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DESTROYER ENGINEERED OPERATING CYCLE (DDEOC)

System Maintenance Analysis
CG-16 and CG-26 CLASS
SURVEILLANCE SYSTEMS/SONAR SYSTEMS
SWAB GROUPS 450/460
SMA 1626-450/460
REVIEW OF EXPERIENCE

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Prepared for
Director, Escort and Cruiser
Ship Logistic Division
Naval Sea Systems Command
Washington, D.C.
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This report, the review of experience, documents the historical maintenance experience for both CG-16 and CG-26 Class surveillance systems/sonar systems, SWAB groups 450 and 460. It presents an analysis of the existing maintenance policy and recommends specific maintenance actions and maintenance policy modifications to improve system material condition. It has been developed for NAVSEA 931X, the manager of the Destroyer Engineered Operating Cycle (DDEOC) Program.

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FOREWORD

This report, the review of experience, documents the historical maintenance experience for both CG-16 and CG-26 Class surveillance systems/sonar systems, SWAB groups 450 and 460. It presents an analysis of the existing maintenance policy and recommends specific maintenance actions and maintenance policy modifications to improve system material condition. It has been developed for NAVSEA 931X, the manager of the Destroyer Engineered Operating Cycle (DDEOC) Program, under Navy Contract N00024-80-C-4026.

SUMMARY

The goal of the Destroyer Engineered Operating Cycle (DDEOC) Program is to effect an early improvement in the material condition of ships at an acceptable cost, while maintaining or increasing their operational availability during an extended operating cycle. In support of this goal, system maintenance analyses (SMAs) are being conducted for selected systems and subsystems of designated surface combatants. The principal element of an SMA is the review of experience (ROE). This report documents the ROE for the CG-16 and CG-26 Class surveillance systems and sonar systems, SWAB groups 450 and 460.

The ROE is an analysis of the impact of the historical maintenance requirements on the operational performance and maintenance program of a ship system and the significance of these requirements to the DDEOC Program. The report documents a recommended system maintenance policy and specific maintenance actions best suited to meeting DDEOC goals.

The ROE for the surveillance systems/sonar systems included an analysis of all available maintenance data sources. The documented maintenance experience of the system was reviewed through analysis of data from the maintenance data system (MDS), casualty reports (CASREPs), and system overhaul records. Initial findings from these sources were correlated with planned maintenance system (PMS) requirements, the alterations program, and system technical manuals. Selected ships were surveyed and discussions were held with appropriate technical groups to validate identified maintenance requirements to identify undocumented maintenance requirements, and to determine the status of current and planned actions affecting the surveillance systems/sonar systems. All findings were evaluated and appropriate conclusions were developed.

A recommended system maintenance policy was defined on the basis of these conclusions; recommendations were then made to implement the policy by periodically accomplishing specific types of corrective maintenance actions. These actions were documented for inclusion as tasks in the CG-16 and CG-26 Class maintenance plans. Also included, as appropriate, were recommendations for improving system preventive maintenance; integrated logistics support; reliability, maintainability, and availability; and depot- and IMA-level capabilities. Implementing these combined recommendations will minimize the adverse impact of corrective maintenance requirements on the extended operating cycle.

The major findings and conclusions of this ROE for the CG-16 and CG-26 Class surveillance systems/sonar systems are summarized as follows:

- With the exception of the AN/SPA-25( ), major repairs to the surveillance systems/sonar systems will be required during baseline overhaul.
- With the exception of the LAPS and the sonar cooling system pumps, major repairs to the sonar system will be required during baseline overhaul.
- Although some parts were identified as high-usage items, supply support is adequate and no specific changes are required.
- Selected equipment for the CG-16 and CG-26 Class surveillance system/sonar systems exhibited similar maintenance histories for identical or functionally similar equipment installed on the DDG-37 and FF-1052 Class ships.
- Ship's force has demonstrated adequate repair capability with only limited IMA assistance.
- The search radar restoration program should continue to refurbish AN/SPS-40, -43, and -49 antennas at 36-month intervals.
- No specific electronic component maintenance problems were found that would preclude reliable operation of the surveillance systems/sonar systems during an extended operating cycle for CG-16 and CG-26 Class ships.
- A follow-on ROE for the AN/SPS-49 should be conducted during FY 1982 or when sufficient operating experience data are available.
- Accomplishment of several field changes and shipalts should significantly reduce the ship's force and IMA corrective maintenance burden.

Reliable operation of the surveillance systems/sonar systems can be expected throughout an extended operating cycle if the recommendations contained in this study are implemented and if existing PMS maintenance requirements are adhered to.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

System maintenance analyses (SMAs) are being conducted as part of the Destroyer Engineered Operating Cycle (DDEOC) Program, managed by NAVSEA 931X. The principal element of an SMA is the review of experience (ROE) of selected systems and subsystems of program-designated surface combatants. This report documents the ROE for the CG-16 and CG-26 Class surveillance systems/sonar systems, SWAB groups 450 and 460, which were selected for analysis because equipments of these systems have been major contributors to the CG-16 and CG-26 Class maintenance burden.

1.2 PURPOSE AND SCOPE

The ROE is an analysis of the impact of the historical maintenance requirements on a ship system's operational performance and maintenance program. It serves as a vehicle for documenting the significance of historical maintenance requirements to the DDEOC Program.

The objective of the ROE is to define and document a maintenance program for CG-16 and CG-26 Class ships that will prevent or reduce the need for unscheduled maintenance while improving material condition and maintaining or increasing ship availability throughout an extended ship operating cycle. The maintenance program defined and documented in an ROE for a selected equipment will be the basis for maintenance tasks to be developed for inclusion in the class maintenance plan (CMP).

The analysis documented in this report is specifically applicable to the surveillance systems/sonar systems SWAB groups 450 and 460, of the CG-16 and CG-26 Class ships. This analysis utilized all available documented data sources from which system maintenance experience could be identified and studied. These sources included maintenance data system (MDS) data, casualty reports (CASREPs), Board of Inspection and Survey (INSURV) reports, departure reports, ship's alteration and repair packages (SARPs), planned maintenance system (PMS) requirements data, system alteration documentation, and system technical manuals. Sources of undocumented data used in this analysis included discussions with ship's force and cognizant Navy technical personnel.

1.3 REPORT FORMAT

The remaining chapters of this report describe the analysis approach (Chapter Two), briefly present the significant system maintenance experience and discuss essential maintenance requirements (Chapter Three), and summarize the conclusions and recommendations derived from the analysis (Chapter Four).

CHAPTER TWO

APPROACH

2.1 OVERVIEW

This chapter describes the approach followed in performing the ROE for equipments and subsystems in the surveillance systems/sonar systems, SWAB groups 450 and 460. These systems were identified for analysis in the *DDEOC Selected Items for Analysis List, CG-16 and CG-26 Classes*, ARINC Research Publication 1653-06-TR-1875. Primary data sources were identified in Section 1.2. The data were used to identify, define, and analyze maintenance requirements that have significantly affected the system's operational availability and material condition. A recommended maintenance strategy and implementation procedures were formulated on the basis of analysis results. The major steps of the analysis were as follows:

- Relevant documented and undocumented historical maintenance data were compiled for the selected equipments or subsystems.
- These data were analyzed to identify and define recurring maintenance requirements that have a significant impact on the operational availability and material condition of these equipments or subsystems.
- The results of ROE analyses were compared with results of previously completed analyses of identical or functionally similar equipment or subsystems (on other classes of ships) to determine if previously identified maintenance strategies and implementation recommendations apply to CG-16 and CG-26 Class ships.
- If previously developed maintenance strategies and recommendations were determined to be applicable to similar equipment or subsystems of the CG-16 and CG-26 Class ships, they were identified and documented in this report. CMP tasks previously developed were modified to reflect their applicability to these two ship classes.
- Where previously developed maintenance strategies and implementation recommendations were not applicable to CG-16 and CG-26 Class ships, a detailed maintenance analysis was conducted to develop the maintenance strategy to be recommended and the steps to be employed in implementing that strategy.

2.2 DATA COMPILATION

The analysis began with the compilation of comprehensive data on the maintenance history of the system. The data file assembled consisted of four key elements: an MDS data bank, a CASREP narrative summary, a system overhaul experience summary, and a system shipalt summary. A library of appropriate technical manuals, bulletins, and related documents was also assembled. The MDS data bank was compiled by examining all MDS data reported for the CG-16 and CG-26 Classes from 1 January 1970 through 31 December 1977. In the case of the CG-16 Class, MDS data reported between 1 January 1970 and completion of modernization were not considered. Thus the data bank for ships of this class includes only the MDS reported maintenance actions occurring between the end of modernization and 31 December 1977. CASREP information was obtained by reviewing CASREPs against the various surveillance systems/sonar systems' equipments during the data period 1 January 1972 through 31 August 1978. Overhaul information was obtained from authorized SARPs and departure reports for ships of both classes.

2.3 MAINTENANCE DATA ANALYSIS

Recurring maintenance requirements affecting the availability and material condition of subsystems or equipments were identified by screening data obtained from the above-described sources, as well as from ship surveys, discussions with Navy technical personnel, and NAVSEA special-interest programs.

MDS data provided the initial and primary source of information screened. The resulting data base includes all part and labor records, as well as narrative material, describing maintenance actions reported against system components. The purpose of the screening process was to identify the maintenance actions that had been reported against the surveillance systems/sonar systems' equipments.

Preliminary analysis of each of the equipments was directed toward determining the historical maintenance profile in terms of reported man-hours per equipment operating year, types of maintenance actions commonly recurring, type and number of repair parts used, CASREP frequency, and past ROH experience. The historical maintenance profile was then compared with similar information developed for identical or functionally similar subsystems or equipments previously subjected to detailed analysis during the performance of ROEs for FF-1052 and DDG-37 Class ships. Further analysis was not conducted where the results of this comparison showed that the maintenance profile for the CG-16 or CG-26 Class equipment was essentially the same as that of an identical or functionally similar subsystem or equipment previously analyzed on another ship class. Instead, the maintenance strategy and implementation recommendations developed for the same or similar equipment on a previously analyzed ship class were identified as being applicable to the CG-16 or CG-26 Class ships, as documented in this report.

Where the results of the historical maintenance profile comparison did not reveal a marked similarity, a detailed maintenance requirements engineering analysis was conducted. Initially, man-hour and parts-usage trends were examined to determine if either parameter increased as a function of time after overhaul, indicating wear-out or deterioration. If no increasing trend was evident, it was assumed that the equipment or subsystem could be expected to continue to operate satisfactorily, exhibiting its current maintenance characteristics throughout an extended operating cycle. If an increasing trend was evident, additional analysis was conducted to identify apparent problems and establish the time at which planned restorative maintenance would be required to prevent an unacceptable increase in maintenance burden and downtime.

Detailed analysis was directed toward defining each recurring significant maintenance requirement in terms of several specific factors: the effect of the maintenance action on the subsystem or equipment, the interval between occurrences of the action, the redundancy of the affected subsystem or equipment, the criticality to mission accomplishment, the resources required to perform the necessary corrective maintenance, and the expected subsystem or equipment downtime.

Once the factors associated with the historically required maintenance actions were identified, the individual types of historical maintenance actions were analyzed to identify any design or maintenance-related problems that would have an impact on the selection of a maintenance strategy. Solutions were then sought by examining each problem in relation to the extent to which it was recognized and its amenability to established types of corrective action. These analysis criteria are expressed in the following questions:

- Is the problem known to the Navy technical community, and has a solution been proposed or established?
- Will a design change reduce or eliminate the problem?
- Is the problem PMS-related? Can it be reduced or eliminated by changes to PMS? (These changes might include adding or deleting requirements, changing periodicity, or developing material condition assessment tests and procedures.)
- Can the problem be reduced or eliminated by improving the system's integrated logistic support (ILS) at the ship's force level?
- Can the problem be reduced or eliminated by improving intermediate maintenance activity (IMA) or depot level capabilities?
- Can this problem be reduced or eliminated by revising the existing maintenance strategy?

An affirmative answer to any question resulted in analysis of the effects of the solution and in an estimate, when possible, of the cost to implement the solution. A negative answer prompted the engineer to go to the next question. After all the questions concerning an individual problem were asked, the alternative solutions were evaluated and the most acceptable alternatives defined and documented as recommendations. These recommended solutions to identified design or maintenance-related problems were then considered during the definition of the maintenance strategy. A further series of implementation recommendations were then formulated to accomplish the objectives of the maintenance strategy selected for the engineered operating cycle (EOC).

2.4 MAINTENANCE PROGRAM DEFINITION

The recommended maintenance program stems directly from the subsystem and equipment maintenance strategies identified by the analysis. The total maintenance program includes both the scheduled and unscheduled preventive maintenance and "engineered" and "qualified" corrective maintenance required to maintain the subsystems and equipments at acceptable levels of material condition and availability over an extended operating cycle. Engineered corrective maintenance comprises those tasks that are well defined and must be accomplished periodically. Qualified tasks are those nonspecific repairs that are likely to be required but cannot be characterized precisely as to nature and frequency.

In development of the implementation recommendations, the results of the analysis were used to identify specific corrective maintenance tasks that would be required periodically. Once these tasks were identified, the frequency of accomplishment, the manpower resources required for accomplishment, and the maintenance level required to perform the work were determined for engineered tasks. Qualified maintenance tasks were also identified, on the basis of historical data, to reserve blocks of man-hours at specified intervals to complete required but nonspecific class C repairs on the subsystems or equipments under analysis.

Where appropriate, additional recommendations were developed for improving subsystem or equipment reliability, availability, and maintainability; system preventive maintenance; logistics support; and IMA- or depot-level capabilities.

The steps described in this section effectively define the maintenance program recommended for the subsystems and equipments identified for detailed analysis in this ROE. Recommendations resulting from this analysis will be used to develop the class maintenance plan (CMP).

CHAPTER THREE

ANALYSIS RESULTS

3.1 OVERVIEW

This chapter presents the results of an analysis of the corrective and preventive maintenance experiences of selected equipments of the surveillance systems/sonar systems, SWAB groups 450 and 460, installed on CG-16 and CG-26 Class ships. The surveillance systems/sonar systems include the AN/SPA-25( ) and AN/SPA-74 repeaters; AN/SPS-10 surface search radar; AN/SPS-40( ), -43, and -49 air search radars; AN/SPS-48( ) height-finding radar; AN/SQS-26( ) sonar set, Louis Allis power supply, and cooling system pumps; and the AN/SQS-23( ) transducer assembly.

These equipments were selected from the *Selected Items for Analysis Lists, CG-16 and CG-26 Classes* (ARINC Research Publication 1653-06-TR-1875, February 1979) on the basis of their respective contributions to the total class maintenance burden as determined by their individual maintenance burden factor (MBF) rankings. The resulting maintenance burden factors reflect the total annual man-hours devoted to corrective or preventive maintenance of equipments included in a specific SWAB category by the combined ships of the class. A total of 173 and 136 equipments were ranked for the CG-16 and CG-26 Classes, respectively. The ranking of the SWAB categories represents the preventive and corrective maintenance burden contribution of each SWAB category in relation to the total class burden. Three categories of information were used to determine this ranking: (1) the ship's force and intermediate maintenance activity (IMA) corrective maintenance man-hour burden (MBF_{CM}) reported in the maintenance data system (MDS), (2) the annual planned maintenance system (PMS) man-hour burden (MBF_{PM}) as determined from equipment maintenance requirement cards (MRCs), and (3) the average number of man-days required for equipment repair during regular overhaul (ROH) as reported in class repair profiles. A summary of these data for the selected surveillance systems/sonar systems equipments is presented in table 3-1, together with their relative corrective and preventive maintenance burden rankings.

Sections 3.2 through 3.6 document the results of the maintenance analyses performed for the selected equipments of the CG-16 and CG-26 Class surveillance systems/sonar systems.

Table 3-1. DATA SUMMARY OF SELECTED SURVEILLANCE AND SONAR SYSTEMS' EQUIPMENTS FOR THE CG-16 AND CG-26 CLASS SHIPS

SWAB Number	Selected Equipment	Applicable APLs	Corrective Maintenance Burden Rank Within Ship	Preventive Maintenance Burden Rank Within Ship	Class Population	MHR_{CM}* (Man-Hours)	MHR_{PM}** (Man-Hours)	ROH Burden (Man-Days)
CG-16 Class								
450-1	AN/SPA-25( )	56982410 56982411 56982418 56982420	46	43	34	446	673	213
	AN/SPA-74	56985001	41	55	9	510	305	-
451-1	AN/SPS-10( )	57036615 57036620	37	46	9	634	521	89
452-1	AN/SPS-43	57039900	14	50	9	2,363	392	-
453-1	AN/SPS-48(V)	57040401 57040405 57040455	6	12	9	4,179	11,213	387
460-1	AN/SQS-23D Transducer	91850801	-	-	9	6	0	470
CG-26 Class								
450-1	AN/SPA-25( )	56982410 56982411 56982418 56982420	35	45	40	1,089	877	284
	AN/SPA-74	56985001	45	62	8	717	234	62
451-1	AN/SPS-10F	57036630	43	52	8	765	559	61
452-1	AN/SPS-40( )	57039615 57039620 57039660 57039665	33	49	5	1,113	795	88
	AN/SPS-43	57039900	34	59	3	1,105	330	88
453-1	AN/SPS-48(V)	57040405 57040451 57040454 5704?455	11	12	8	3,741	11,251	179
460-1	AN/SQS-26BX	51091608 57091609 57091610	4	16	7	8,934	7,913	1,186
	LAPS	32523001	-	-	4	-	-	-
	Controller	151160003	-	-	8	-	-	-
	Pump	816110340	-	-	8	-	-	-

*Combined average reported ship's force and IMA corrective maintenance man-hours expended on a particular equipment per year for the entire class population of that equipment.
**Total required annual PMS man-hours as reflected by appropriate MRCs for the entire class population of that equipment.

3.2 RADAR DISTRIBUTION SYSTEMS (SWAB 450-1)

The radar distribution system provides distribution of air search; surface search; and identification, friend-or-foe (IFF) signals to plan position indicators (PPIs). The system consists of the AN/SPA-25( ), AN/SPA-74, and AN/SPA-66( ) indicator groups, and distribution switchboards and associated equipment. Of the equipments within the radar distribution systems boundary, the AN/SPA-25( ) and AN/SPA-74 were selected for analysis.

3.2.1 AN/SPA-25( ) (APLs 56982410, 56982411, 56982418, 56982420)

3.2.1.1 Background

The AN/SPA-25( ) indicator groups are the same equipments for both the CG-16 and CG-26 Classes. There are four modifications, each identified with a separate APL as follows:

Designation	APL	Manufacturer	Applicable Hulls, CG-XX
AN/SPA-25	56982410	Motorola, Inc.	17,18,19,20,23,24,28,29,30,31, 32,33,34
AN/SPA-25A	56982411	Motorola, Inc.	16,22,29,30,31,33,34
AN/SPA-25B	56982418	Litton, Inc.	18,21,27
AN/SPA-25C	56982420	Weston Instruments, Inc.	16,22,27,28,30

These equipments are similar with respect to their function, circuitry, repair parts, and preventive maintenance requirements; therefore, the equipments are discussed together as one, regardless of APL or manufacturer, and are identified by the designation AN/SPA-25( ). The total number of units per ship and the number of each specific APL for each ship vary; the CG-16 and CG-26 Class MDS data indicated equipment populations of 33 and 40 units, respectively.

The MDS data analyzed reflected a total maintenance experience of 52.4 ship operating years (SOYs) for the CG-16 Class and 60.4 SOY for the CG-26 Class.

3.2.1.2 Discussion

The maintenance profile of the AN/SPA-25( ) for the CG-16 and CG-26 Classes was established by reviewing MDS burden data such as narratives, CASREPs, PMS requirements, SARPs, departure reports, and repair profiles.

MDS Summary

Table 3-2 lists the reported AN/SPA-25( ) ship's force and IMA corrective maintenance man-hours for the CG-16 and CG-26 Classes and compares them with the corrective maintenance man-hours reported by the previously

Table 3-2. COMPARISON OF AN/SPA-25( ) AND AN/SPA-74 CORRECTIVE MAINTENANCE BURDEN AMONG FF-1052, DDG-37, CG-16, and CG-26 CLASS SHIPS

Equipment	Class	Total Equipment	Total Equipment Operating Years (EOY)	Corrective Maintenance Man-Hours Expended					
				Ship's Force		IMA		Ship's Force + IMA	
				Total	Per EOY	Total	Per EOY	Total	Per EOY
AN/SPA-25( )	FF-1052	133	342.0	3,754	11.0	77	0.2	3,831	11.2
56982410	DDG-37	24	91.2	2,692	24.5	158	1.7	2,850	3.2
56982411 56982418	CG-16	33	187.7	2,509	13.4	185	1.0	2,694	14.4
56982420	CG-26	40	268.2	5,981	22.3	182	0.7	6,163	22.9
AN/SPA-74	FF-1052	46	156.3	11,621	74.3	746	4.8	12,367	79.1
56985000	DDG-37	10	52.1	3,432	65.9	108	2.1	3,540	68.0
56985001 56985005	CG-16	9	52.4	2,869	54.8	53	1.0	2,922	55.8
	CG-26	9	60.4	4,746	78.6	66	1.1	4,812	79.7

accomplished analyses* for the FF-1052 and DDG-37 Classes. Differences among the burden rate (man-hours per EOY) data for the four classes could not be attributed to any one particular source. Errors in reporting and determining man-hours and differences in skill levels or experience are typical of the contributors to these various burden rates. This burden data rate is relatively low for electronic equipments, and small reporting errors can have a significant effect on the computation of burden rates. A review of the CG-16 and CG-26 Class MDS narratives in conjunction with the MDS man-hours burden summaries indicated that the reported tasks, which were incurred as a result of failed components, were similar to those identified in the previously completed AN/SPA-25( ) analyses for the FF-1052 and DDG-37 Classes. These tasks included the replacement of various transistors and the parts listed in table 3-3. The majority (78 percent) of maintenance actions involved routine replacements of parts and minor adjustments, which are within the capability of ship's force. A total of 738 maintenance actions were performed on the AN/SPA-25( ) for both classes; of that total, 70.3 percent (519) were involved with replacement of parts. The results of the FF-1052 and DDG-37 Class analyses also indicated that 69 and 68 percent, respectively, of the maintenance actions involved parts replacements and that remaining actions were only minor adjustments. It was concluded, therefore, that the range of burden rates was not excessive and that the experienced burden rates were equivalent among the four classes.

CASREP Summary

A total of eight CASREPs for both the CG-16 and CG-26 Classes were submitted during 1 January 1976 through 31 August 1978. This relatively small number of CASREPs was indicated also by the results of the anlaysis of the FF-1052 (20 CASREPs) and DDG-37 (nine CASREPs) Classes. CASREPs were submitted primarily for part nonavailability during the repair of randomly failing components. On the basis of the relatively few CASREPs reported and the random nature of the causes of the reports, it was concluded that random failures within the AN/SPA-25( ) were not mission degrading, since there are multiple installations of these units on board each class.

Parts-Usage Summary

Table 3-3 lists selected parts-usage data for the AN/SPA-25( ) and compares them with the significant-usage parts identified for the FF-1502 and DDG-37 Classes. Neither part listed for the AN/SPA-25( ) was a supply support problem; both parts are authorized spares with an allowance of one. No CASREPs were incurred as a result of these parts' failure; COSAL support was determined to be satisfactory. On the basis of a parts-usage analysis, it was determined that the AN/SPA-25( ) has had no major problems with repair parts supply.

*ARINC Research Publication 1646-03-11-1614, *System Maintenance Analysis, FF-1052 Class Data Display System*, May 1977 and ARINC Research Publication 1652-03-5-1684, *System Maintenance Analysis, DDG-37 Class Radar Data Display System*, December 1977.

Table 3-3. SIGNIFICANT PARTS-USAGE COMPARISON SUMMARY FOR THE AN/SPA-25 AND AN/SPA-74

NSN	Nomenclature	Use	Total Class Part Population				Number of Replacements				Ratio of Parts Used to Total Population				Number of Ships Reporting Usage				Part Usage per Ship per Operating Year (SOY)			
			Class				Class				Class				Class				Class			
			1052	37	16	26	1052	37	16	26	1052	37	16	26	1052	37	16	26	1052	37	16	26
AN/SPA-25																						
9N-5960-709-0499	Electron Tube		133	24	33	40	60	7	22	38	0.4	0.3	0.7	1.0	20	4	7	6	0.5	0.2	0.4	0.6
9N-5960-855-4281	Cathode Ray Tube		133	24	33	40	29	11	27	38	0.2	0.5	0.8	1.0	11	6	6	9	0.2	0.3	0.5	0.6
AN/SPA-74																						
9N-5960-193-5087	Electron Tube	Unit 2500	92	20	18	18	103	30	47	18	1.1	1.5	2.6	1.0	34	6	9	5	0.7	0.6	0.9	0.3
9N-5961-837-7262	Transistor 2N697	Unit 2100	322	70	63	63	452	211	188	197	1.4	3.0	3.0	3.1	35	10	9	8	2.9	4.0	3.6	3.3
9N-5961-846-7338	Transistor 2N1358	Unit 2100	230	50	45	45	178	74	74	109	0.8	1.5	1.6	2.4	27	7	8	7	1.1	1.4	1.4	1.8
9N-5961-883-9177	Transistor 2N2212	Unit 2100	368	80	72	72	497	238	238	228	1.4	3.0	2.3	2.4	34	10	9	8	3.2	4.6	4.5	3.8
9N-5961-892-0921	Cathode Ray Tube		46	10	9	9	31	4	3	1	0.7	0.4	0.3	0.1	20	3	2	1	0.2	0.1	0.1	~0

Depot-Level Maintenance Summary

On the basis of a review of seven SARPs, the depot-level maintenance history for the AN/SPA-25( ) includes six class B overhauls, (with an average burden of 71 man-days), and one class C repair, (with a burden of 39 man-days). This analysis indicated a relatively low ship's force burden and few significant failures of parts; therefore, class C repair, as determined by POT&I (rather than by class B overhaul), should provide a satisfactory level of repair for the AN/SPA-25( ) during BOH and follow-on ROH. Class C repairs, as indicated by POT&I and CSMP results, were recommended by the two previously accomplished AN/SPA-25( ) analyses for the FF-1052 and DDG-37 Classes.

The requirement for class B overhaul of the AN/SPA-25( ), specified by the CG-16 and CG-26 Class DDEOC repair requirements for BOH, should be deleted from those documents; a qualified task should be included in the CG-16 and CG-26 CMP for depot-level accomplishment of class C repairs to the AN/SPA-25( ) during follow-on ROH, as indicated to be necessary by POT&I and CSMP results.

PMS Summary

PMS MIP R-176/1-19 was reviewed for adequacy, and no changes are recommended.

3.2.1.3 Recommendations

Substantial evidence, such as similar maintenance burden rates, CASREP rates, and repair-parts-usage rates, supports implementing a maintenance policy for the AN/SPA-25( ) on board the CG-16 and CG-26 Class ships that is equivalent to the policy previously recommended by the AN/SPA-25( ) analyses for the FF-1052 and DDG-37 Classes.

On the basis of this analysis, the following recommendations should be adopted for the CG-16 and CG-26 Class ships:

- For the BOH:
  - Perform class C repairs to the AN/SPA-25( ) as indicated to be necessary by POT&I and CSMP results.
  - Delete requirement for class B overhaul of AN/SPA-25( ) in CG-16 and CG-26 Class DDEOC repair requirements for BOH.
- For the follow-on ROH, - include a qualified task in the CMP for depot-level accomplishment of class C repairs to the AN/SPA-25( ) as indicated to be necessary by POT&I and CSMP results.

3.2.2 AN/SPA-74 (APL 56985001)

3.2.2.1 Background

Each CG-16 and CG-26 Class ship has one AN/SPA-74 indicator group or AN/SPA-50( ) indicator group installed. Since the AN/SPA-74 is essentially the same as the AN/SPA-50( ) in design and operation [the AN/SPA-74 was converted from an AN/SPA-50( ) by the installation of field change four], the data base used for this analysis contains data for both the AN/SPA-74 and AN/SPA-50( ). The analysis, therefore, was conducted by using the combined data, which reflected 52.4 SOY of operating experience for the CG-16 Class ships and 60.4 SOY of operating experience for the CG-26 Class ships. Recent configuration data indicated that all ships of both classes have the AN/SPA-74 installed, with the exception of the CG-17, -22, and -31 (which have the AN/SPA-50A installed).

3.2.2.2 Discussion

The maintenance profile of the AN/SPA-74 for the CG-16 and CG-26 Classes was established in the same way as the profile for the AN/SPA-25( ).

MDS Summary

Table 3-2 summarizes the AN/SPA-74 ship's force and IMA corrective maintenance man-hours for the CG-16 and CG-26 Classes and compares those man-hour figures with the corrective maintenance man-hours reported by the previously accomplished AN/SPA-74 analyses for the FF-1052 and DDG-37 Classes. The AN/SPA-50 and AN/SPA-74 units on board the FF-1052 and DDG-37 Class ships are similar equipments; therefore, maintenance burden data reported for each unit can be summed to obtain a total burden for the newer AN/SPA-74. The CG-16 and CG-26 Class AN/SPA-50 and AN/SPA-74 burden data were combined in this manner and then used with the previously documented FF-1053 and DDG-37 Class data to compare the historical maintenance burden experience among all four classes. A comparison of the burden rate (man-hours per EOY) data among the classes reveals a fairly close similarity of AN/SPA-74 maintenance burden experience. A review of the CG-16 and CG-26 Class MDS narratives in conjunction with the MDS man-hour burden summaries indicated that the reported tasks, which were incurred as a result of failed components, were similar to those identified in the FF-1052 and DDG-37 Class analyses. Of the 422 maintenance actions required for the AN/SPA-74 aboard both CG-16 and CG-26 Classes, 75 percent (335 actions) involved parts replacement; the results of the analyses for the FF-1052 and DDG-37 Classes indicated that 74 and 89 percent (respectively) of the total maintenance actions for the AN/SPA-74 involved parts replacement.

Most of the repair actions completed on the AN/SPA-74 involved replacement of vacuum tubes and numerous transistors in the following units:

- Sweep generator subassembly (unit 700)
- Deflection output subassembly (unit 2100)
- High voltage power supply (unit 2500)

The FF-1052 and DDG-37 Class analyses each listed the following components as the major burden producer for the indicator group:

Unit	Description
600	Sweep control subassembly
700	Sweep control subassembly
2100	Deflection output subassembly
2500	High voltage power supply

It was concluded that the experienced burden rates were similar, and that the reported maintenance histories of the indicator groups were similar for all four classes analyzed.

CASREP Summary

The deflection output subassembly, unit 2100, and sweep generator subassembly unit 700, were identified in five out of a total of nine CASREPs reported during the data period investigated. The results of the CASREP analyses for the FF-1052 Class and DDG-37 Class indicated that units 2100, 2500, and 700 were the most often reported causes of CASREPs. Seventeen out of 18 and 56 out of 91 CASREPs were attributed to failures within these units for the FF-1052 and DDG-37 Class, respectively. Units 700, 2100, and 2500 were the cause of the majority of CASREPs reported for all four classes investigated.

Parts-Usage Summary

Table 3-2 lists selected parts-usage data for the AN/SPA-74 and compares the data with the significant usage parts identified for the FF-1052 and DDG-37 Classes. The table lists the usage data of those parts which exhibited high usage rates for all four ship classes. Usage rates, (as indicated by the ratio of parts replaced to total population) differed, but no cause could be determined for different rates among the ship classes. All of these high-usage-rate parts are allowable spares and, with the exception of the cathode ray tube, are located within units 2100 and 2500.

Discussions with NAVSECNORDIV technical personnel revealed that the replacement of units 600, 700, 2100, and 2500 with more reliable circuitry is included in a major field change designed to improve AN/SPA-74 (AN/SPA-50A) reliability. Field changes 3 and 8, for the AN/SPA-74 and AN/SPA-50A, respectively, have been conditionally accepted for installation and are currently planned for installation in several trial equipments by the end of 1979. Installation of these field changes, which essentially replace approximately 80 percent of existing circuitry, should reduce significantly the burden associated with these equipments. Therefore, it is recommended that field changes 3 and 8 be accomplished (after these field changes have been acceptance tested) for the AN/SPA-74 and AN/SPA-50A, respectively.

Depot-Level Maintenance Summary

The depot-level maintenance history, which is based on MDS narratives and departure report data, includes class B overhauls of the AN/SPA-74. These overhauls took an average of 69 man-days to be accomplished. A review of SARPs revealed that class B overhaul was recommended in five out of seven SARPs. This maintenance history is similar to the historical depot-level burden data for the FF-1052 and DDG-37 Classes.

Until field changes 3 and 8 are available for fleet-wide installations, class B overhaul should be accomplished at BOH and follow-on ROH on the basis of the depot-level maintenance history and the relatively high burden caused by the failure of parts within units 600, 700, 2100, and 2500. Substantial evidence exists, as a result of these historical maintenance burden analyses, to support the implementation of a maintenance policy for the AN/SPA-74 (AN/SPA-50A) on board the CG-16 and CG-26 Class ships that is equivalent to the policy previously recommended for the FF-1052 and DDG-37 Classes.

3.2.2.3 Recommendations

On the basis of this analysis, the following recommendations should be adopted for the CG-16 and CG-26 Class ships:

- For the BOH, perform class B overhaul of the AN/SPA-74 (AN/SPA-50A). (This task is currently included in the CG-16 and CG-26 Class DDEOC repair requirements for BOH.)
- For the follow-on ROH, include an engineered task in the CMP for depot-level accomplishment of class B overhaul to the AN/SPA-74 (AN/SPA-50A).
- For reliability and maintainability, accomplish field changes 3 and 8, when available, to the AN/SPA-74 and AN/SPA-50A, respectively.

3.3 SURFACE SEARCH RADAR SYSTEM (SWAB 451-1) AN/SPS-10( ) RADAR (APLs 57036615, 57036620, 57036630)

The surface search radar system consists of the AN/SPS-10( ) and LN-66 radar sets, associated waveguides, and antenna assemblies. The primary function of the system is surface target detection and tracking; however, the radar sets are also used for short-range navigation and have the capability to detect low-flying aircraft. The LN-66 is a commercially produced radar that provides a relative plot presentation on its own cathode ray tube (CRT) indicator. The AN/SPS-10( ) is the primary surface search radar for many Navy ships. It displays a true bearing plot of returned video on a separate CRT radar repeater and is the only surface search equipment that exhibited a maintenance burden significant enough to be selected for detailed analysis.

3.3.1 Background

Three versions of the AN/SPS-10 are installed on the CG-16 and CG-26 Class ships: CG-16 is equipped with the AN/SPS-10(C) (APL 57036615), while the remaining eight ships of the class have an AN/SPS-10(D) (APL 57036620) installed; an AN/SPS-10(F) (APL 53036630) is installed on each of the CG-26 Class ships. The three configurations of the radar are similar in terms of design, function, repair parts, and preventive maintenance requirements; therefore, their historical maintenance burden data were summed to obtain an overall data base that reflected 52.4 and 60.4 ship operating years (SOY) of experience for the CG-16 and CG-26 Class ships, respectively. Since the AN/SPS-10 was also installed on the FF-1052 and DDG-37 Classes and was previously analyzed, the documented results of their analysis will be compared with CG-16 and CG-26 Class analysis results to determine if equivalent maintenance histories were experienced.

3.3.2 Discussion

3.3.2.1 MDS Summary

Table 3-4 compares the MDS historical maintenance burden data for the CG-16 and CG-26 Class ships with the results of the two previously accomplished AN/SPS-10 analyses for the FF-1052 and DDG-37 Class ships. An examination of the data reveals that the burdens are similar; MDS narrative data indicated that the AN/SPS-10 historical MDS maintenance burden, in terms of type and level of repair and equipment failures, is equivalent to that burden previously determined for the two other classes. The receiver/transmitter (RT-272A) contributed 45 percent of the reported ship's force corrective maintenance burdens for the CG-16 and CG-26 Class ships. Although exact percentages were not available, the FF-1052 and DDG-37 Class analyses also indicated that the receiver/transmitter was responsible for a major portion of their burdens. Maintenance actions reported against the receiver/transmitter unit were primarily for part replacement. Antenna/pedestal assembly AS-936/SPS-10 accounted for 30 percent of the remaining maintenance burden, while miscellaneous repairs performed on the remaining units constituted the other 25 percent.

3.3.2.2 CASREP Summary

CASREP data indicated 0.9 and 1.0 CASREPs per SOY for the CG-16 and CG-26 Class ships, respectively, which compares closely with the 0.8 CASREPs per year for the DDG-37 Class ships. The FF-1052 Class exhibited a CASREP rate of 0.4 per SOY; causes for this difference could not be identified because of the random failures observed in the data. The types of failures reported for the FF-1052 Class were similar to those for the other three classes; there appears to be no appreciable difference in the historical maintenance burden for the four classes (as reported by CASREPS). The antenna/pedestal assembly was found to be a major source of CASREPs for the CG-16 and CG-26 Class ships, with 17 out of 38 (or 45 percent) of the total CASREPs for both classes. The remaining CASREPs were attributed

Table 3-4. COMPARISON OF AN/SPS-10 CORRECTIVE MAINTENANCE BURDEN AMONG FF-1052, DDG-37, CG-16, AND CG-26 CLASS SHIPS							
Class	Total Ship Operating Years (SOY)	CORRECTIVE MAINTENANCE MAN-HOURS EXPENDED					
		Ship's Force + IMA		IMA		Ship's Force + IMA	
		Total	Per SOY	Total	Per SOY	Total	Per SOY
FF-1052	151.4	7,573	50.0	479	3.2	8,052	53.2
DDG-37	43.9	2,894	66.0	29	0.7	2,923	66.6
CG-16	52.4	2,783	53.1	38	0.7	2,821	53.8
CG-26	60.4	3,911	64.8	157	2.5	4,068	67.4

to randomly occurring parts failures. It was concluded that the maintenance history reported by CASREPs for the CG-16 and CG-26 Classes is similar to the history that was identified for the FF-1052 and DDG-37 Classes, and that the antenna/pedestal assembly was the major contributor to system downtime.

3.3.2.3 Parts-Usage Summary

The high-usage-rate parts identified for the CG-16 and CG-26 Class and FF-1052 Class ships are presented in table 3-5. DDG-37 Class parts-usage data were not available for comparison. Because of their usage rate, the following parts were selected for detailed analysis in the FF-1052 Class analysis:

Part	Circuit Symbol	NSN
Receiver crystal	CR-3002 through CR-3004	9N 5961-615-4309
Transmit/receive tube	V3002	9N 5960-262-0174
Magnetron	V3001	1N 5960-968-3852
Motor/clutch	B3002	9G 6105-308-5315

Similar findings for the CG-16 and CG-26 Class analysis indicated that the maintenance experience with these parts is equivalent to the FF-1052 Class experience. The results of the DDG-37 Class analysis were derived from a comparison of DDG-37 Class burden data with FF-1052 Class burden data. Corrective measures have been undertaken to reduce the impact of these part failures on the AN/SPS-10 maintenance burden: field changes 13 and 21 improve receiver crystal reliability; better quality control of pulse transformers should reduce the replacement rate of T/R tubes and magnetrons. Shipalt documentation indicated that shipalts CG-16-1320 and CG-26-424, *Install AN/SPS-10 Solid-State*, will accomplish the complete replacement of the present tube-type AN/SPS-10 with an all-solid-state equipment, designated AN/SPS-67. The AN/SPS-67 is currently undergoing

Table 3-5. AN/SPS-10 SIGNIFICANT PARTS USAGE COMPARISON SUMMARY

NSN	Nomenclature	Total Class Part Population			Number of Replacements			Ratio of Parts Used to Total Population			Number of Ships Reporting Usage			Part Usage per Ship per Operating Year		
		Class			Class			Class			Class			Class		
		1052	16	26	1052	16	26	1052	16	26	1052	16	26	1052	16	26
9N 5960-045-8639	Electron Tube	414	81	81	558	30	65	1.4	0.4	0.8	*	2	4	3.7	0.6	1.1
9N 5960-060-6626	Electron Tube	92	18	18	329	139	143	3.6	7.7	7.9	40	8	9	2.2	2.7	2.4
9N 5960-106-0423	Electron Tube	46	9	9	280	17	9	6.1	1.9	1.0	*	7	4	1.8	0.3	0.1
9N 5960-116-9969	Electron Tube	46	9	9	246	15	29	5.6	1.7	3.2	*	5	7	1.6	0.3	0.5
9N 5960-166-7674	Electron Tube	184	36	36	96	10	62	0.5	0.3	1.7	24	2	9	0.6	0.2	1.0
9N 5960-166-7685	Electron Tube	184	36	36	301	43	108	1.6	1.3	3.0	*	7	8	2.0	0.9	1.8
9N 5960-262-0163	Electron Tube	184	36	36	103	44	18	0.6	1.2	0.5	26	7	5	0.7	0.8	0.3
9N 5960-262-0174	Electron Tube	45	9	9	280	85	83	0.1	9.4	9.2	*	8	9	1.8	1.6	1.4
9N 5960-284-5823	Electron Tube	92	18	18	104	28	45	1.1	1.6	2.5	38	5	8	0.7	0.5	0.7
9G 6105-308-5315	Motor/Clutch	46	9	9	42	12	5	0.9	1.3	0.6	27	6	3	0.3	0.2	0.1
9N 5961-496-5575	Electron Tube	184	45	45	301	51	12	1.6	1.1	0.3	*	8	5	2.0	1.0	0.2
9N 5961-615-4509	Semiconductor	138	27	27	1622	580	567	11.8	21.5	21.0	42	9	9	10.7	11.1	9.4
1N 5960-804-0957	Electron Tube	92	18	18	198	72	133	2.2	4.0	7.4	*	8	9	1.3	1.4	2.2
1N 5915-831-1548	Network (PFN)	46	9	9	38	12	13	0.8	1.3	1.4	20	6	7	0.3	0.2	0.2
9N 5960-836-6504	Electron Tube	46	9	9	246	39	60	5.4	8.8	6.7	*	8	9	1.6	1.5	1.0
1N 5960-968-1852	Magnetron	46	9	9	309	106	138	6.7	11.8	15.3	45	8	9	2.0	2.0	2.3

*Unable to determine total number of ships reporting.

technical evaluation and is programmed for installation aboard the CG-16 Class in 1982 or 1983, depending on funding requirements. The CG-26 Class will receive the new equipment later, probably in 1984 or 1985. Table 3-3 also shows that electron tubes reflect the major portion of the identified high-replacement-rate parts. Historically, tube replacement has been considered a routine corrective action rather than a major maintenance procedure. Until the AN/SPS-10 is replaced with the AN/SPS-67, replacement of electron tubes is expected to have little impact on maintenance burden; therefore, no changes are recommended. It was concluded that corrective measures have been identified and implemented to alleviate the maintenance burden attributed to the identified high-replacement-rate parts, and that the installation of the new solid-state AN/SPS-67 will eliminate electron tube problems. It is recommended, therefore, that field changes 13 and 21 be installed where applicable in all AN/SPS-10( ) radar sets.

3.3.2.4 Depot-Level Maintenance Summary

SARP data and current CG-16 and CG-26 repair profiles indicate that class B overhaul of the AN/SPS-10( ) is a routine overhaul requirement. For the CG-16 Class, 10 out of 11 SARPs indicated class B overhaul, while for the CG-26 Class, class B overhauls were recommended in three out of five SARPs. On the basis of the number of possible failures of repair parts (particularly electron tubes), the historical depot-level burden data, and the results of the earlier analyses of the FF-1052 and DDG-37 Classes, it is recommended that a class B overhaul be accomplished during BOH and, if necessary, during follow-on ROH if the AN/SPS-67 is not installed as a replacement system.

3.3.2.5 Antenna/Pedestal Assembly

As stated previously, a review of CASREP and MDS data indicated that the antenna/pedestal assembly AS-936/SPS-10 has also been a major contributor to CG-16 and CG-26 Class burdens. A total of 17 CASREPs (45 percent of the system total) were submitted for antenna/pedestal failures, and nearly 30 percent of the maintenance man-hours reported can be attributed to this equipment. Ship overhaul documentation indicates that class B overhaul of the antenna/pedestal assembly is a routine repair item requiring an average of 28 man-days. The FF-1052 analysis noted that corrosion-related failures in the antenna/pedestal assembly were responsible for a large man-hour burden. The analysis recommended the establishment of an antenna turnaround program to provide for uniform overhaul and consistent performance. The DDG-37 Class analysis stated that maintenance burdens were similar to those of the FF-1052 Class and concurred with the antenna recommendations. Discussions with NAVSEA technical personnel (SEA 652) indicated that the AN/SPS-10( ) antenna is included in an overhaul program, with overhaul or replacement at ROH intervals in accordance with the *Search Radar Restoration Program Plan*, published by NAVSEA (SEA 6522); therefore, the current maintenance strategy of run-to-failure with routine PMS accomplishment should remain unchanged. It is recommended that the AS-936/SPS-10 antenna/pedestal assembly be class B overhauled or exchanged with a refurbished unit during BOH and follow-on ROH.

3.3.2.6 Maintenance Policy

It was concluded from this comparative analysis that the maintenance experience for the AN/SPS-10( ) aboard the CG-16 and CG-26 Class ships is equivalent to that experience previously analyzed for the FF-1052 and DDG-36 Class ships, and that the FF-1052 and DDG-37 Class recommendations are applicable to the AN/SPS-10( ) aboard the CG-16 and CG-26 Class ships. Therefore, the following FF-1052 and DDG-37 Class recommendations are appropriate for implementation in the CG-16 and CG-26 Classes:

- Perform class B overhaul or exchange of AS-936/SPS-10 antenna/pedestal assembly during BOH.
- Perform class B overhaul of AN/SPS-10( ) radar.
- Perform class B overhaul or exchange of AS-936/SPS-10 antenna/pedestal assembly during follow-on ROH.
- Perform class B overhaul of AN/SPS-10( ) radar during ROH.

3.3.3 Recommendations

On the basis of this analysis, the following recommendations should be adopted for the CG-16 and CG-26 Class ships:

- Maintain the present run-to-failure maintenance strategy with current PMS tasks.
- For the BOH:
  - Perform class B overhaul or exchange of the AS-936/SPS-10 antenna/pedestal assembly.
  - Perform class B overhaul of the AN/SPS-10( ) radar.

(These tasks are currently included in the CG-16 and CG-26 Class DDSOC repair requirements for BOH.)

- For the follow-on ROH:
  - Include an engineered task in the CNP for depot-level accomplishment of class B overhaul of the AN/SPS-10( ) radar.
  - Include an engineered task in the CNP for depot-level accomplishment of class B overhaul or exchange of the AS-936/SPS-10 antenna/pedestal assembly.
- For reliability and maintainability, ensure that field changes 13 and 21 are installed.

3.4 AIR SEARCH RADARS (SWAB 452-1)

The primary purpose of the air search radars is to detect remote air targets and provide target range and bearing information to the shipboard radar data distribution system. These tracking data then may be displayed and processed for use by various shipboard fire control systems.

This air search function is currently provided by three different two-dimensional (range and bearing) radar sets for the CG-16 and CG-26 Class ships: AN/SPS-40( ), AN/SPS-43, and AN/SPS-49 radar sets. Table 3-6 summarizes the air search radar set distribution for the CG-16 and CG-26 Class ships. Each ship is equipped with one air search radar set.

Table 3-6. AIR SEARCH RADAR DISTRIBUTION FOR CG-16 AND CG-26 CLASS SHIPS

Nomenclature	APL	CG-16 Class Applicable Hulls	CG-26 Class Applicable Hulls
AN/SPS-40C Radar	57039660		31, 32, 33, and 34
AN/SPS-40D Radar	57039665		29
AN/SPS-43 Radar	57039900	16, 17, 18, 20 21, 22, 23, and 24	27, 28, and 30
AN/SPS-49 Radar	57040400CL	19	26

Baseline overhaul (BOH) will modify the present air search radar configuration by replacing most of the existing tube-type AN/SPS-40( ) and AN/SPS-43 radar sets with the newer solid-state AN/SPS-49 radar set. CG-28, -31, and -34 are currently scheduled to retain their present air search radar sets (see table 3-6) after BOH and receive the AN/SPS-49 radar set during the first ROH subsequent to BOH. Accomplishment of shipalts CG-16-1151 and CG-26-0331 will provide these air search radar alterations to the CG-16 and CG-26 Class ships, respectively.

Each air search radar set requires several additional government-furnished equipments to function as a complete air search system, including radar repeaters, a synchro amplifier, and an IFF subsystem. For this analysis, these government-furnished equipments are addressed and discussed as part of the AN/SPS-40/43/49 radar set.

The different air search radar sets were each examined; the results of these examinations are presented in the following subsections.

3.4.1 AN/SPS-40( ) Air Search Radar (CG-26 Class Only)

3.4.1.1 Background

The accumulation of historical maintenance data for the CG-26 Class AN/SPS-40( ) radar sets comprises data reflecting three different radar set configurations: AN/SPS-40B, AN/SPS-40C, and AN/SPS-40D.

A comparison of the average reported corrective maintenance burden and the APLs for each radar set indicated that the AN/SPS-40B, -40C, and -40D radar sets are very similar, with only minor component differences.

All AN/SPS-40B radar sets previously on board the CG-26 Class ships have been modified to the C or D configurations. However, since the AN/SPS-40B maintenance data are similar to those of the AN/SPS-40C and -40D radar sets, these data were included in the AN/SPS-40( ) radar set data analysis.

Shipalt CG-26-331, *ASMD Plan, Replace AN/SPS-43 with AN/SPS-49*, is currently programmed for accomplishment during BOH of three of the five ships on which AN/SPS-40( ) radars are being installed. The two remaining ships will retain the AN/SPS-40( ) radar sets until follow-on ROH. Therefore, the recommendations made in this subsection apply only to those ships that will not receive the new AN/SPS-49 radar set during BOH (CG-31 and CG-34).

3.4.1.2 Discussion

MDS Summary

Table 3-7 summarizes the reported ship's force and IMA corrective maintenance man-hours for the AN/SPS-40B, -40C, and -40D radar sets.

Table 3-7. CORRECTIVE MAINTENANCE BURDEN SUMMARY FOR CG-26 CLASS AN/SPS-40( ) RADAR SETS

Equipment Population	Total Ship Operating Years (SOY)	Corrective Maintenance Man-Hours Expended					
		Ship's Force		IMA		Ship's Force + IMA	
		Total	Per SOY	Total	Per SOY	Total	Per SOY
5	14.5	1,410	94.6	63	4.2	1,473	98.9

A review of the MDS narratives indicated that the majority of the maintenance tasks completed by ship's force were for the replacement of failed parts and components. No regular patterns appeared for any particular type of repair action.

The reported IMA man-hours were expended for troubleshooting assistance (44 man-hours), antenna repair (10 man-hours) and miscellaneous repairs (nine man-hours). No repetitive IMA corrective maintenance actions were observed.

The results of the analysis of the FF-1052 Class AN/SPS-40C( ) radar set review of experience were similar to these findings.

Parts-Usage Summary

Table 3-8 lists AN/SPS-40( ) significant parts usage. The data revealed that electron tubes have the highest replacement rate. Spares are carried on board and these tubes are readily replaced by ship's force. Historically, electron tube replacement has been considered a routine corrective action rather than a major maintenance procedure.

None of the parts listed in table 3-8 exceeded the expected usage rates determined by the Ship Parts Control Center (SPCC) master base replacement factor list.

The COSAL part support is considered to be adequate. Therefore, parts failure or replacement is not expected to present a problem during an extended operating cycle, and no part-related changes are recommended.

CASREP Summary

The available CASREP data for the AN/SPS-40( ) radar set were examined; the results indicated that 27 CASREPs were reported, at an average rate of 1.6 per ship operating year. The reported casualties were random, and no recurring maintenance problems were identified.

Depot/Intracycle Maintenance Summary

The appropriate SARPs and departure reports were not available for review. However, conversations with NAVSECNORDIV technical personnel indicated that the AN/SPS-40( ) radar sets historically have required a class B overhaul during ROH.

PMS Summary

PMS MIP R-13/4-78 was reviewed to identify any scheduled tasks requiring outside assistance. MRC C-1 of MIP R-13/4-78 indicated that the following AN/SPS-40( ) radar set units were to be overhauled during each shipyard availability:

Unit 10 - Compressor

Unit 12 - Antenna

Unit 17 - Distilled-to-fresh-water heat exchanger

Unit 18 - Distilled water pump

The available corrective maintenance data (MDS and CASREPs) for units 10, 17, and 18 were examined; it was found that the maintenance burden contributed by these units was minimal. There were no repetitive maintenance actions or failures identified that would prevent reliable operation of these units during an extended operating cycle. Therefore, for these radar set units, extension of the cyclic requirements listed in MRC C-1 from 36 months to 60 months is feasible. The results of the analysis of the

Table 3-8. SUMMARY OF AN/SPS-40B, -C, -D AIR SEARCH RADAR SIGNIFICANT PARTS USAGE

NSN	Nomenclature	Total Class Part Population	Number of Replacements	Ratio of Parts Used to Total Population	Number of Ships That Reported Usage
1N 5960-168-7818	Electron Tube	10	21	2.1	5
9N 5960-454-6990	Electron Tube	10	29	2.9	5
4N 5960-466-2258	Electron Tube	5	13	2.6	5

FF-1052 Class surveillance radar system are in agreement with this finding. The overhaul of these units should be included as part of an AN/SPS-40( ) radar set class B overhaul to be accomplished during BOH. It is recommended that a note be added to the CG-26 Class repair requirements for BOH [class B overhaul - AN/SPS-40( ) radar set] to overhaul units 10, 17, and 18 of the AN/SPS-40( ) radar set during BOH in accordance with MRC C-1 of MIP R-13/4-78.

Because of the anticipated BOH replacement of three of five of the AN/SPS-40( ) radar sets with the new AN/SPS-49 radar sets, and because of the lack of repetitive or substantial corrective maintenance problems observed in the data, major changes to the present maintenance strategy of "run to failure" and performing the preventive maintenance prescribed by PMS are considered inappropriate.

Results of this analysis indicate that class B overhaul does adequately prepare the AN/SPS-40( ) radar set for the intracycle. Therefore, it is recommended that a class B overhaul of the AN/SPS-40( ) radar set be accomplished at BOH, provided that the AN/SPS-40( ) radar set is not replaced by the AN/SPS-49 radar set.

As part of the search radar restoration program, the AS-2782A antenna (unit 12) is scheduled for replacement during each ROH and SRA-1, thereby retaining a maximum overhaul or replacement interval of 36 months. This requirement was developed on the basis of the restoration program experience with this antenna and has been specified by NAVSEA memo 934X/WIP Ser 8255 of October 17, 1978, from NAVSEA 934X (931X) to NAVSEA 652. On the basis of this NAVSEA requirement, it is recommended that the AS-2782A antenna be replaced at BOH with a refurbished antenna. It is also recommended that an engineered task be included in the CG-26 Class CMP for depot-level replacement of the AS-2782A antenna during the SRA-1 subsequent to BOH.

This requirement is not currently included in the CG-26 Class DDEOC repair requirements for BOH. On the basis of the findings of this analysis, it is recommended that the CG-26 Class DDEOC repair requirements for BOH be changed to include a requirement to accomplish class B overhaul of those AN/SPS-40( ) radar sets which are not replaced by the newer AN/SPS-49 radar sets.

3.4.1.3 Recommendations

The following recommendations should be adopted for all CG-26 Class AN/SPS-40( ) radar sets that are not being replaced during BOH with the AN/SPS-49 radar sets:

- BOH requirements
  - Perform class B overhaul of the AN/SPS-40( ) radar set (to include units 10, 17, and 18) in accordance with MRC C-1 of MIP R-13/4-78.

- •• Replace the AS-2782 antenna with a refurbished unit in accordance with NAVSEA memo 934X/WIP Ser 8255 of 17 October 1978.

  Note: The CG-26 Class DDEOC repair requirement to class B overhaul the AN/SPS-40( ) radar set should be changed to include overhauling units 10, 17, and 18 in accordance with NRC C-1 of MIP R-13/4-78.

- Intracycle requirements - Include an engineered task in the CG-26 Class CMP for depot-level replacement of the AS-2782A antenna during SRA-1 with a refurbished unit.

3.4.2 AN/SPS-43 Air Search Radar

3.4.2.1 Background

The AN/SPS-43 air search radar is currently installed aboard eight CG-16 Class ships (all except CG-19) and three CG-26 Class ships (CG-27, -28, and -30), as shown in table 3-6. AN/SPS-43 radar sets were installed on CG-19 and CG-26 during portions of the MDS data period. Therefore, the maintenance data reported by these two ships are included in the review of experience for the CG-16 and CG-26 Class AN/SPS-43 air search radar.

The AN/SPS-43 radar sets installed on the CG-16 and CG-26 Class ships are identical, and examination of the MDS data indicated that the maintenance experience for the AN/SPS-43 radar sets of each class was similar. Therefore, both ship classes are discussed together.

Shipalts CG-16-1151 or CG-26-331, *ASMD Plan, Replace AN/SPS-43 with AN/SPS-49*, are currently programmed for accomplishment during BOH of all but one of the 11 ships on which the AN/SPS-43 radar set is installed. The CG-28 is now scheduled to retain the AN/SPS-43 radar set until the ROH subsequent to BOH. Therefore, all recommendations made in this subsection will apply only to ships that will retain the AN/SPS-43 radar set until follow-on ROH.

3.4.2.2 Discussion

MDS Summary

Table 3-9 summarizes the ship's force and IMA corrective maintenance man-hours reported for the CG-16 and CG-26 Class AN/SPS-43 radar sets. This table shows that the ship's force maintenance burdens experienced for the CG-16 and CG-26 Classes were nearly the same.

A review of the MDS narratives indicated that the majority of the ship's force corrective maintenance time reported was expended replacing failed parts and components, performing minor adjustments to the equipment, and troubleshooting.

Table 3-9. CORRECTIVE MAINTENANCE BURDEN SUMMARY FOR CG-16 AND CG-26 CLASS AN/SPS-43 RADAR SETS								
Ship Class	Equipment Population	Total Ship Operating Years (SOY)	Corrective Maintenance Man-Hours Expended					
			Ship's Force		IMA		Ship's Force + IMA	
			Total	Per SOY	Total	Per SOY	Total	Per SOY
CG-16	9	50.4	13,195	262	501	11.1	13,756	273
CG-26	4	26.4	7,158	271	134	5.1	7,292	276.2

The relatively small IMA corrective maintenance burden was primarily attributable to nonrecurring equipment failures and service requirements that were not within ship's force capabilities. Field change installations, test equipment calibration, and the overhaul of several coolant pumps and an antenna motor were the major IMA burden-producing tasks. The few remaining IMA tasks were for minor technical assistance to ship's force.

Parts-Usage Summary

The parts-usage data were screened to identify any parts that exhibited usage rates higher than expected, as determined from the parts-usage source data from SPCC. Three parts were identified; they are shown in table 3-10.

Table 3-10. AN/SPS-43 RADAR SET SIGNIFICANT PARTS-USAGE SUMMARY					
NSN	Nomenclature	Total Class Part Population	Number of Replacements	Ratio of Parts Used to Total Population	Number of Ships That Reported Usage
9N 5960-230-5226	Electron Tube	192	66	.3	5
9L 6640-776-0688	Filter	12	54	4.5	7
9N 5960-985-9059	Electron Tube	72	349	4.8	7

These three parts were examined further to evaluate their individual impact on the ship's force maintenance burden. A review of the MDS narratives and the AN/SPS-43 radar set APL indicated that these parts are readily replaced by ship's force personnel, and are all stocked as onboard repair parts. In addition, there have been multiple orderings of these parts on each JCN, indicating excessive orderings for "insurance" reasons. The replacement of any of these parts is not considered a major maintenance action, but rather a routine corrective action. Supply support, therefore, was considered to be adequate, and no changes are recommended.

CASREP Summary

Review of the AN/SPS-43 radar set CASREPs indicated that 57 CASREPs were reported during the 35.3 ship-operating-year CASREP data period (1.6 CASREPs per SOY). Further examination of the reported CASREPs did not identify any recurring failure modes or any increase in the CASREP rate as time out of overhaul increased. The reported failures appeared to be random in nature and largely attributable to part or component failure. No significant stock problems were identified.

PMS Summary

A review of MIP R-95/1-A8 (AN/SPS-43 radar set) did not identify any requirements for which outside assistance would be necessary. The present required PMS for the AN/SPS-43 radar set was judged to be adequate.

Depot-Level Maintenance Summary

A review of the available SARPs indicated that the AN/SPS-43 radar set (including the synchro amplifier and cooling system) had received class B overhauls during eight of the 11 shipyard overhauls examined; each class B overhaul took an average of 360 shipyard man-days to complete.

The limited utilization of the AN/SPS-43 radar sets aboard CG-16 and CG-26 Class ships after BOH and the fact that no indication of significant maintenance actions were found in the historical maintenance review suggest implementing a maintenance policy that is the same as the present one. It is recommended that those AN/SPS-43 radar sets which will remain on board the CG-26 Class ships after BOH receive a class B overhaul during BOH.

A review of the available SARPs also indicated that the AS-1091 antenna and the AB-564 antenna pedestal were either class B overhauled (with an average burden of 64 man-days) or replaced with refurbished units during regular availabilities.

The search radar restoration program, initiated by COMNAVSEASYSCOM (SEA652L), provides a totally coordinated management effort designed to furnish adequate material, funding, and logistic support to meet existing and planned fleet requirements for search radar antenna and pedestal restoration. Under this plan, the AN/SPS-43 radar antenna (AS-1091) and pedestal (AB-564) have a planned restoration cycle of three to four years; those CG-26 Class ships which will retain the AN/SPS-43 radar set after BOH should be scheduled for AN/SPS-43 antenna and pedestal restoration (class B overhaul or exchange with refurbished units) during BOH on the basis of the search radar restoration program plan. It is also recommended that an engineered task be included in the CG-26 Class CMP to replace the AN/SPS-43 antenna and pedestal every 40 months on the basis of the search radar restoration program plan.

3.4.2.3 Recommendations

On the basis of the results of the AN/SPS-43 radar set analysis, the following recommendations should be adopted for those CG-26 Class ships which will retain the AN/SPS-43 radar set after BOH:

- BOH requirements
  - Perform class B overhaul of the AN/SPS-43 radar set (including the cooling system components and the synchro amplifier).
  - Perform class B overhaul or replacement of the AS-1091 antenna and AB-564 antenna pedestal in accordance with the search radar restoration program plan.

(These tasks are currently included in the CG-16 and CG-26 Class DDEOC repair requirements for BOH and should be deleted from the CG-16 Class document.)

- Intracycle requirements - Include an engineered task in the CMP for depot-level accomplishment of class B overhaul or replacement of the AS-1091 antenna and AB-564 antenna pedestal every 40 months in accordance with the search radar restoration program plan

3.4.3 AN/SPS-49 Air Search Radar

3.4.3.1 Background

Shipalts CG-16-1151 and CG-26-331, *ASMD Plan, Replace AN/SPS-43 with AN/SPS-49,* provide for a new solid-state air search radar, designated AN/SPS-49, for CG-16 and CG-26 Class ships. Currently, one ship (CG-19) has an AN/SPS-49 radar installed; however, the available maintenance data were not sufficient to permit establishing a useful historical maintenance profile for the AN/SPS-49 radar set.

3.4.3.2 Discussion

Analysis Scope

This analysis was limited by the lack of substantial historical maintenance data. Data availability for the AN/SPS-49, which was calculated on the basis of currently known BOH schedules, is as follows:

FY	Ship Operating Years of Data
1979	2.9
1980	5.3
1981	10.5
1982	16.7
1983	27.4
1984	40.0

A review of the maintenance data at a later date would be desirable, considering the increasing availability of operating experience and maintenance data for the AN/SPS-49. It is recommended that a review of the maintenance experience with the AN/SPS-49 be conducted at a later date; the earliest recommended review date would be at the end of FY 1982.

Search Radar Restoration Program Plan

An AN/SPS-49 antenna, AS-3263, is included in the NAVSEA (SEA 652) search radar restoration program plan. Discussions with NAVSEA technical personnel revealed that a combination restorative program for the AS-3263 antenna and pedestal assembly is included in current restoration cycle planning. The planned replacement schedule provides for: (1) replacement of the antenna reflector during SRA-1 and ROH, thus retaining a 36-month cycle similar to that for the AN/SPS-40C, and -40D radar antenna; and (2) replacement of the pedestal assembly at each ROH. This replacement schedule should be included in the CMP for CG-16 and CG-26 Class ships. It is recommended, therefore, that engineered tasks be included in the CG-16 and CG-26 Class CMPs for depot-level replacement of the antenna reflector every 40 months, and for replacement of the pedestal assembly each ROH.

PMS Summary

The current MIP for the AN/SPS-49 radar set (MIP R-703/1-A8) was reviewed, and no requirements were identified that would normally require outside assistance. The existing PMS requirements are adequate, and no changes are recommended.

3.4.3.3 Recommendations

On the basis of this analysis, the following recommendations should be adopted for the CG-16/26 Class ships:

- For the intracycle - include an engineered task in the CG-16 and CG-26 Class CMPs for depot-level replacement of the AN/SPS-49 antenna reflector every 40 months.
- For the follow-on ROH - include an engineered task in the CG-16 and CG-26 Class CMPs for depot-level replacement of the AN/SPS-49 antenna and pedestal assembly.
- Conduct a follow-on review of maintenance burden experience at a future date. On the basis of known ROH schedules, the earliest recommended review date would be at the end of FY 1982.

3.5 HEIGHT-FINDING RADAR (SWAB 453-1) AN/SPS-48(V) AND AN/SPS-48C(V) (APL 57040405)

The 3-D air search surveillance system for the CG-16/26 Classes is the AN/SPS-48(V) series radar. The AN/SPS-48(V) is a three-dimensional (range, azimuth, and height-finding) air search, computer-controlled, frequency-scanning, multiple-beam pulsed radar. This system is used to detect, identify, and compute the height of an aircraft and is the primary source of target designation data for the surface missile system. Shipalts CG-16-1034 Rev 1 and CG-26-0179 Rev 1 modify the basic radar set to form the AN/SPS-48A(V) for the CG-16 and CG-26 Classes, respectively. This modification adds moving target indicator (MTI) capability and improves radar detection performance in clutter. Shipalts CG-16-1035 and CG-26-0180 modify the AN/SPS-48A(V) radar to form the AN/SPS-48C(V) for the CG-16 and CG-26 Classes, respectively, and incorporate automatic detection and tracking (ADT) capabilities, which improve clutter rejection, target detection speed and reliability, and overall performance of the radar system with the naval tactical data system (NTDS). The programmed, post-BOH configuration for the CG-16/26 Classes includes the AN/SPS-48C(V) modification for all ships within the classes. The AN/SPS-48C(V) contains the following functional systems:

- Antenna system
- Transmitter system
- Receiver system
- Frequency synthesizer system
- Computer system
- Power supply system
- Display system
- Moving-target indication (MTI) system
- Automatic detection and tracking (ADT) system

The major support systems for the AN/SPS-48(V) series radars are the demineralized water coolant system (DWCS), the air-pressurization system, and the ship's ac power system.

3.5.1 Background

Although the AN/SPS-48C(V) modification is currently installed or is being installed on six ships of the two classes, little historical maintenance information on the AN/SPS-48C(V) was available within the data base used for this analysis. However, because the AN/SPS-48C(V) is essentially an AN/SPS-48A(V) with the ADT capability added, the analysis was based on the AN/SPS-48A(V) maintenance actions and documentation. A total of 15 ships from both classes reported data on the AN/SPS-48A. Of the total of 36.1 ship operating years (SOY) for the AN/SPS-48A(V), 0.75 SOY was attributed to the AN/SPS-48C(V). Corrective and preventive maintenance data for the ADT system were incorporated as appropriate to the analysis. The data reflecting maintenance on the original configuration are not included in the analysis because of major changes incorporated in the modifications.

These equipments are identical for both the CG-16 and CG-26 Classes and will be discussed together. Significant differences in the data between the classes are presenced when those differences are useful for analysis purposes.

The present configuration for the AN/SPS-48(V) series radars on the CG-16/26 Class is as follows:

Modification	Hull No. (CG-XX)
AN/SPS-48A(V)	18,21,22,24,27,29,31,32,33, and 34
AN/SPS-48C(V) - completed	16,19,20,23,28, and 30
AN/SPS-48C(V) - in progress (BOH)	17

3.5.2 Discussion

3.5.2.1 MDS Summary

Table 3-11 is a summary of AN/SPS-48(V) radar set maintenance burden figures obtained from MDS data files for the CG-16 and CG-26 Classes. Also shown in the table are the maintenance burden data for the DDG-37 Class. A comparison of the data reveals similar maintenance burdens among the three classes. Differences in the rate data could not be attributed to any single source; errors in reporting and determining man-hours, differences in skill levels or experience, and variations in configuration are typical of the contributors to the variances in experienced maintenance burden data found in the analysis.

Table 3-11. COMPARISON OF AN/SPS-48A(V) CORRECTIVE MAINTENANCE BURDEN DATA BETWEEN CLASSES

Class	Total Ship Operating Years	Corrective Maintenance Man-Hours Expended					
		Ship's Force		IMA		Ship's Force + IMA	
		Total	SOY	Total	SOY	Total	SOY
16 (7 ships)	14.1	4,180	296	53	3.8	4,233	300
26 (8 ships)	22.0	8,267	375	72	3.3	8,339	379
37 (6 ships)	16.8	9,017	537	274	16.3	9,291	553

Further investigation of the MDS narrative data on an individual ship basis for the CG-16 and CG-26 Classes revealed no appreciable differences in the type of tasks completed, the equipment or components affected, and the man-hour burdens incurred by these two classes of ships when the data were compared with similar data for the DDG-37 Class. Therefore, variances in the burden figures presented herein do not suggest maintenance strategies different from the strategies found in the results of the DDG-37 Class analysis.

3.5.2.2 CASREP Summary

CASREP data were reviewed to the extent necessary to establish similarity between the results of the DDG-37 Class analysis and those of the CG-16 and CG-26 Class analyses. The comparison revealed little difference among the three classes with respect to the cause of the CASREP. High-voltage-component failures within the transmitter section were the dominant cause of CASREP reporting. The transmitter and waveguide systems accounted for 68 percent of the total downtime on the CG-16 Class and 51 percent of the total downtime on the CG-26 Class. These results are consistent with the DDG-37 Class analysis results (which attributed 70 percent of total downtime to transmitter or waveguide failures). The number of CASREPs per ship operating year were compared; the results showed that the CG-16 and CG-26 Classes, which experienced 3.8 and 3.3 CASREPs per year, respectively, compared closely with the DDG-37 Class, which experienced 4.0 CASREPs per SOY. It is concluded, therefore, that the maintenance burden reported by CASREP for the CG-16 and CG-26 Classes is similar to that for the DDG-37 Class.

3.5.2.3 Parts-Usage Summary

Parts-usage data were screened to identify recurring failures. The results show that the high-usage parts identified were those same parts that had been identified previously for the DDG-37 Class. Of the 14 significant-usage parts found by the DDG-37 Class analysis, 13 were found in the screening for the CG-16 and CG-26 Classes. Table 3-12 provides a comparison of parts-usage data for the three classes. Of those significant-usage parts, common to all three classes, none experienced usage rates higher than those rates predicted by using Navy supply system source data.

3.5.2.4 Depot-Level Maintenance Summary

Departure reports and SARPs were also reviewed to establish the depot-level historical maintenance profile. The results of the review indicate that the tasks completed during an overhaul period for the AN/SPS-48A(V) are consistent in terms of classes of repair with the recommended tasks listed in the DDG-37 Class analysis and DDG-37 Class repair profile.

It is concluded that substantial evidence exists (as a result of these historical maintenance data analyses) to support implementing a maintenance policy for the AN/SPS-48C(V) on board the CG-16 and CG-26 Classes that is equivalent to the policy previously recommended for the DDG-37 Class. The following DDG-37 Class maintenance actions are appropriate for implementation in the CG-16 and CG-26 Classes:

- Perform class B overhaul of AN/SPS-48( ) components not affected by shipalts at BOH.
- Perform class B overhaul of antenna or replace antenna with restored antenna, if available, at BOH.

Table 3-12. AN/SPS-48A(V) SIGNIFICANT PARTS USAGE COMPARISON SUMMARY

NSN	Nomenclature	Total Class Part Population			Number of Replacements			Ratio of Parts Used to Total Population			Number of Ships Reporting Usage			Part Usage per Ship Operating Year		
		Class			Class			Class			Class			Class		
		16	26	37	16	26	37	16	26	37	16	26	37	16	26	37
4N 5840-001-1617	Detector, Transmitter	7	8	6	4	6	7	0.6	0.8	1.2	2	4	5	0.3	0.3	0.4
4N 5960-001-1632	Electron Tube, 2nd Stage Amplitron	7	8	6	8	14	24	1.1	1.7	4.0	3	5	6	0.6	0.6	1.4
4N 5840-009-8566	Radio Frequency Amplifier	14	16	12	15	15	14	1.1	0.9	1.2	5	5	4	1.1	0.7	0.8
4N 5840-025-9326	Master Oscillator	14	16	12	4	8	8	0.3	0.5	0.7	3	5	4	0.3	0.4	0.5
9N 5960-058-8783	Thyratron	2135	2440	1830	431	748	763	0.2	0.3	0.4	4	7	6	30.5	34.0	50.5
2N 5960-082-3489	Electron Tube	21	24	18	36	32	34	1.7	1.3	1.9	6	6	6	2.6	1.5	2.0
1N 4140-182-1454	Ventilating Fan	14	16	12	1	14	15	0.1	0.9	1.2	1	6	6	0.1	0.6	0.9
2N 5960-287-7229	Driver Amplitron	7	8	6	6	5	9	0.9	0.6	1.5	3	3	4	0.4	0.2	0.5
1N 5840-771-0249	Detector	35	40	30	6	4	5	0.2	0.1	0.2	2	2	4	0.4	0.2	0.3
2N 5960-771-6560	Electron Tube (4M TWT)	7	8	6	9	24	16	1.3	3.0	2.7	3	6	5	0.6	1.1	1.0
4N 5960-791-3359	Amplitron	7	8	6	7	9	9	1.0	1.1	1.5	2	4	2	0.5	0.4	0.5
9N 5960-833-6062	Electron Tube	14	16	12	15	20	15	1.1	1.2	1.2	4	6	5	1.1	0.9	0.9
9N 5960-836-6504	Electron Tube	28	32	24	23	41	20	0.8	1.3	0.8	4	7	6	1.6	1.9	0.9

- Perform class B overhaul of radar cooling system at BOH.
- At each SRA, perform class C repairs to AN/SPS-48( ) as required by CSMP. Include as a qualified task in CG-16 and CG-26 Class maintenance plan (CMP).
- Perform class C repairs to AN/SPS-48( ) at each ROH as required by POT&I and CSMP results. Include this action as a qualified task in CG-16 and CG-26 CMP.
- Perform class B overhaul of antenna or replace antenna with restored antenna, if available, at ROH. Include this action as an engineered task in CG-16 and CG-26 CMP.
- Perform class B overhaul of radar cooling system at ROH. Include this action as an engineered task in CG-16 and CG-26 CMP.

The installation of the elliptical waveguide system, recommended in the DDG-37 Class analysis, also applies to the CG-16 and CG-26 Classes; these installations have been completed on approximately 50 percent of the CG-16 and CG-26 Class ships, with the remaining ships programmed for future accomplishment of the modification. Shipalts CG-16-1176 and CG-26-0344, *Install Elliptical Waveguide*, provide for a waveguide system that, because of its electromagnetic characteristics, has a higher power-handling capability and is less susceptible to arcing than the original rectangular waveguide configuration. These shipalts also specify that installation of the new waveguide system should be accomplished when the rectangular system's condition deteriorates to the point where the system is uneconomical to repair. It was concluded that such an alteration would reduce waveguide arcing problems that are being experienced currently and would also provide an improved material condition of the waveguide system upon departure from BOH.

3.5.2.5 Integrated Logistics Support Summary

The results of the DDG-37 Class analysis indicated that any lessening of the diagnostic skills of technicians graduating from the AN/SPS-48 Navy training course would be detrimental to the availability of the AN/SPS-48C(V) during an extended operating cycle. The addition of the ADT modification requires additional training with respect to computer diagnostics, maintenance, and operation. A ship survey conducted as part of this analysis revealed that ship's force desires more practical experience in the formal school environment with the AN/SPS-48(V) system. The results of this analysis agree with the DDG-37 Class analysis; it is concluded that the Naval Sea Systems Command should review the routine evaluations of the curriculum and of the graduates of the AN/SPS-48C(V) Navy training course to continually assure the adequacy of the training program.

3.5.3 Recommendations

On the basis of this analysis, the following recommendations should be adopted for the CG-16 and CG-26 Class ships:

- For the BOH
  - Perform class B overhaul of those AN/SPS-48( ) components which are not affected by shipalts.
  - Perform class B overhaul of antenna or replace antenna with restored antenna, if available.
  - Perform class B overhaul of the radar cooling system.

(These tasks are currently included in the CG-16 and CG-26 Class DDEOC repair requirements for BOH.

  - Accomplish shipalts CG-16-1176 and CG-26-0344, *Install Elliptical Waveguide*, as applicable.
- For the follow-on ROH
  - Include a qualified CMP task to perform class C repairs as required by POT&I and CSMP results.
  - Include an engineered CMP task to perform class B overhaul of antenna or replace antenna with restored antenna, if available.
  - Include an engineered CMP task to perform class B overhaul of the radar cooling system.
- For integrated logistics support, NAVSEA technical personnel should review routine evaluations of the curriculum and of the graduates of the AN/SPS-48C(V) Navy training course to continually assure the course's adequacy.

3.6 SONAR SYSTEMS SURFACE SHIPS (SWAB 460-1)

The underwater surveillance system provides an anti-submarine warfare (ASW) capability to identify and track submarines, and to provide shipboard fire control systems with target bearing and range data. The AN/SQS-23 series sonar set on board the CG-16 Class and the AN/SQS-26 series sonar set on board the CG-26 Class constitute the systems in SWAB 460-1. The AN/SQS-23 series is currently programmed for replacement by an all-solid-state electronic system (designated AN/SQQ-23B) and was not analyzed for this report; however, the transducer group for the AN/SQS-23 (TR-208A), which is to be retained for use with the replacement AN/SQQ-23B system, was analyzed. The equipments in SWAB 460-1 for the CG-26 Class that were selected for analysis include (1) sonar set AN/SQS-26, (2) Louis Allis power supply (LAPS), and (3) sonar/radar cooling system pumps. The results of the analysis of these groups of equipments are presented in the following subsections.

3.6.1 Sonar Set AN/SQS-26 (Series) (APLs 57091608, 57091609, 57091610) (CG-26 Class Only)

3.6.1.1 Background

Two modifications of the AN/SQS-26 series are found currently in the CG-26 Class; major equipment differences and configuration variances between the two modifications make each modification substantially different from the other. The CG-27 has the AN/SPS-26 AXR (APL 57091608), while the CG-26 through CG-34 have the AN/SQS-26BX modifications (APL 57091610). For the purposes of this analysis, all equipments are discussed together as one functional system, designated AN/SQS-26 ( ), regardless of APLs. However, maintenance practices that are not common because of configuration differences are discussed separately. The class lead ship, CG-26, is undergoing modernization and will receive the AN/SQS-53A sonar set as the replacement system for the AN/SQS-26 series on this ship. It is expected that the AN/SQS-53A sonar set will be the configuration for the follow-ships within the class; however, this configuration change is not expected to occur until the mid-1980s.

Data for the analysis reflected maintenance experience of 48 ship operating years (SOY) for the AN/SQS-26BX and 7.1 SOY for the AN/SQS-26AXR.

3.6.1.2 Discussion

MDS Summary

The historical maintenance profile for the AN/SQS-26( ) sonar set was obtained by reviewing MDS narrative data, CASREPs, PMS [illegible], SARPs, and overhaul departure reports. The results of the MDS data review are presented in table 3-13, which shows that ship's force experienced nearly all (95 percent) of the total reported burden. Random failures of electronic equipments and components were the principal contributors to the overall maintenance burden. Table 3-14 lists the total repair actions, the number of repair actions requiring parts, summaries of deferral actions, when-discovered, and cause codes for the repair. As can be seen from the distribution of repair actions, the typical failure for the AN/SQS-26( ) resulted in the replacement of parts by ship's force, with little outside assistance required. Failures were discovered mainly during normal operation and were judged by ship's force to be the result of normal wear-out or aging. In addition, there were no identifiable failure modes that occurred at a periodic rate. Trend-line analysis of ship's force man-hours was accomplished, and the results indicated no significant trends in the expected maintenance burden for a 54-month operating cycle. Specific deficiencies in present maintenance practices could not be identified, and the general tendency of ship's force maintenance burden was to remain fairly constant over time. One ship (CG-30), had not had an overhaul for 23 quarters; this afforded the opportunity to present a model maintenance history profile of at least five years for the AN/SQS-26( ) sonar set. It was concluded from the MDS review that ship's force maintenance personnel are adequately trained; that ship's force perform maintenance on the

Table 3-13. CG-26 CLASS AN/SQS-26 CORRECTIVE MAINTENANCE BURDEN SUMMARY

Equipment	APL	Population	Total Ship Operating Years (SOY)	Ship's Force Man-Hours		IMA Man-Hours		Total Man-Hours	
				Number	Per SOY	Number	Per SOY	Number	Per SOY
AN/SQS-26BX	57091610	7	48.0	41,538	865.4	2263	47.1	43,801	912.5
AN/SQS-26AXR	57091608	1	7.1	5,949	837.9	145	20.4	6,094	858.3
Louis Allis Power Supply (LAPS)	32523001	8	55.1	3,387	61.5	131	2.4	3,518	63.8
LAPS Static Controller	15116003	8	55.1	4,758	86.4	73	1.3	4,831	87.7
Cooling System Pumps	016110340	16	55.1	444	8.1	488	9.1	932	16.9

Table 3-14. SELECTED MDS DATA FOR AN/SQS-26( ) SONAR				
Description	AN/SQS-26 BX		AN/SQS-26 AXR	
	Number	Percent of Total	Number	Percent of Total
Number of Repair Actions (Total)	2,634	100	405	100
Number of Repair Actions Requiring Parts	2,037	77	311	77
When Discovered:				
During operation	1,236	47	236	58
During inspection	462	18	54	13
When lighting off or starting	100	4	35	9
During PMS or system test	561	21	44	11
Not applicable/other	275	10	36	9
Cause:				
Normal stress/deterioration	1,862	71	292	72
Manufacturer/installation defects	70	3	7	2
Abnormal/Environment	123	5	18	4
Lack of knowledge or skill	33	1	4	1
Inadequate instruction/procedure	89	3	7	2
Inadequate design	11	.4	1	2
Not applicable/other	446	17	76	19
Deferrals:				
Lack of materials	660	25	71	18
Outside assistance	162	6	42	10
Work backlog/operational priority	135	5	33	8
Miscellaneous reasons	82	3	10	2

AN/SQS-26( ) system with only minimal outside assistance; that the corrective maintenance tasks performed, primarily nonperiodic electronic module/component replacement and minor adjustments, are readily accomplished (given the availability of necessary repair parts); and that, on the basis of the NDS data analysis, extension from a 36-month to a 54-month (± 6 months) overhaul cycle is feasible. IMA man-hours contributed five percent of the total burden for the AN/SQS-26BX. The task that contributed most of this burden of 2,263 man-hours was the inspection and grooming of the sonar dome steel window, with 1,600 man-hours (or 70.3 percent of the total). Shipalt CG-26-0149, *Installation of Sonar Dome Rubber Window (SDRW)*, improves SONAR perfromance and reduces maintenance and repair. The rubber acoustic window resists marine growth and saltwater deterioration, (the major source of IMA burden for the system) and, if damaged, can be more economically repaired than the steel dome. Three ships of the class, (CG-29, -31, and -34) have all-steel domes and are currently scheduled in the FMP for accomplishment of shipalt CG-26-0149. It was concluded that the primary cause of the historical IMA maintenance burden should be eliminated with the installation of the rubber window. Therefore, it is recommended that shipalt CG-26-0149 be accomplished during BOH for the remaining hulls of the class. Shipalt CG-26-0384, *Install SONAR Dome Rubber Coating,* would also provide protection from system degradation caused by marine growth; this shipalt should be accomplished if shipalt CG-26-0149 is not authorized for accomplishment. If either shipalt is not accomplished, the requirements of COMNAVSURFLANTINST 9000.1, article 10552.5, apply. This article specifies that AN/SQS-26-equipped ships with all-steel domes shall schedule a SONAR underwater dome scrub (SUDS) before commencement of refresher training and approximately every six months thereafter. For all-steel dome ships, it is recommended that an engineered task be included in the CMP for IMA accomplishment of a SUDS at six-month intervals.

CASREP Summary

CASREP data for the period 1 January 1972 through 31 August 1978 were analyzed to determine those recurring maintenance actions requiring (1) parts that were not available, or (2) outside assistance at the time of the casualty. Eighty-eight CASREPs were prepared during 40.2 SOY, for an average of 2.2 CASREPs per SOY. Of the total downtime of 87,800 hours, 44 percent (or 38,632 hours) was attributed to supply reasons -- e.g., parts were either not on board or not carried -- and 56 percent (or 49,120 hours) to maintenance actions. The CASREPs for the AN/SQS-26AXR, reviewed separately, indicated a CASREP rate of 2.3 per SOY. Outside assistance was required for 12 out of 88 CASREPs and was attributable to isolated, one-time-only failures or degraded performance that could not be predicted. The results of the CASREP review of this complex system were not considered indicative of significant maintenance problems.

PMS Summary

PMS MIP SO-29/2-78 for the AN/SQS-26BX was reviewed to determine the requirements for outside assistance and possible CMP tasks. The following requirements were evaluated as to the adequacy of the task, frequency, and level of accomplishment:

- C-3, overhaul of heat exchangers
- C-4, transducer element and cabling impedance measurement using AN/WQM-5 test set
- 60M-1, replacement of cooling-water flexible hoses

The first two requirements have 36-month cyclic periodicity, as defined by AN/SQS-26BX PMS MIP SO-29/2-78; replacement of cooling-water hoses, 60M-1, has a specified frequency of 60 months. Each equipment is discussed in the following paragraphs.

It was determined that the maintenance burden of the heat exchangers was minimal: one CASREP, with a total downtime of 506 hours and no maintenance actions other than scheduling of an overhaul, was observed in the MDS burden data. This minimal burden presented little evidence against extending the overhaul period to 54 months. It is therefore recommended that cyclic requirement C-3 of MIP SO-29/2-78 be extended to a 54-month overhaul cycle and that a class B overhaul of the heat exchangers be accomplished during BOH and follow-on ROH.

Sonar transducer replacement policy is established by NAVSEA instruction 9460.4A, which specifies the following:

- AN/SQS-26AXR with TR-198 transducer elements and AN/SQS-26BX with TR-203A transducer elements shall have all defective elements replaced at ROH.
- During the intracycle period, defective elements are replaced only if more than 57 elements in the entire array or more than 15 elements in any single aperture have failed.

Defective transducer elements are determined during pre-arrival inspections and tests prescribed by cyclic requirement C-4. The low maintenance burden observed in the MDS and CASREP data for the transducer elements indicated that extension of cyclic requirement C-4 from 36 to 54 months is feasible. Four maintenance actions, for a total of 297 ship's force man-hours and one CASREP, were required as a result of defective transducers. During the data period investigated, 305 of 4,032 transducer elements were replaced; this reflects a replacement rate of 6.35 elements per ship per year. It was concluded that the transducer elements have experienced a limited number of failures and a relatively low replacement rate and maintenance burden. On the basis of this conclusion and the NAVSEA policies on transducer replacement, it is recommended that the C-4 cyclic requirement to test the elements and cabling before regular overhaul be extended to 54 months, and that an engineered task be included in the CMP for depot-level replacement of defective transducer elements and associated cabling during follow-on ROHs as indicated necessary by POT&I and CSMP results. This depot-level replacement task, currently included in the CG-26 Class DDEOC repair requirements for BOH, encompasses both the AN/SQS-26AXR and AN/SQS-26BX sonar sets.

Replacement of the sonar cooling-water hoses, specified in MIP SO-29/2-78 requirement 60M-1, should be accomplished at BOH and follow-on ROH. MDS data indicated that 28 ship's force man-hours were expended on replacement of cooling hoses and one CASREP resulted from a cooling-water hose failure. This burden was judged to be minimal and did not justify modifying the task frequency. It is therefore recommended that the 60M-1 requirement of MIP SO-29/2-78 be maintained at the prescribed frequency; the hoses should be replaced at BOH and during follow-on ROHs as part of the class B overhaul for the sonar set.

Parts-Usage Summary

Parts-usage data were screened to identify significant usage parts for the AN/SQS-26BX sonar set. Table 3-15 lists selected parts-usage data. The computed "experienced" best replacement factors, BRF_e, were compared with available BRF data published by SPCC in the *Master Best Replacement Factor List*. For those components with BRFs listed, the CG-26 Class "experienced" usage rates are either similar to or significantly below the fleet-wide usage rate. For those parts or components which have no data for comparison, further investigation did not indicate any problems that would create a need for change in the supply support for the AN/SQS-26( ) sonar set.

On the basis of the maintenance burden reviews, the present maintenance policy for the AN/SQS-26 series sonar and related systems is adequate. Therefore the primary conclusion from the analysis is that the AN/SQS-26BX and AN/SQS-26AXR sonars can be maintained in a satisfactory readiness posture throughout the EOC on CG-26 Class ships. This conclusion assumes that all maintenance factors (e.g., PMS tasks, skill levels, and parts availability) remain unchanged and that completion of BOH repairs is accomplished to bring the equipment up to a satisfactory material condition.

Although ship's force has adequately performed the majority of the corrective maintenance for the AN/SQS-26 during the operating cycle, the critical ASW functions provided by this system require that the AN/SQS-26 be in the best possible material condition before entering the DDEOC. Therefore, a class B overhaul during BOH and each follow-on ROH is recommended. Historically, the depot-level maintenance burden has been a result of class B overhauls. A review of CG-26 Class SARPs indicated that 10 of 11 SARPs recommended a class B overhaul; the average overhaul burden was 782 man-days.

3.6.1.3 Recommendations

On the basis of this analysis, the following recommendations should be adopted for the CG-26 Class ships:

- For the BOH:
  - Perform Class B overhaul of these AN/SQS-26 series sonar set equipments which are not affected by shipalts. Include in this requirement PMS MIP SO-29/2-78 cyclic tasks C-3 (overhaul of heat exchangers) and 60M-1 (replacement of cooling-water flexible hoses).

Table 3-15. SIGNIFICANT PARTS USAGE FOR THE AN/SQS-26BX SONAR SET*

NSN	Nomenclature	Total Class Part Population	Number of Replacements	Ratio of Parts Used to Total Population		SPCC Published BRF	Ships That Reported Usage
				Ratio	BRF_e**		
9C 6110-014-2381	Amplifier, Electronic	112	49	.44	.0638	0.0634	7
9N 5960 018 1274	Transistor	2464	421	.44	.0642	No Data	6
1N 5960 419 9364	Scan Converter Tube	14	45	3.2	.4658	1.4000	6
2P 5845 763 8653	Switching	7	10	1.4	.2072	No Data	3
1N 7440 789 8098	Outline Transmitter	14	12	.85	.1232	0.1242	7
2P 5845 796 7892	Transmitter Module	7	23	3.3	.4783	No Data	6

*Parts data for the AXR modification could not be screened, since only one ship has this modification and was judged not to be a good indicator of usage for comparison purposes.

**BRF_e is the "experienced" best replacement factor computed by : $BRF_e = \frac{\text{Annual Usage Rate}}{\text{Total Part Population}}$

BRF_e is used to compare experienced usage for the class with SPCC-published BRFs on the basis of fleet usage.

•• Replace defective AN/SQS-26 series sonar set transducer elements as required by POT&I and CSMP results.

(There tasks are currently included in the CG-26 Class DDEOC repair requirements for ROH.)

•• Accomplish shipalt CG-26-0149, *Installation of SONAR Dome Rubber Window*, or, as the less desirable alternative, shipalt CG-26-0384, *Install SONAR Dome Rubber Coating*, as applicable to CG-29, -31, and -34.

- For the intracycle, include an engineered task in the CMP for IMA-level accomplishment of a sonar underwater dome scrub (SUDS) to the AN/SQS-26 series sonar set as required by COMNAVSURFLANT INST 9000.1, article 10552.5. This requirement applies to all-steel-dome ships only (CG-29, -31, and -34).
- For the follow-on ROH:

•• Include an engineered task in the CMP for depot-level accomplishment of class B overhaul of those AN/SQS-26 series sonar set equipments which are not affected by shipalts. Include in this requirement PMS MIP SO-29/2-78 cyclic tasks C-3 (overhaul of heat exchangers) and 60M-1 (replacement of cooling-water flexible hoses).

•• Include a qualified task in the CMP for the depot-level replacement of defective AN/SQS-26 series sonar set transducer elements as required by POT&I and CSMP results.

3.6.2 LAPS and Related Components (APLs 32523001, 151160003)

3.6.2.1 Background

The sonar power supply (LAPS) is a combination of static and rotary electrical equipments utilized to provide a low-voltage, high-current source of power for active transmission. The LAPS contains four separate equipment groups: two motor generator (MG) sets, lubrication stand, MG static controller, and three input transformers. Although there are three configurations, each identified by a separate APL, the LAPS equipment is addressed as one functional group, identified by APL 32523001. The static controller (APL 151160003) has several configurations and is addressed as part of the LAPS system. MDS historical maintenance burden data from each configuration were summed to achieve a total maintenance burden profile; that profile reflects 55.1 SOY for the LAPS, including the static controller.

3.6.2.2 Discussion

MDS Summary

The results of the MDS burden analysis, summarized in table 3-13, indicate that ship's force experienced approximately 98 percent of the total reported burden for the LAPS system. The MDS narratives indicated a ship's force corrective maintenance burden distribution as shown in

Table 3-16. DISTRIBUTION OF LAPS CORRECTIVE MAINTENANCE BURDEN			
Maintenance Action	Number of Occurrences	Ship's Force Man-Hours	Percent of Total Man-Hours
Replacement of semi-Conductors (transistors, diodes, SCRs)	68	1,990	(24.4)
Replacement of electronic modules	22	688	(8.5)
Replacement of resistors, capacitors	25	136	(1.7)
Replacement of fuses	43	434	(5.3)
Replacement of magnetic amplifiers	2	106	(11.3)
Totals (Electronics)	160	3,354	(41.2)
MG set repairs (Unknown)*	2	280	(3.4)
MG set replacement (1)	1	593	(7.3)
MG set oil-leak repairs	3	52	(.6)
MG set bearing replacement	1	82	(1.0)
Lube-oil pump repairs	6	41	(.5)
Totals (MG set Related)	13	1,048	(12.8)
Non-identifiable repairs	10	2,178	(26.8)
Miscellaneous repairs	41	1,561	(19.2)
Totals for LAPS (Electronics, MG Set, and Miscellaneous)	224	8,141	(100.0)

*Narratives too brief to identify specific repair actions.

table 3-16. As indicated by the data, replacement of the electronic modules and components reflect a significant (41.2 percent) portion of the LAPS maintenance burden. Non-identifiable repairs, which accounted for nearly 27 percent of the total man-hours, were a result of accounting for maintenance actions reported but not described completely in the MDS narratives. Nonperiodi., one-time repairs and replacements of consumable-type parts such as indicator lamps were summarized under miscellaneous repairs. These data indicate that the bulk of the LAPS maintenance burden experienced by ship's force is a result of random electronic component and part failures rather than the failure of an MG set or the support system's mechanical components and parts. Repairs to the mechanical portions of the LAPS amounted to less than one-third of the burden generated by the electronic components. IMA actions totaled 204 man-hours, or 3.7 man-hours per SOY. Review of the MDS narratives did not reveal any significant IMA maintenance actions.

CASREP Summary

CASREP analysis revealed that 18 LAPS-related CASREPs were reported from 1 January 1972 through 31 August 1978, for an average rate of 0.4 CASREPs per SOY. Only one ship reported significant (2,958 hours) downtime caused by MG set maintenance (in this case, a total replacement action). It was concluded that the LAPS MG sets were not a significant contributor to CASREPs. This conclusion is further substantiated by the results of a review of CASREP data for the FF-1052 Class, which has the AN/SQS-26CX sonar set installed. The FF-1052 Class data indicated a total of 86 CASREPS, for an average rate of 0.6 CASREPs per SOY; three CASREPs were attributed to LAPS MG set failure. Of the remaining CASREP-documented failures, there were no recurring failure modes. Further, the distribution of failures was random. On the basis of the observed random failure pattern and the relatively low CASREP rate, it was concluded that the LAPS had not experienced any significant maintenance problem that contributed to the preparation of CASREPs.

PMS Summary

PMS MIP SO-96/1-78 was reviewed to determine the requirements for outside assistance and possible CMP tasks. The following requirements were evaluated as to the adequacy of the task, frequency, and level of accomplishments:

- R-4 - Inspect motor generator, lubrication system, and cooling system; test nitrogen cylinder and associated gauges; and replace unit 4 check valves.
- C-1 - Replace flexible hoses and fittings.

Both of these requirements are scheduled for completion during shipyard availability. On the basis of the MDS data review and CASREP review, no changes to requirement R-4 are needed.

Paragraph 10552.7 of COMNAVSURFLANTINST 9000.1 specifies that replacement of the LAPS flexible saltwater cooling hoses and fittings shall be accomplished at 36-month intervals. This requirement (C-1) should therefore be accomplished during the BOH and included in the CG-26 CMP. It is recommended that an engineered task be included in the CMP for depot-level replacement of the LAPS flexible saltwater cooling hoses and fittings every 36 months after BOH.

Depot-Level Maintenance Summary

The depot-level historical maintenance profile, identified by reviewing SARPS and the CG-26 Class repair profile dated May 1979, indicated that class B overhauls of the LAPS were recommended in six of 11 SARPs reviewed; the average burden for an overhaul was 547 man-days (4,376 man-hours).

Review of the NDS and CASREP data indicated that the bulk of the corrective maintenance burden was due to electronic component failures, which historically exhibit a constant faulure rate (that is, there are no wear-out modes or aging effects). A class B overhaul would do little to reduce the corrective maintenance burden associated with the LAPS since the mechanical components, which would be restored to like-new condition and thereby would be less likely to fail, reflect a fairly small percentage (13 percent) of the total LAPS burden. Class B overhaul of the electronics would result in an insignificant reduction in overall burden because the electronic component failures observed in the data review exhibited random, unpredictable behavior. In addition, five of the 11 SARPS reviewed indicated that class C repairs were a satisfactory level of repair for the LAPS.

It is concluded that class C repairs as determined by the results of POT&I or ship's CSMP would provide an adequate repair level for the LAPS during each ship's overhaul. Therefore, it is recommended that a qualified task be included in the CG-26 Class CMP for depot-level accomplishment of class C repairs during BOH and each succeeding ROH as indicated necessary by POT&I and ship's CSMP results. The requirement for class B overhaul of the LAPS specified by the CG-16 and CG-26 Class DDEOC repair requirements for BOH should be deleted from that document.

Although no particular problems were indicated by this analysis, fleet inputs to the DDEOC program have indicated concern over the LAPS-related maintenance burden. As indicated by table 3-13, the combined man-hour burdens for the LAPS equipment yielded a total burden of well over 8,000 man-hours or 148 man-hours per SOY, a substantial ship's force maintenance burden. An analysis of the LAPS is being conducted in conjunction with an in-depth engineering analysis of the AN/SQS-26CX. General Electric of Syracuse, New York is conducting the analysis effort.

Parts-Usage Summary

Parts-usage data were examined and, on the basis of the few parts that were initially screened, it was determined that there are no major supply support problems for LAPS.

3.6.2.4 Recommendations

The present maintenance policy for the LAPS should be maintained for the extended operating cycle. As a result of the historical maintenance burden analyses, the present maintenance policy is judged to be adequate, and the LAPs can be maintained in a satisfactory readiness posture throughout the EOC. On the basis of the analysis, the following recommendations should be adopted for the CG-26 Class ships:

- For the BOH:
  - Perform class C repairs to the LAPS equipment as indicated necessary by POT&I and CSMP results.

- • Accomplish depot-level replacement of flexible saltwater cooling hoses in accordance with paragraph 10552.7 of COMNAVSURFLANTINST 9000.1.
- • Delete the requirement for class B overhaul of LAPS in CG-26 Class DDEOC repair requirements for BOH.

- For the intracycle, include an engineered task in the CMP for depot-level replacement of flexible saltwater cooling hoses and fittings at 36 months.
- For the follow-on ROH, include a qualified task in the CMP for depot-level accomplishment of class C repairs to the LAPS as indicated necessary by POT&I and CSMP results.

3.6.3 Sonar System Cooling Pumps (APL 016110340)

3.6.3.1 Background

Cooling water for the high-energy, heat-producing components within the AN/SQS-26 series sonar set is provided by a fresh water system supplied to various sonar equipment heat exchangers. The system contains pumps, piping, valves, and saltwater and fresh water heat exchangers that function to keep the sonar set within temperature operating limits. This cooling system is also shared by the air search radar system [AN/SPS-40( ) series or AN/SPS-43 series depending on hull]. The cooling system pumps were selected for analysis on the basis of their contribution to the overall class burden. Three configurations of cooling system pumps are examined:

Hull	APL	Manufacturer
27	016100264	Goulds
28, 32, 34	017030101	Carver
29, 30, 31, 33	016110340	Aurora

The equipments are functionally similar and will be discussed together regardless of APL or manufacturer. Data for the analysis reflected 107.4 EOY of maintenance experience.

3.6.3.2 Discussion

MDS Summary

Table 3-13 lists the reported MDS burden for the fresh water cooling pumps for the radar and sonar cooling system. Analysis of the MDS narratives revealed that ship's force corrective maintenance burden amounted to 444 man-hours distributed as follows:

Maintenance Actions	Number of Occurrences	Ship's Force Man-Hours
Overhaul of pumps	8	322
Replacement of mechanical seals	7	107
Replace wearing rings	1	5
Replace bearings	1	10

The burden rate was 8.1 man-hours per SOY or 4.0 man-hours per EOY. The primary failure mode was mechanical seal leakage; however, replacement of mechanical seals without a complete overhaul (which includes the replacement of mechanical seals, wearing rings, and shaft sleeves and bearings) did not appear to be a significant burden on the basis of occurrences of the task. The average maintenance burden for seal replacement was 15.3 man-hours. SMA 218-728, *FF-1052 Class ASROC Missile Heating and Cooling System and Radar-Sonar Electronic Fresh Water Cooling System,* indicated that the average burden rate for the radar and sonar cooling water pumps ranged from 3.6 to 5.7 man-hours per EOY -- a relatively low burden rate for pumps of this type. The pumps analyzed for the FF-1052 Class ships are similar in operating characteristics to those analyzed for the CG-26 Class ships; therefore, the burden of 4.2 man-hours per EOY for the CG-26 Class radar/sonar cooling water pumps was relatively low also.

The IMA maintenance burden of 488 man-hours was due primarily to overhaul of the pumps; a complete overhaul of a pump by an IMA facility created an average burden of 122 man-hours per pump.

No periodic failure rate could be determined from the data. However, on the basis of the few instances of pump overhauls observed in the MDS data base, replacement of worn out internal pump parts occurred at intervals that varied from 3.3 months to 40.3 months; the average interval, based on 16 maintenance actions, was 18.4 months. These replacements included maintenance actions identified as single part replacements, such as mechanical seals, ship's force overhauls, and overhauls accomplished by an IMA. These data were too random and too limited in terms of specific failures to be used as an accurate basis for predicting failure modes. However, the data were useful as an indicator of possible corrective maintenance during the intracycle between overhauls.

CASREP Summary

CASREP data for 1 January 1972 through 31 August 1978 indicated that one CASREP, reflecting a total downtime of 1,403 hours, occurred during that period for the radar and sonar cooling system pumps; this failure was not evidence of any recurring class-wide problems and was therefore judged to be a minimal burden.

PMS Summary

PMS task requirements were reviewed for adequacy and outside assistance requirements, and no changes are recommended.

Depot-Level Maintenance Summary

The depot-level historical maintenance profile, determined by review of CG-26 Class SARPs and the CG-26 Class repair profile, indicated that class B overhauls of the entire radar and sonar cooling system (including the pumps) are accomplished during each ship's overhaul.

The pumps installed in the AN/SQS-26 sonar and air search radar cooling system have not been a significiant burden. Either one of the pumps will accommodate the total system demand if the second pump fails. Ship's force personnel are normally able to accomplish corrective maintenance on the pumps without outside assistance, and some corrective maintenance (contributing relatively minor burden) will be required during an extended operating cycle. It is recommended, on the basis of the low burden experienced by ship's force and the system redundancy, that class C repairs be accomplished on the radar and sonar cooling pumps during BOH and each succeeding ROH as indicated necessary by POT&I and CSMP results. In addition, a qualified task should be included in the CG-26 Class CMP for depot-level accomplishment of class C repairs of the radar and sonar cooling-water pumps during follow-on ROH as indicated necessary by POT&I and CSMP results.

3.6.3.3 Recommendations

No changes to ship's force maintenance practices are recommended; PMS requirements should be maintained during the EOC. On the basis of this analysis, the following recommendations should be adopted for the CG-26 Class ships:

- For the BOH:
  - Perform class C repairs to the SQS-26/SPS-40/SPS-43 cooling-water pumps as indicated necessary by POT&I and ship's CSMP results.
  - Delete requirement for class B overhaul of LAPS in CG-26 Class DDEOC repair requirements for BOH.
- For the follow-on ROH, include a qualified task in the CMP for depot-level accomplishment of class C repairs to the SQS-26/SPS-40/SPS-43 cooling-water pumps as indicated by POT&I and ship's CSMP results.

3.6.4 AN/SQS-23D Tranducer, TR-197/TR-208A (APLs 91849700, 91850801)

3.6.4.1 Background

Eight of the CG-16 Class ships are equipped with the TR-208A sonar transducer, and the remaining ship of the class (CG-22) has a TR-197. The

TR-208A is manufactured by Dynamics Corporation of America, Massachusetts Division, Hingham, Massachusetts, and the TR-197 is manufactured by Raytheon, Lexington, Massachusetts. Both transducers are functionally similar; therefore, their maintenance histories are discussed together.

3.6.4.2 Discussion

A total of only four maintenance actions and 36 man-hours (all ship's force) were reported against the AN/SQS-23D transducers during the data period. Three of these actions (34 man-hours) were reported for TR-197 maintenance by CG-22, and one maintenance action representing the remaining two man-hours was for TR-208A maintenance. The corrective and preventive maintenance burden is insignificant in relation to other system equipment maintenance; however, the transducer was selected for analysis because of its average overhaul repair requirement of 470 man-days, which was the tenth largest ROH burden among the SWABs analyzed. The primary reason for this low corrective maintenance burden and high ROH burden is the location of the transducer inside the sonar dome. In order to perform transducer maintenance, drydocking of the ship is normally required. Therefore, most of the maintenance required is accomplished during ROH periods.

Review of ship overhaul documents indicated that replacement of transducer elements is the most common repair action required during ship overhauls. The guidelines for transducer and element replacement are contained in NAVSEAINST 9460.1A; those guidelines state that at ROH or during the intracycle period between ROHs, the test procedures in part II of NAVSEA 0967-LP-410-2000 and applicable PMS maintenance requirements are to be used to test transducer performance. NAVSECNORDIV and NAVSEA (660T) personnel conduct a system degradation analysis on test results and determine the extent of repairs to be accomplished.

As a result of the MDS data reviewed, and because no CASREPs were submitted for transducer failures, it was concluded that the current run-to-failure maintenance strategy with routine PMS accomplishment is adequate to maintain the AN/SQS-23D transducer throughout an extended operating cycle. It is therefore recommended that the CG-16 Class sonar transducers be subjected to pre-overhaul test and performance evaluation, with repairs accomplished as required during ROH. In compliance with NAVSEAINST 9460.1A, it is also recommended that tasks be included in the CG-16 CMP for accomplishing pre-overhaul test and evaluation of the sonar transducers and repairing or replacing the transducers as necessary during each subsequent ROH.

3.6.4.3 Recommendations

On the basis of the results of this ROE, the following recommendations are considered applicable and should be adopted for the CG-16 Class AN/SQS-23D sonar:

- At ROH, repair or replace the transducer as necessary on the basis of pre-overhaul system performance test analysis results.

- Maintain the current run-to-failure maintenance strategy for the AN/SQS-23D transducer.
- Include a qualified task in the CG-16 CMP to repair or replace the AN/SQS-23D transducer at each ROH as necessary, on the basis of pre-overhaul system performance test analysis results.

CHAPTER FOUR

CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

The following significant conclusions resulted from this review of experience:

- With the exception of the AN/SPA-25( ), major repairs to the surveillance systems/sonar systems will be required during baseline overhaul.
- With the exception of the LAPS and the sonar cooling system pumps, major repairs to the sonar system will be required during baseline overhaul.
- Although some parts were identified as high-usage items, supply support is adequate and no specific changes are required.
- Selected equipment for the CG-16 and CG-26 Class surveillance system/sonar systems exhibited similar maintenance histories for identical or functionally similar equipment installed on the DDG-37 and FF-1052 Class ships.
- Ship's force has demonstrated an adequate capability to perform repairs with only limited IMA assistance.
- The search radar restoration program should continue to refurbish AN/SPS-40, -43, and -49 antennas at 36-month intervals.
- No specific electronic component maintenance problems were found that would preclude reliable operation of the surveillance systems/sonar systems during an extended operating cycle for CG-16 and CG-26 Class ships.
- A follow-on ROE for the AN/SPS-49 should be conducted during FY 1982 or when sufficient operating experience data are available.
- Accomplishment of several field changes and shipalts should significantly reduce the ship's force and IMA corrective maintenance burden.

4.2 RECOMMENDATIONS

Corrective actions and planning activities identified by this ROE are categorized as follows:

- Baseline overhaul requirements
- Intracycle maintenance requirements
- Follow-on ROH requirements
- Reliability and maintainability improvements
- IMA improvements
- Depot-level improvements
- PMS changes
- Integrated logistic support (ILS) improvements

Specific recommendations from this review of experience are summarized in table 4-1.

Table 4-1. SUMMARY OF ROH RECOMMENDATIONS			
Recommendation Number	Component	Recommendation	Reference Section
Baseline Overhaul Requirements			
1	AN/SPA-25( )	Perform class C repairs as indicated necessary by POTSI and CSMP results. Delete requirement for class B overhaul in CG-16 and CG-26 Class [illegible] repair requirements for ROH.	3.2.1.3
2	AN/SPA-74	Perform class B overhaul of the AN/SPA-74.	3.2.2.3
3	AN/SPS-10F	Perform class B overhaul of the AN/SPS-10F; perform class B overhaul of antenna/pedestal assembly or replace with refurbished units.	3.3.1.3
4	AN/SPS-49( )	Perform class B overhaul of the AN/SPS-49( ) including units 16, 17, and 18; remove and replace antenna/pedestal assembly with refurbished units; change CG-26 [illegible] repair requirements for ROH to include overhaul of units 16, 17 and 18.	3.4.1.3
5	AN/SPS-43	Perform class B overhaul of the AN/SPS-43 including cooling system components and synchro amplifier; perform class B overhaul of antenna/pedestal assembly or replace with refurbished units. Delete requirements for class B overhaul in CG-16 Class repair requirements for ROH.	3.4.2.3
6	AN/SPS-48	Perform class B overhaul of the AN/SPS-48 including antenna group and cooling system; replace antenna group with refurbished unit if available.	3.5.1.3
		Accomplish Shipalts CG-16-1176 and CG-26-0144, *Install Elliptical Waveguide*, as applicable.	3.5.1.3
7	AN/SQS-26( )	Perform class B overhaul of AN/SQS-26( ) including overhaul of heat exchangers and replacement of flexible hoses; replace defective transducer elements as required by POTSI and/or CSMP. Accomplish shipalt CG-26-0149, *Installation of Sonar-Dome Rubber Window (SDRW)*, or shipalt CG-26-0164, *Install Sonar-Dome Rubber Coating* as applicable to CG-29, -31, and -34.	3.6.1.3
8	LAPS	Perform class C repairs as indicated necessary by POTSI and CSMP results; replace flexible, saltwater cooling hoses and fittings. Delete requirements for class B overhaul of LAPS in CG-26 Class [illegible] repair requirements for ROH.	3.6.2.3
9	Sonar Cooling Pumps	Perform class C repairs as indicated necessary by POTSI and CSMP results. Delete requirement for class B overhaul of LAPS in CG-26 Class [illegible] repair requirements for ROH.	3.6.3.3
10	AN/SQS-23 Transducer	Replace defective transducer elements as required by POTSI and CSMP results.	3.6.4.3
Intracycle Requirements			
11	AN/SPS-49( )	Remove and replace antenna/pedestal assembly with refurbished units during SRA-1.	3.4.1.3
12	AN/SPS-43	Perform class B overhaul of antenna/pedestal assembly or replace with refurbished units every [illegible] months.	3.4.2.3
13	AN/SPS-49	Replace AN/SPS-49 antenna reflector every 40 months.	3.4.1.3
14	AN/SQS-26( )	Accomplish Sonar Underwater Dome Scrub (SUDS) at 6-month intervals on steel dome ships (CG-29, -31, -34).	3.6.1.3
15	LAPS	Replace flexible, saltwater cooling hoses and fittings at 36 months.	3.6.2.3
ROH Requirements			
16	[illegible]	Perform class C repairs as indicated necessary by POTSI and CSMP results.	[illegible]
17	AN/SPA-74	Perform class B overhaul of the AN/SPA-74.	[illegible]
18	AN/SPS-10F	Perform class B overhaul of the AN/SPS-10F or replace with refurbished unit if not replaced by [illegible]; perform class B overhaul of antenna/pedestal assembly or replace with refurbished units.	3.3.1.3
19	AN/SPS-49	Replace AN/SPS-49 antenna and pedestal assembly with refurbished units.	[illegible]
20	AN/SPS-48	Perform class C repairs to AN/SPS-48( ) as required by POTSI and CSMP results; perform class B overhaul of antenna group or replace with refurbished units; perform class B overhaul of AN/SPS-48( ) cooling system.	3.5.1.3
21	AN/SQS-26	Perform class B overhaul of AN/SQS-26( ) including overhaul of heat exchangers and replacement of cooling water flexible hoses; replace defective transducer elements as required by POTSI and CSMP results.	3.6.1.3
22	LAPS	Perform class C repairs as indicated necessary by POTSI and CSMP results; replace flexible saltwater cooling hoses and fittings.	3.6.2.3
23	AN/SQS-23 Transducer	Replace defective transducer elements as required by POTSI and CSMP results.	3.6.4.3
24	Sonar Cooling Pumps	Perform class C repairs as indicated necessary by POTSI and CSMP results.	[illegible]
Reliability and Maintainability Improvements			
25	AN/SPA-74	Accomplish field change [illegible] for the [illegible], field change [illegible] when available for installation.	[illegible]
26	AN/SPS-10F	Ensure field changes [illegible] and [illegible] are installed.	[illegible]
Integrated Logistics Support Improvements			
27	AN/SPS-49	Conduct a follow-on review of maintenance burden experience during FY [illegible].	[illegible]
28	[illegible]	[illegible] evaluations of curriculum and graduates of the [illegible] training course to continually assure its adequacy. These reviews should be conducted by [illegible] technical personnel.	[illegible]
[illegible] Changes - None			
Depot-Level Improvements - None			
[illegible] Improvements - None			

LIST OF REFERENCES

The following selected references were used as the basis for the review of experience of the CG-16 and CG-26 Class surveillance systems/ sonar systems, SWAB groups 450 and 460:

ARINC Research Corporation, *System Maintenance Analysis, AN/SQS-26CX Detecting-Ranging Sonar System*, Analysis 301-4631, Draft, 7 November 1975.

ARINC Research Corporation Publication 1646-03-11-1614, *System Maintenance Analysis, FF-1052 Class Data Display System Review of Experience, SMA 305-411*, May 1977.

ARINC Research Corporation Publication 1652-03-5-1684, *System Maintenance Analysis, DDG-37 Class Radar Data Display System, Review of Experience, SMA 37-303-411*, December 1977.

ARINC Research Corporation Publication 1646-03-3-1581, *System Maintenance Analysis, FF-1052 Class Surveillance Radar System, Review of Experience, SMA 303-450*, February 1977.

ARINC Research Corporation Publication 1653-06-7-1886, *System Maintenance Analysis, DDG-37 Class Surveillance Radar Systems, Review of Experience, SMA 37-304-450*, January 1979.

ARINC Research Corporation Publication 1646-03-23-1646, *System Maintenance Analysis, FF-1052 Class ASROC Missile Heating and Cooling and Radar-Sonar Electronic Fresh Water Cooling System, Review of Experience, SMA 218-728*, September 1977.

COMNAVSURFLANT COSAL

COMNAVSURFLANTINST 9000.1, NAVSURFLANT maintenance manual

COMNAVSURFPAC COSAL

COMNAVSURFPACINST 4700.1, NAVSURFPAC maintenance manual

DDEOC Repair Requirements for BOH (CG-16 Class) July 1977

DDBOC Repair Requirements for BOH (CG-26 Class) August 1977

Naval Education and Training Command, Electronics Technician 3 and 2, Volume 2, NAVEDTRA 10195-A.

Naval Education and Training Command, Electronics Technician 1 and C, NAVEDTRA 10192-D.

NAVSEA 0967-LP-312-3010, technical manual, *Waveguide System for AN/SPS-48 Series*

NAVSEA 0967-LP-312-3020, technical manual, *Demineralized Water Coolant System AN/SPS-48*

NAVSEA 0967-LP-312-3030, technical manual, *Dry Air Pressurization System, AN/SPS-48*

NAVSEA 0967-LP-443-2010(C), technical manual, *Radar Set AN/SPS-48A(V)*, Vol. 1.

NAVSEA 0967-LP-604-6010(C), preliminary technical manual, *Radar Set AN/SPS-48C(V)*, Vol. 1.

NAVSEA 0967-LP-598-1010, technical manual, *Operation and Maintenance, AN/UYK-20*

NAVSEA 0967-LP-368-2010, technical manual, *Sonar Set AN/SQS-26BX*

NAVSEA 0967-LP-409-1010, technical manual, *Sonar Set AN/SQS-26AXR*

NAVSEA 0967-LP-447-2010, technical manual, *Sonar Set AN/SQS-23D*

NAVSEA 0967-LP-221-3010, technical manual, *Indicator Group, AN/SPA-25, AN/SPA-25A, AN/SPS-25C*

NAVSEA 0967-LP-445-8010, technical manual, *Indicator Group, AN/SPA-25B*

NAVSEA 0967-LP-103-8017, technical manual, *Radar Set, AN/SPS-10F*

NAVSEA 0967-LP-441-9010(C), technical manual, *Radar Set, AN/SPS-40C*

NAVSEA 0967-LP-052-8010(C), technical manual, *Radar Set, AN/SPS-43*

NAVSEA OLSS-48-01, *Operational Logistics Support Summary for AN/SPS-48( ) Series Radar Set*

NAVSEA 931X memo 934X/WIP Ser 8255 of October 17, 1978 addressed to NAVSEA 652 concerning replacement intervals for AN/SPS-40 radar antennas

NAVSEA 0900-LP-098-6010, *Ship Work Authorization Boundaries for Surface Ships*, March 1978

NAVSEA ship alteration records, NAVSEA form 4720/4, various

NAVSEA 652, *Search Radar Restoration Program Plan*

NAVSEAINST 9460.4A, *Sonar Transducer/Hydrophone Replacement Criteria and Delegation of Responsibility; Replacement Program for*, 9 March 1979

Naval Sea Support Centers, Atlantic, Pacific, ship equipment configuration accounting system (SECAS) 506.1 Reports, CG-16, CG-26 Class hull numbers

OPNAV 4790.3, *Ship's Material Maintenance Management Manual (3M)* Volumes I - III

OPNAVINST 4720.20, *Fleet Modernization Program (FMP)*; planning procedure for:

PERA (CRUDES), *CG-16 Repair Profile*, December 1978

PERA (CRUDES), *CG-26 Repair Profile*, issue number 2, May 1979

PERA (CRUDES), *Ship Alteration Information Manual (SAIM)*, CG-16, CG-26 Class ships, 1978

PERA (CRUDES), POT&I plan for CG-26

Ship's Parts Control Center (SPCC), KIC master index

SPCC *Master Best Replacement Factor List*, 22 May 1978

MDS parts-usage and maintenance data for CG-16 and CG-26 Classes, 1 January 1970 through 31 December 1977

CASREP data for CG-16 and CG-26 Classes, 1 January 1972 through 31 August 1978

Ship alteration management information system (SAMIS)

CG-16, CG-26 Class SARP summary sheets

PMS MIPs R-6/2-A8, R-13/4-78, R-30/2-A8, R-81/P7-48, R-81/S-48, R-95/1-A8, R-176/1-19, R-703/1-A8, SO-29/2-78, SO-29/4-48, SO-29/S-48, SO-29/6-78, SO-96/1-78, SO-561/1-78, A-28/82-A6, A-160/P10-85, A-160/2-86.

Trip report dated 14 March 1979, ARINC Research Corporation visit to USS Dale (CG-19)

Trip report dated 21 May 1979, ARINC Research Corporation visit to USS Wainwright (CG-28).