show that a total of about $429.4 million was expended on the AN/SQS-26 sonar from program inception through fiscal year 1969. These expenditures and the purposes for which they were made are shown below.

	Expenditures (millions)
Development	$ 92.6
Purchase of production units	290.0
Other (test equipment, training courses, etc.)	46.8
Total	$429.4

DELIVERY

Late delivery of AN/SQS-26 sonars and, in some instances, related delays in shipbuilding programs have been common in the AN/SQS-26 sonar system program. Of 75 production units of the sonar delivered through December 1969, 53 were delivered from 1 to 20 months later than originally specified in the production contracts. In several instances

the contract delivery schedules were revised to extend the delivery date.

We discussed the late delivery of the sonars with a Navy contracting official who informed us that the shipbuilding program with which the AN/SQS-26 sonars were associated had incurred delays for a number of reasons and that one of these reasons was late delivery of the sonars. In this regard, most of the 28 CX systems procured in 1964 were delivered about 5 to 7 months later than required by the original contract delivery schedule. Most of these systems were to be installed on new destroyer escorts of the DE-1052 class. According to the Navy, late delivery of the sonars was anticipated at the time the initial contracts were awarded for these ships. As a result, agreements were reached with the shipbuilders so that, about 6 months after the ship contracts were awarded, the contracts were modified at no cost to the Government to extend ship deliveries by 5 months because of delayed sonars.

Late delivery of design information relating to the AN/SQS-26 sonars also contributed to increased costs for the DE-1052 class ships. One shipyard was given the responsibility for developing the shipbuilding plans for all ships of this class. Delays by the sonar contractor in providing this shipyard with information regarding the configuration of the sonar system, which was needed to develop space arrangements, foundation requirements, and cabling requirements, contributed to a major claim from the shipyard. In 1969 the Navy and the shipbuilder agreed to a settlement of over $96 million for the shipbuilder's claim for compensation because of Government-caused delays in the shipbuilding program. The Navy informed us that, although unavailability of AN/SQS-26 sonar information was one of the factors involved in the delays, the specific portion of the claim attributable to this factor could not be readily determined. A Navy official informed us that additional claims involving the AN/SQS-26 sonar had been submitted by two other shipbuilders and that these claims were expected to be settled in 1970.

Navy documents indicate that the delivery schedule slippages of the early AN/SQS-26 CX sonars produced by General Electric were basically attributable to inadequate

engineering effort. In this regard, the Navy concluded that General Electric had spread its engineering effort thinly over the three AN/SQS-26 efforts that it was concurrently undertaking--design and production of the CX model, the AXR model, and the XN-2R model. When major design problems arose in the development of the XN-2R, the contractor had its engineering staff put first priority on the XN-2R at the expense of work on the CX model and the AXR.

COMPLEXITY OF EQUIPMENT

By being designed to incorporate two detection modes not previously used, as well as including new state-of-the-art techniques, the AN/SQS-26 sonar became more complex than any of its predecessor surface ship sonar systems. The Navy records that we reviewed indicated to us that this increased complexity adversely affected fleet performance, particularly from the standpoint of equipment operation and maintenance. This was especially true of the earlier models of the AN/SQS-26 sonar system. At the time of our review, there had been little fleet experience with the later models (AXR and CX models).

LOGISTIC SUPPORT

Excluding the two experimental models, there have been five separate models of the sonar system in the fleet. Even after the AXR retrofit program is completed, there will still be three separate models--the AXR, BX, and CX--in the fleet. Because of differences in the various models, there has been a general lack of commonality among the assemblies making up these models, although, according to the Navy, the AXR systems have a degree of commonality of assemblies with the CX systems. However, it has been necessary for the Navy supply system to stock many more types of spare parts for the AN/SQS-26 sonar system than would have been necessary if there had been only one model of the system. We have not attempted to measure the extent of added cost and other effects that this condition has had on the Navy supply system.

TRAINING PROGRAMS

Prior to 1964 there was no formal training program for sonar operators and maintenance men for the AN/SQS-26 sonar. After training programs were established, it became necessary to have a separate program for each model because of the differences in equipment configuration which required separate training manuals, repair techniques, operating procedures, and display interpretations. In the early phases of the sonar program, fleet commanders complained that operational effectiveness was impaired because of the shortage of trained sonar operators and maintenance personnel.

We did not attempt to evaluate the effectiveness of the training programs or to determine the added cost of having to train operators and maintenance personnel for each sonar model.

CHAPTER 5

DEPARTMENT OF THE NAVY COMMENTS

The Assistant Secretary of the Navy (Financial Management), in commenting on a draft of this report in his letter of July 28, 1970 (app. I), agreed that the AN/SQS-26 program had experienced each of the problems cited in this report. He stated, however, that the report did not cite the notable successes achieved under the program, with particular emphasis on results since 1966, and that demonstrated performance had met or exceeded, in all respects, the specific operational requirements for the sonar. He stated further that the Navy had no alternative means of meeting the antisubmarine warfare threat when it accepted the risk of concurrent development and production of the AN/SQS-26 sonar.

With respect to the Assistant Secretary's comment that the notable successes achieved under the program have not been cited in this report, we believe that two points should be made. First, if successful performance was achieved on the sonars produced since 1966, this performance was not available to the fleet until mid-1969. Prior to that time, the fleet was operating with earlier models of the sonar that were not providing the antisubmarine warfare capability that was expected of them.

Secondly, the successes in the sonar program cited by the Navy in its comments relate only to the most recent sonar models--the AXR and CX models. There are only a few units of these two models now in the fleet. We reviewed reports received from ships on which these models are installed. In many instances these reports comment favorably on the performance of the sonars, but the reports do not evaluate performance in relation to established operational requirements, nor do they, in our opinion, contain sufficient information to permit such an evaluation to be made. Moreover, a Navy official informed us that the Navy's view that the current models met or exceeded operational requirements was based on the technical evaluation test for the XN-2R model and on factory tests. In view of the past history of this sonar program, we question the wisdom of

relying upon such tests to conclude that performance of these later models meets or exceeds operational requirements.

In this connection, testing under less than operational conditions could provide results that differ from performance when the equipment is used at sea aboard antisubmarine warfare ships. For the current models, such tests involved testing (1) assemblies rather than a complete system, (2) in the absence of expected environmental conditions, and (3) controlled by highly trained technicians and engineers rather than by Navy electronics personnel who would be expected to operate the equipment. The same types of tests were conducted on the earlier sonar models, and it was found that operational performance at sea differed from the results of factory tests and the technical evaluation.

The degree to which the Navy had a reasonable alternative of meeting the antisubmarine warfare threat other than by concurrent development and production of the AN/SQS-26 sonar is, of course, a matter of judgment. In detailed comments accompanying the Assistant Secretary's letter of July 28, 1970, we were advised that the other options available to the Navy at the time that the concurrency decisions were made were (1) to delay the shipbuilding program until the AN/SQS-26 sonar test and evaluation programs had been completed, or (2) to contract for older model sonars (AN/SQS-23) for the new destroyer-type ships--the latter being costly since it would have required eventual replacement by AN/SQS-26 sonars.

With respect to the first of the two options, we would not suggest that the shipbuilding program should have been delayed, since we recognized that such action might have compromised fleet effectiveness. However, with respect to the second option--use of the AN/SQS-23 sonar--it appears that this might have been an acceptable alternative.

A Navy Underwater Sound Laboratory technical memorandum prepared in April 1958 stated that the AN/SQS-23 sonar could be modified to include a bottom-bounce capability and could be delivered in calendar year 1958. The memorandum concluded that:

> "*** a simple modification to the AN/SQS-23 for bottom bounce operation, would appear to be worthwhile for the cost involved. Bottom bounce operation should be possible in certain areas and some basic information should be obtainable for future systems."

In April 1964, after the Navy began using AN/SQS-26 sonars on operational ships, the Commander in Chief, Atlantic Fleet, became concerned over the sonar's poor performance and recommended that all planned procurements of the sonar be canceled, that new construction ships be equipped with AN/SQS-23 sonars, and that the entire AN/SQS-26 program be reviewed to correct deficiencies in the sonar. As a result of fleet experience with the sonar at that time, he stated:

> "It is, however, my firm conviction that we cannot afford any more destroyer types with their raison d'etre, i.e., their sonar, in a less than fully operational status. In this regard, I object strongly to premature production of large numbers of complex expensive equipments which have not been proven operationally."

We recognize that substituting the AN/SQS-23 sonar, either on a fulltime or temporary basis, would have involved certain additional costs to the Navy. However, had this substitution been made and had the AN/SQS-26 sonar system been fully developed and tested before it was placed into production, the $29 million AXR retrofit program would not have been necessary.

Moreover, on the basis of the information available to the Navy early in the sonar program, it appears to us that using the AN/SQS-23 sonar until the AN/SQS-26 sonar was fully developed and tested would have been technically feasible and operationally desirable. As discussed above, the Navy Underwater Sound Laboratory found that the AN/SQS-23 sonar could be modified to include the bottom-bounce capability, and the Commander in Chief, Atlantic Fleet, preferred the AN/SQS-23 sonar over the earlier models of the AN/SQS-26 sonar, because under actual operating conditions the latter performed poorly.

CHAPTER 6

COMMENTS OF AN/SQS-26 CONTRACTORS

Comments on a draft of this report were also obtained from General Electric Company (app. II) and Edo Corporation (app. III), contractors for development and production models of the AN/SQS-26 sonar.

In its comments, General Electric stated that the problems that are to be expected in any complex development program involving significant advances in technology had been overcome before the preproduction phase of the AN/SQS-26CX was completed in 1967. In stating this view, General Electric failed to give recognition to the problems encountered by the Navy with the earlier sonar models and to the fact that these problems resulted from the production of the sonars before development and testing had been completed.

Moreover, although the preproduction phase with associated testing of the CX model may have been completed in 1967, it appears that all problems with this sonar system may not have been identified and solved at that time. In this regard, U.S. Navy Underwater Sound Laboratory, responsible for monitoring technical aspects of the AN/SQS-26 program, in a report dated May 1968, stated that preproduction test data had been, for the most part, completed. In the report, however, the Laboratory stated that sea tests being conducted with the XN-2R model had disclosed important deficiencies that would have an impact on AN/SQS-26 production hardware if they were not corrected. It therefore appears questionable whether all the problems associated with the AN/SQS-26 were resolved in 1967, as indicated by General Electric.

In its comments, General Electric Company also indicated that our draft report did not sufficiently emphasize the increase in capability that the AN/SQS-26 sonar provides over other sonars, that the report was overly critical of the reliability and maintainability of AN/SQS-26 sonars, and that the report gave an erroneous impression regarding the timeliness of delivery of General Electric-produced sonars.

We agree that the AN/SQS-26 sonar, if it performs as desired, will represent a significant improvement over pre-AN/SQS-26 sonars in the field of submarine detection. In citing the performance of the current model of the AN/SQS-26 sonar as an example of high reliability and maintainability, however, General Electric did not consider that its earlier production models of the AN/SQS-26 had to receive extensive retrofit and that one of the principal reasons for this was low reliability. Had a complete and timely testing program been conducted on the experimental models, this problem could have been disclosed prior to manufacture of the production models.

General Electric stated that it had generally met or exceeded its AN/SQS-26 contract delivery schedules. In many instances, however, these delivery schedules had been revised to extend the initial delivery dates. Thus, although General Electric, for the most part, might have met the revised dates, the Navy received the sonars later than was originally required to meet the needs of its shipbuilding program.

Both General Electric and Edo were of the opinion that the decision to approve concurrent development and production for the AN/SQS-26 sonar was correct. This matter is discussed on pages 20 and 21.

CHAPTER 7

GAO VIEWS ON CONCURRENT DEVELOPMENT AND PRODUCTION

As stated in this report, we believe that the difficulties experienced with the AN/SQS-26 sonar system resulted, in large part, from the Navy's ordering the sonars into production before they were fully developed and tested. The practice of concurrently developing and producing weapon systems was a matter of concern to the Blue Ribbon Defense Panel appointed by the President and the Secretary of Defense in July 1969 to study the organization, structure, and operations of the Department of Defense. In its report of July 1, 1970, the Panel recommended that:

> "A new development policy for weapon systems and other hardware should be formulated and promulgated to cause the reduction of technical risks through demonstrated hardware before full-scale development, and to provide the needed flexibility in acquisition strategies."

The Panel's report also stated that the new policy should provide:

> "A general rule against concurrent development and production, with the production decision deferred until successful demonstration of developmental prototypes."

In our report to the Congress, "Adverse Effects Of Large-Scale Production Of Major Weapons Before Completion Of Development And Testing, Department of the Navy" (B-163058, November 19, 1970), we recommended that the Navy revise its instruction on concurrent development and production to provide for the submission of meaningful data to the Assistant Secretaries who make concurrency decisions. In addition, we recommended that the Navy Audit Service give consideration to making regularly scheduled audits into the practice of concurrent development and production. These recommendations were generally agreed to by the Navy, and we are not making further recommendations at this time.

MATTERS FOR CONSIDERATION BY THE CONGRESS

In a prior report to the Congress, "Need For Management Improvement In Expediting Development Of Major Weapon Systems Satisfactory For Combat Use" (B-163058, November 17, 1969), we suggested that, to enable the Congress to exercise appropriate legislative controls over the funding of major defense systems, the Congress may wish to require that the Secretary of Defense:

--Determine, prior to authorizing production of a new system or major modification of an existing system, that all its significant components have satisfactorily met all prescribed developmental tests.

--Notify the appropriate congressional committees in any case where the Secretary considers that authorization of production is essential, even though not all developmental tests have been satisfactorily completed. Such notification should include the reasons for authorizing concurrent development and production and the status of development of each significant component.

We believe that the Navy's experience with the AN/SQS-26 sonar further illustrates the need for the Congress to be provided with information showing when the practice of concurrent development and production is employed by the Department of Defense to acquire major defense systems.

CHAPTER 8

SCOPE OF THE REVIEW

Our fieldwork, completed during fiscal year 1970, included an examination of technical development plans, specific operational requirements, technical reports, contract files, concurrency authorizations, correspondence files, and various other project documents necessary for developing a complete history of the AN/SQS-26 program from inception to its current status. In performing the review, we analyzed pertinent records and interviewed responsible officials at the Naval Ship Systems Command, Washington, D.C.; the Navy Underwater Sound Laboratory, New London, Connecticut; and the Navy Operational Test and Evaluation Force, Norfolk, Virginia. We also obtained cost and funding data, compared sonar performance with established requirements, developed a chronological history of the system, and analyzed various problem areas.

APPENDIXES

DEPARTMENT OF THE NAVY
OFFICE OF THE SECRETARY
WASHINGTON, D. C. 20350

28 JUL 1970

Dear Mr. Bailey:

The Secretary of Defense has asked me to reply to your letter of 28 May 1970 which forwarded the GAO draft report on adverse effects of producing the AN/SQS-26 surface ship sonar system before completion of development and tests.

I am enclosing the Navy reply to the report.

Sincerely,

Charles A. Bowsher

CHARLES A. BOWSHER
ASSISTANT SECRETARY OF THE NAVY

Mr. Charles M. Bailey
Director, Defense Division
U. S. General Accounting Office
Washington, D. C. 20548

Encl:
(1) Department of the Navy Reply to GAO Draft Report of 28 May 1970 on Adverse Effects of Producing the AN/SQS-26 Surface Ship Sonar System Before Completion of Development and Tests (OSD Case #3120)

Department of the Navy Reply

to

GAO Draft Report of 28 May 1970

on

Adverse Effects of Producing the AN/SQS-26 Surface Ship Sonar System Before Completion of Development and Tests, Department of the Navy

(OSD Case No. 3120)

I. GAO Findings and Conclusions.

GAO reviewed the Navy's development and acquisition of selected antisubmarine warfare systems at the request of Congressman Sidney R. Yates. This report covers the AN/SQS-26 sonar, a hull-mounted, surface ship sonar system designed to detect, classify, localize, and track submerged submarines at long range from ASW (Antisubmarine warfare) ships. GAO states that the AN/SQS-26 sonar system has a history spanning about 15 years, and through June 1969, had cost the Government over $429 million. Sonar systems in use prior to 1955 employed two techniques, i.e., the passive mode and the direct-path mode. In the early 1950's the Navy evaluated the potential threat that would be posed by the Soviet submarine fleet and concluded that a more effective ASW capability was needed to detect and track submarines at long-range. Navy research culminated in the development of two new detection techniques having long-range capabilities, i.e., the bottom-bounce mode and the convergence-zone mode. To develop a sonar system employing these modes, the Navy initiated the AN/SQS-26 system.

GAO states that the Navy began procurement of the AN/SQS-26 sonar for fleet use before initial development and testing were completed. GAO found that: (1) the system has provided the Navy with certain ASW capabilities it previously did not have; (2) performance of the system has been below expectations; (3) the systems development cost increased from an estimated $12 million in May 1960, to an estimated $101 million as shown in supporting data for the FY 70 budget estimate; and (4) delivery of the individual sonar systems has often been delayed.

GAO makes no recommendations.

II. Navy Position

The AN/SQS-26 sonar program did experience each of the problems cited in the GAO report during the eleven (11) year span covered. The report does not cite the notable successes that the program has achieved, or the fact that since 1966, the AN/SQS-26 sonar program has been characterized by the firm adherence to planned delivery schedules, estimated costs, standardization criteria, successful completion of technical evaluation, service approval, and demonstrated performance equal to or exceeding in all respects the specific operational requirements.

The Navy had no reasonable alternative means of meeting the ASW threat when it accepted the risk of pursuing concurrent development and production of the AN/SQS-26 sonar. The requirement for improved ASW detection performance in new construction ships forced the Navy to accept this risk.

GAO note: The Navy's reply included detailed comments on specific paragraphs in the report draft. These comments were lengthy and, therefore, are not included herein. They were, however, appropriately considered in the preparation of this report.

GENERAL ELECTRIC
COMPANY
ELECTRONIC SYSTEMS DIVISION

ROY H. BEATON
VICE PRESIDENT

P.O. BOX 1122
SYRACUSE, NEW YORK 13201

July 1, 1970

Mr. C. M. Bailey, Director
United States General Accounting Office
Defense Division
Washington, D. C. 20548

Dear Mr. Bailey:

As stated earlier in my June 16 letter to Mr. J. L. DiGuiseppi, the General Electric Company appreciates the opportunity to review and comment on the draft copy of your proposed report to the Congress on "Adverse Effects of Producing the AN/SQS-26 Surface Ship Sonar System Before Completion of Development and Tests by the Department of the Navy." I wish to thank Mr. DiGuiseppi for his prompt response of June 19, extending the due date of our comments to July 28, 1970. As you can see, we have made a strong effort to beat this deadline, in order that you may have sufficient time to consider our comments on this draft report.

We have approached our review of this draft report as objectively as possible, with primary attention to its overall content in comparison with our knowledge of the program. In addition, we have carefully reviewed the report to determine what might appear to us to be possibly significant errors in fact and omission. We are summarizing in this letter our comments on those points which we feel are of particular importance for your consideration of change. Specific items which we feel should be either corrected or amplified are contained in "Attachment A" to this letter. [See GAO note.]

General Comments:

As your report indicates, the General Electric Company has been involved in the AN/SQS-26 sonar program since 1958, when we received a contract for the experimental XN-2 model. As one might reasonably expect, any complex development program involving significant advances in sophisticated technology is bound to encounter some problems during its early stages. On this program, however, problems such as these were overcome before the preproduction phase of the AN/SQS-26 CX was completed in 1967. Reports which we have received from operating personnel in the Navy indicate a high degree of satisfaction with the performance at sea of both the CX equipments and AXR models. Additionally, we are especially proud that all 57 systems delivered through December 31, 1969, with the exception of ten that were only one to two months late, have been delivered by General Electric on or ahead of contract schedules. Still further, all of the AXR modification kits were delivered on schedule.

GAO note: Attachment A to this letter included detailed comments on specific statements in the report draft. These comments expanded on the matters discussed in this letter and were relatively lengthy. Therefore, these comments are not included herein, but they were appropriately considered in the preparation of this report.

Mr. C. M. Bailey

I. Performance Capability:

The draft report states that, although the AN/SQS-26 provides the fleet with "certain ASW capabilities it previously did not have", system performance requirements "have not been achieved in a number of areas" (unidentified). Actually, the added capabilities which the AN/SQS-26 provides, compared with all other available surface ship sonars, represents a quantum jump in terms of the effectiveness of the surface ship's ASW capabilities. Pre-SQS-26 sonars are limited to ranges of three to four miles in the shallow surface layer of the ocean and are not capable of detection below that layer. The much greater range of the AN/SQS-26 in the surface layer, when combined with the below-layer capabilities provided by the convergence-zone and bottom-bounce modes of operation, add orders-of-magnitude to the coverage previously provided by individual ships, thereby tremendously increasing their effectiveness. Production model AN/SQS-26 systems delivered by General Electric Company have met all technical performance specifications contractually called for, which, we believe, reflect the Navy's operational requirements.

II. Delivery:

The draft report states that AN/SQS-26 deliveries have often been delayed and implies that sonar deliveries may have had a major effect on shipbuilders' extra cost claims. Statements such as "of 75 production sonars delivered through December, 1969, 53 were delivered from 1 to 20 months late" imply that significantly late deliveries by General Electric existed throughout the program. A summary of General Electric's record on production deliveries through December 31, 1969, is as follows:

5 were 2 months later than contract
5 were 1 month later than contract
47 were on or ahead of schedule

With the exception of one CX training equipment that was one month late, all deliveries since December, 1963, have been on or ahead of contract schedules, either as originally issued or revised before due dates. General Electric has not been informed by either the Navy or by the shipyards, with whom we have separate contracts to assist in installation work, that CX equipment deliveries have actually been a limiting item in ship deliveries. In addition, we have not witnessed any case where it appeared that the CX sonar delivery has held up ship delivery.

III. Reliability/Maintainability:

The draft report is written in a manner that is highly critical of the SQS-26 sonar's reliability and maintainability. This criticism is undeserved, in our judgment, because we are particularly proud of having exceeded much more stringent specifications and goals in these areas than had ever been called for or achieved in predecessor sonar systems. Actually, General Electric CX equipment demonstrated a mean-time-between-failures (MTBF) of three times better than contract requirements. In addition, fleet performance reports reaching us are excellent and highly laudatory.

Mr. C. M. Bailey

IV. Concurrent Development/Production:

In stating that the result of going ahead with production before resolution of all technical problems produced delivery delays and cost growth, the draft report implies that there were alternatives available to the Navy which would have been less costly and/or more timely. We feel that a discussion of potentially available alternatives is essential to this type of report, if the reader is to obtain an objective analysis in at least some depth. Since General Electric does not have all of the information necessary to perform such an in-depth analysis, we have not attempted to do so. In reviewing the facts which we do have, however, we do not believe that there was any alternative open to the Navy at the time that could have completely met the ASW threat to which the AN/SQS-26 program was directed.

Summary:

Recognizing the importance of this intended report to the Congress, we respectfully request that serious consideration be given to modification and changes in the areas on which we have commented. We believe that such changes would give a more balanced picture of the true performance gain in sonar capabilities that resulted from the program, the improvement in results that occurred throughout the life of the program, and the Navy alternatives that were available when the original decisions to proceed were made.

In any event, we again wish to express our appreciation for the opportunity to review this draft report. We hope that our comments will be of some positive benefit. Please be assured that General Electric will be happy to be of any further assistance desired in discussing or clarifying our comments.

Very truly yours,

R. H. Beaton
Vice President and General Manager
Electronic Systems Division

RHB:mz
attachment

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EDO corporation

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CABLE ADDRESS "SEAFLOATS" NEW YORK
TELEPHONE 212 445-6000

10 July 1970

Mr. C. M. Bailey, Director
United States General Accounting Office
Defense Division
Washington D. C. 20548

Dear Mr. Bailey:

Thank you for inviting us to comment on your proposed report to the Congress on "adverse effects of producing the AN/SQS-26 Surface Ship Sonar System before completion of development and tests by the Department of the Navy".

We certainly agree that there were disadvantages to producing the AN/SQS-26 prior to completion of development and test. However, the disadvantages must be weighed against the advantages to be gained in producing "next generation" hardware in time to meet an existing threat. Further, the alternatives insofar as operational readiness must be considered. Despite our most sophisticated tools for establishing and solving complicated math models and scenarios, the final decision is still a matter of judgment.

The initiation of the AN/SQS-26 Program in the late 1950's was motivated by a much more critical consideration than the attainment of longer detecting and tracking ranges. It was well known that even the very best hull mounted sonar systems, available at that time, were limited to unacceptably short detection ranges in adverse water conditions, a situation existing in ocean areas of great interest to the U.S. Navy. This limitation was clearly inhibiting any real improvement in surface ship ASW capability.

The appearance of the nuclear submarine, with its overwhelming improvement in speed, endurance and depth, crystallized the need for "reliable" detection independent of water conditions. The advancement of the nuclear submarine to operational status emphasized the urgency

of developing a system with the potential to cope with this problem.

Research and development tools had demonstrated the feasibility of detection by employing bottom bounce and convergent zone techniques. So, the SQS-26 Program designed to exploit these techniques, was initiated to achieve a new capability rather than to improve an existing one. When a major shipbuilding program was launched, dedicated to improving our ASW capability, the SQS-26 System became a prime candidate for "concurrency" consideration. We believe that under the circumstances, the correct decision was made. Had the decision been delayed, the new ships would have been designed to accommodate sonars existing in 1958 and it would have been prohibitively expensive, if even possible, to backfit the AN/SQS-26 System. Further, the growth potential of our surface ship ASW capability would have been severely limited.

Edo Corporation's involvement in the AN/SQS-26 Program was confined to the XN-1 experimental model and the BX production model.

The XN-1, delivered to the Navy for installation in December 1960, served as a vehicle for providing knowledge of the environment, refining specification requirements and for demonstrating the bottom bounce and convergent zone techniques. The development of the XN-1 resulted in an operational transducer (sound projector and echo receiver) design of such increased efficiency that substantial savings were possible in the auxiliary electrical systems of ASW vessels using the SQS-26. The XN-1 also pushed the state of the art in many other areas and remained an operational fleet sonar for some eight years until the Willis A. Lee (DL-4) was mothballed in July 1969.

The AN/SQS-26 (BX) was awarded to Edo Corporation in June 1962. The last of the eighteen (18) equipments was delivered in December 1966. Although a relatively short time elapsed between the XN-1 and BX award (four years), the state of the art in solid state circuitry had advanced almost a generation. Consequently, the BX was specified and designed as a totally solid state system as compared to less than a 50 percent solid state content in the XN-1. In addition, after award of the BX, the so called "ility" disciplines (reliability, maintainability, etc.) were introduced and the BX was required to accommodate these both in design and test. Despite these and many other

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changes from the XN-1, the first BX was delivered to the Navy in less than three years from contract date.

The Edo Corporation takes great pride in its contribution to the SQS-26 Program and in the achievements of the SQS-26 BX Sonar System. The first BX was installed and checked out ready for sea in an unprecedented six week period. During the six week technical evaluation at sea, an on-line availability in excess of 99 percent was demonstrated. Fleet experience with the SQS-26 (BX) has been similar to that of the technical evaluation with ships reporting over 2000 hours of operation with but 1-5 hours of down time, a notable achievement for so complex a system.

The SQS-26 (BX) has significantly added to the knowledge and capability of the fleet with sixteen systems at sea (plus two serving as training units). The so called bottom bounce and convergent zone techniques can only be proven useful and a real advantage if tested and evaluated on a number of ASW ships under a wide range of conditions as related to ocean bottom, depth of water and ocean areas involved. Continued use of the SQS-26 on a number of ships will refine and increase the value of these new operational techniques, to the detriment of the enemy.

The SQS-26 Program has been costly but, for the moment, provides the only real potential in the fleet for dealing with the sophisticated nuclear submarine missile threat.

Thank you again for the invitation to comment.

Very truly yours,

Gerald Albert

GA/ms

Gerald Albert
for W. R. Ryan
President

PRINCIPAL OFFICIALS OF THE DEPARTMENT OF DEFENSE RESPONSIBLE FOR ADMINISTRATION OF ACTIVITIES DISCUSSED IN THIS REPORT

	Tenure of office	
	From	To
DEPARTMENT OF DEFENSE		
SECRETARY OF DEFENSE:		
Melvin R. Laird	Jan. 1969	Present
Clark M. Clifford	Mar. 1968	Jan. 1969
Robert S. McNamara	Jan. 1961	Feb. 1968
Thomas S. Gates, Jr.	Dec. 1959	Jan. 1961
Neil H. McElroy	Oct. 1957	Dec. 1959
DEPUTY SECRETARY OF DEFENSE:		
David M. Packard	Jan. 1969	Present
Paul H. Nitze	July 1967	Jan. 1969
Cyrus R. Vance	Jan. 1964	June 1967
Roswell L. Gilpatric	Jan. 1961	Jan. 1964
James H. Douglas	Dec. 1959	Jan. 1961
Thomas S. Gates, Jr.	June 1959	Dec. 1959
Donald A. Quarles	May 1957	May 1959
DEPARTMENT OF THE NAVY		
SECRETARY OF THE NAVY:		
John H. Chafee	Jan. 1969	Present
Paul R. Ignatius	Sept. 1967	Jan. 1969
Charles F. Baird (acting)	Aug. 1967	Sept. 1967
Robert H. B. Baldwin (acting)	July 1967	Aug. 1967
Paul H. Nitze	Nov. 1963	June 1967
Fred Korth	Jan. 1962	Nov. 1963
John B. Connally, Jr.	Jan. 1961	Dec. 1961
William B. Franke	June 1959	Jan. 1961
Thomas S. Gates, Jr.	Apr. 1957	June 1959

	Tenure of office	
	From	To
DEPARTMENT OF THE NAVY (continued)		
CHIEF OF NAVAL OPERATIONS:		
Adm. Elmo R. Zumwalt, Jr.	July 1970	Present
Adm. Thomas H. Moorer	Aug. 1967	June 1970
Adm. David L. McDonald	Aug. 1963	July 1967
Adm. George W. Anderson	Aug. 1961	July 1963
Adm. Arleigh A. Burke	Aug. 1955	Aug. 1961
CHIEF OF NAVAL MATERIAL:		
Adm. J. D. Arnold	Oct. 1970	Present
Adm. Ignatius J. Galantin	Mar. 1965	June 1970
Vice Adm. William A. Schoech	July 1963	Mar. 1965
Vice Adm. George F. Beardsley	July 1960	June 1963
COMMANDER, NAVAL SHIP SYSTEMS COMMAND (note a):		
Rear Adm. Nathan Sonenshein	July 1969	Present
Rear Adm. Edward J. Fahy	Feb. 1966	July 1969
Rear Adm. William A. Brockett	Apr. 1963	Feb. 1966
Rear Adm. Ralph K. James	Apr. 1959	Apr. 1963

[a]Naval Ship Systems Command succeeded Bureau of Ships May 1, 1966.

U.S. GAO Wash., D.C.